International Transport Forum

Valuing Convenience in Public Transport

Roundtable Summary and Conclusions

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Mark Wardman
University of Leeds, United Kingdom

OECD

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ROUNDTABLE SUMMARY AND CONCLUSIONS

Mark WARDMAN
University of Leeds, United Kingdom

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VALUING CONVENIENCE IN PUBLIC TRANSPORT

Glossary of Terms:

GC:	Generalised Cost, reflecting the quantified disutility of a travel option in money units
GT:	Generalised Time which is Generalised Cost converted into time units
IVT:	In-Vehicle Time
Late:	Mean lateness on schedule
OVT:	Out-of-Vehicle Time
RP:	Revealed Preference
RR:	Reliability Ratio (Relative value of the standard deviation of travel time and mean travel time)
SD:	Standard Deviation of Travel Time (or Lateness)
SDE:	Schedule Delay Early which is the mean amount of arriving early relative to the preferred arrival time
SDL:	Schedule Delay Late which is the mean amount of arriving late relative to the preferred arrival time
SP:	Stated Preference
WTP:	Willingness-to-Pay

FOREWORD

The experience of transport systems users, in terms of comfort, reliability, safety and above all convenience, is critical in determining demand for transport services, at least when there is a choice of alternative ways to travel. Convenience is one of the strongest attractions of the private car for passenger transport. For users of public transport, convenience is also clearly important but not always clearly defined and not often measured in designing transport systems or monitoring their operating performance. In many situations, an increase in public transport convenience reduces the unit costs of travel (euros/dollars per hour or cents per minute) and so provides benefits equivalent to an increase in travel speed. This report focuses on convenience and its importance to the user experience. It reviews operational definitions of convenience, evidence for the willingness of users to pay for convenience and the use of indicators to assess and improve the convenience of public transport, with a view to making it more effective and more competitive.

1. INTRODUCTION

1.1 Aims and Needs

It is straightforward that making public transport more convenient raises the probability that it will be chosen over alternative transport modes and can raise overall transport demand. It is less straightforward but crucial to understand how users value convenience compared to other characteristics of service, and to produce operational and measurable indicators of convenience. The International Transport Forum therefore convened a roundtable meeting in September 2013 to review international experience with measurement of convenience in order to establish best practice and extract common messages. It also looked into practical use of convenience measures in cost-benefit analysis and in performance measurement.

This report summarises the issues discussed at the roundtable and aims to consolidate evidence on the valuation of public transport convenience for the broader benefit of the transport community of policy makers, operators, academics and consultants, and ultimately public transport users.

The Roundtable was of the view that the practice of accommodating convenience in transport planning, forecasting, policy and appraisal across the world is very variable and often absent. This document serves to:

- Highlight the importance of convenience;

- Provide empirical evidence that can be used to improve services;
- Serve as a stimulus to operators, planners and policy makers to take convenience attributes into account in their decision making;
- Encourage research in the area to derive locally relevant parameters;
- Improve understanding in contexts where evidence already exists through additional research that provides more detailed or better insights.

Where cost-benefit analysis has been used to appraise transport investment projects, the value of in-vehicle time (IVT) has historically dominated, not least because it was the first element of time to be valued in money terms, and remains the single most important parameter in appraisal. This is also because of the dominance of car schemes in transport appraisal where there is no need for convenience terms. As a result, there have over many years been numerous reviews of the value of in-vehicle travel time savings, (Hensher, 1976; MVA et al., 1987; Lawson, 1989; Waters, 1992; Wardman, 1998, 2001, 2004; Miller, 1996; de Jong et al., 1998, 2004; Booz Allen and Hamilton, 2000; Bickel et al., 2004; Shires and de Jong, 2009; Abrantes and Wardman, 2011; Douglas and Wallis, 2013; Wardman et al., 2013).

In many countries that conduct appraisal of transport investments and policies, public transport has at some times in the past been seen as a 'private' good with fare-box revenue for which financial appraisal is sufficient, in contrast to the provision of road capacity that is essentially a 'public' good which requires a broader cost-benefit analysis.

The world has now moved on and there is broader acceptance that public transport schemes should be appraised in a similar fashion to highway schemes[1] which therefore brings into play a broader range of attributes that are critically important in determining the attractiveness of public transport. In addition, and importantly, there is now a large body of evidence relating to the valuation of the drivers of convenience. However, it is not clear that best use is being made of evidence to identify and justify improvements in public transport convenience.

An overview and review of travellers' willingness to pay valuations for convenience improvements is therefore timely and it is this purpose that this document seeks to serve. We do not aim to provide recommendations but rather summarise the evidence so that:

- It provides a useful resource for planners and public transport operators;
- It serves as a benchmark against which to assess emerging evidence;
- It inspires both greater inclusion of convenience measures in appraisal and further research to provide local parameters or improved insights.

1.2 Scope

A discussion of what is meant by convenience is provided in section 2.1 below. Suffice to say at the outset that the Roundtable took as its remit the following time-related attributes other than IVT that impact on the convenience of public transport:

- The inconvenience of public transport not being immediately accessible and available, which might be termed Out-of-Vehicle Time (OVT). This covers:

1. However, we note that highway scheme appraisals rarely include 'analogous multipliers', such as might account for time spent in congested as opposed to free flow traffic or represent different qualities of road surface.

- *Walking time to, from and during a public transport journey*
- *Access to public transport modes more generally that is not necessarily walking*
- *Waiting time, either at the origin point or subsequently transferring between services or modes*

- The inconvenience of not being able to travel at the desired time. This covers:
  - *Differences to and variations upon desired departure times*
  - *Service Frequency*
- The inconvenience of having to interchange, independent of the walk and wait time involved.
- The inconvenience of unreliable services and arriving late.
- The inconvenience of the absence of good user information relating to factors such as wayfinding, real time arrivals, timetables, payment options and the like.
- The inconvenience of crowding and having to stand and the inconvenience of the longer journey times that can stem from crowding.

Whilst other elements of inconvenience could be added, there are practical limitations to the scope of the Roundtable discussion and the convenience factors covered are considered to be the most important aspects.

Although valuations can be used in forecasting the demand consequences of changes in convenience, that is not the focus of this document which is instead focused firmly upon travellers' willingness to pay for more convenient public transport services suitable for use in cost-benefit analysis for appraisal purposes.

1.3 The Potential Benefits of Transferability

Valuations of convenience factors such as walking and waiting are typically expressed in equivalent units of IVT rather than as monetary values. Thus if walking time savings are regarded to be twice as important as the same amount of IVT savings, the walk time multiplier is two.

An attraction of working with time multipliers is that they are potentially much more transferable across different contexts and cultures than are monetary values that suffer from the vagaries of the currency markets, different income levels and living standards, and the income levels of the travelling public differing from average income levels which can be particularly acute in less developed economies. Multipliers are also far more readily interpreted and assessed and there is now a significant amount of evidence relating to them.

Money values of IVT exist in numerous countries, either as the outcome of specific studies or, more importantly, because they can be proxied by reference to wage rates since much value of IVT evidence is expressed in terms of the wage rate. It is then a straightforward matter to obtain the monetary valuations of the convenience variables needed by cost-benefit analysis by applying the multipliers to the money value of IVT used.

In addition to the direct or deduced evidence on values of IVT in many countries, some have evidence on convenience multipliers, most usually for walking and waiting time. Even then it remains useful to assess the values used against other evidence, of which there is now a significant amount, and also to extend coverage to elements of convenience for which local values do not exist.

1.4 Approach

We are not here claiming that there have been no reviews of convenience attributes, although there is little on the scale of the review of IVT values. Notable reviews exist of multipliers associated with walk and wait time (McKnight, 1982, Waters, 1992; Wardman 2004; Australian Transport Council 2006; Abrantes and Wardman, 2011, Wardman, 2013), travel time variability (Noland and Polak, 2002; Tseng, 2008; Li et al., 2010; Carrion and Levinson, 2012; Wardman and Batley, 2014), headway (Wardman, 2004, 2013; Australian Transport Council, 2006; Wallis et al., 2013), and crowding (Li and Hensher, 2011; Wardman and Whelan, 2011; Wallis et al., 2013).

We recognise that the literature containing specific results on the multipliers of interest here is now large and that it is clearly far beyond the scope of this piece of work to review it. But neither is it particularly authoritative to cover an arbitrary selection of studies that have provided evidence whilst identifying a selection of what might be regarded to be the ‘key’ studies in the area can be a subjective matter.

The approach we have adopted is to build upon the review evidence that exists and then to draw upon specific, readily accessed, material to provide supplementary detail on specific issues.

1.5 Structure

Section 2 provides background discussion on what is convenience in the public transport market, clearly setting out what we regard to be the principal convenience variables and why they are important, along with a summary and discussion of current official recommendations and other guidance.

In section 3, we address the issue of measuring public transport convenience variables, how we go about including them in a measure of the attractiveness of public transport and how these inclusions are valued in terms of travellers’ willingness to pay for improvements.

Section 4 provides an overview of empirical evidence for multipliers of walk and wait time, displacement time and headway, transfer penalties, reliability, crowding and information provision. We here make use of existing review material supplemented with studies that provide detailed insights.

Section 5 deals with the future research agenda whilst section 6 considers the policy implications. Concluding remarks are set out in section 7.

2. BACKGROUND

2.1 What is Convenience?

Convenience is related to ‘absence of effort’ in utilizing transport services that are ‘fit for purpose’ in the way they are operated. The concept is narrower than service quality, and transport analysts have long distinguished cost, time, convenience and comfort, where the latter has to do with how pleasant the trip is (Hensher, 1975). There is, however, no general consensus of what convenience represents in a public transport context, and the term is used even without explicit definition. Nor is it unknown that studies that review a large amount of international valuation evidence do not specify what convenience is or indeed rarely use the term (VTPI, 2009; Wardman, 2013).

This lack of clarity on what precisely is convenience is not confined to transport. In the broader marketing literature, and comparatively recently, Berry et al. (2002) stated that:

> *"Convenience is acknowledged to be increasingly important to consumers, yet no known research has defined the service convenience construct or examined how it is evaluated. Although most researchers and managers consider service convenience to involve more than locational proximity or hours of operation, the specific types of service convenience have not been established".*

They go on to define five types of convenience: decision convenience, access convenience, transaction convenience, benefit convenience and post-benefit convenience. At least the first four resonate closely with factors underpinning the attractiveness of public transport.

Claffey (1964) provides one of the earliest definitions of convenience in a travel context. It is stated as being "greatest when users least have to adjust their personal plans and living habits to use transit, and when the difficulties of getting to transit stations and aboard transit vehicles are minimized".

Another early study (Stopher et al., 1974) pointed out what has become something of a recurring theme of varied definitions of convenience across studies, recognising that, "It is most probably that each individual respondent to a transportation survey defines comfort and convenience in an individual fashion". They suggested that the attractiveness of public transport can be decomposed into four generic elements; safety, cost, comfort and convenience. Comfort was defined to "refer to the environment in which the trip is made, the extent to which a trip may be enjoyed or not" whilst in contract convenience "refers to the efficiency and effectiveness with which a person can be transported from origin to destination". The latter was stated to cover access and egress, in-vehicle time, walking, waiting, reliability and the number of changes.

The resource paper prepared for this roundtable by Anderson et al. (2013) provides a very thorough coverage of how convenience has been interpreted. They point out that convenience is an "ambiguous concept" and that the car serves as a benchmark as "the very essence of convenient travel". The latter is invariably characterised by being door to door, with very limited access and egress, the absence of waiting and the ability to travel at the desired departure time in one's own space or shared with friends or family. Admittedly, car travel can have its inconveniences, ranging from congested traffic conditions through to difficulties finding a place to park through to having to clean the car on a weekend! But linking convenience to the features of car travel points towards it covering time-related characteristics such as access and egress time, service frequency, the need to transfer during a journey interchange and crowding. We might also add the 'time invariant' costs of hours of operation, acquiring trip information and tickets, and accessibility for people with special needs.

Anderson et al. (2013) pointed us to relevant definitions of terms. The Oxford English Dictionary defines **convenience** and **convenient** as:

> "**convenience** [noun]... the state of being able *to proceed with something without difficulty …..* the quality of being *useful, easy*, or *suitable* for someone … a thing that contributes to an easy and *effortless* way of life..."
>
> "**convenient** [adjective]…fitting in well with a person's *needs*, *activities*, and *plans* involving *little trouble or effort* . *helpfully placed* or *occurring*.."

As such they state:

> Thereby a *suitable* public transport service would offer the correct capacity and design which is comfortable for its purpose. A reliable, punctual, safe service, offering necessary information, appropriate ticketing and integration will allow the traveller to *proceed without difficulty*. Access and egress to public transport is facilitated by *helpfully*
> *placed and available* (occurring) boarding points, *fitting* with *activities* which give rise to travel demand.

They conclude that essentially "proceeding without difficulty" or "with little effort" is synonymous with the attributes of generalized cost. They cite Crocket and Hounsell (2005) who claimed that "it is possible to consider convenience in rail travel as an embodiment of four themes: access/egress, station facilities/environment, frequency of service/scheduling and interchange between train services."

The Roundtable took the view that convenience is a function of the time aspects, other than scheduled in-vehicle time, along with the ability to travel at the desired time. Arriving late and having to transfer were indisputably seen as sources of inconvenience. The level of crowding chiefly affects comfort but we include it here since there is an element of inconvenience in crowding, such as when it impinges on the ability to undertake activities during the course of a journey[2]. In common with the preceding variables it can be expressed as a time multiplier and can be expected to be a significant element of generalised cost.

Our coverage is therefore based on an 'enhanced Generalised Cost approach', as set out in equation 1 in section 3.2 below. The Roundtable felt that a pragmatic way forward was to

2. Factors not included in convenience are: safety, security, comfort, scheduled journey time and speed.

prioritise what we regarded to be key elements that will add most to a fuller representation of the attractiveness of public transport and, importantly, can be measured and valued. It regarded these to be the inconvenience related to:

- Access and egress time, and in particular walking time at any stage of the journey;
- Waiting time, including that spent transferring between services or modes;
- Not being able to travel at the desired time, covering service headway and displacement time;
- Having to transfer during a journey;
- Travel time variability;
- Absence of good information;
- Crowding.

2.2 Why Do We Care About Convenience?

Convenience is important because it matters, or should matter, to existing and potential public transport users, policy makers and regulators, funding bodies, and operators. It matters because:

- It is a significant element of the overall attractiveness of public transport, directly impacting on the wellbeing of travellers;
- Poor performance provides a significant barrier to use, thereby thwarting policy efforts to switch more people to sustainable modes of travel;
- There are ever-rising expectations for convenience;
- Improving convenience is particularly important in efforts to attract discretionary travellers, such as those who would otherwise drive, to public transport, and therefore contribute to strategic planning objectives such as reduced traffic and parking congestion, vehicle accidents and pollution emissions;
- There is a relationship between improved convenience and the financial performance of public transport;
- Transportation planning in practice often involves trade-offs between public transport convenience and other objectives;
- Convenience affects broader mobility objectives.

Public transport travel time unit costs (Euros/dollars per hour, or cents per minute) are highly variable. When travel conditions are favourable (good walking and waiting conditions, clean and comfortable vehicles, convenient user information, etc.), the generalised journey time cost of public transport travel can be lower than that of car travel, since passengers experience minimal stress and can use their travel time productivity (resting, working, socialising, etc.); for this reason travellers will sometimes choose a longer duration public transport trip than would be required to drive so they can use their time in a worthwhile manner. However, if public transport conditions are unfavourable (uncomfortable, unpleasant, unsafe, difficult to use, etc.) unit travel times tend to be higher than for car, which inevitably reduces public transport use.

Sommers (1969) was an early attempt at examining users' attitudes to various dimensions of public transport, and convenience featured highly. The rank ordering of importance was time, convenience, comfort, safety, weather based reliability, cost, noise and mechanical reliability. Another early study (Paine et al., 1969) was more extensive with importance ratings covering 33 time, cost, convenience, comfort, safety and attitudinal terms. Again convenience issues rated highly, with reliability and travel time being the two most important attributes.

Public transport users regularly prioritise convenience improvements. Recent market research of bus users in the UK (Passenger Focus, 2010a) explored 30 possible improvements to bus services. Convenience factors featured highly, including reliability (1st), frequency (2nd), seat availability (3rd) and buses that cover a wider range of destinations (5th). Notably a 5 minute journey time reduction, outside our definition of convenience, was rated as the 23rd most important improvement! As for rail passengers (Passenger Focus, 2010b), the most important priority for improvement amongst the 31 attributes covered was prices followed by reliability (2nd), sufficient trains at the time of travel (3rd), availability of seats (4th), information on delays (5th), information on train times and platforms (6th) and queuing time (7th). A journey time reduction of 5 minutes was 11th.

Trompet et al. (2013) provide an international dimension across 10 different cities using a standard set of questions relating to the three most important features of bus service quality out of eight presented. The range across the cities (in 2012) of the percentages of respondents citing an aspect of service quality as amongst the three most important criteria were:

- Availability (frequency and reliability of service, hours of operation): 86-98
- Accessibility (ease of getting on and off): 8-17
- Information (availability and quality of maps, timetables, delay information): 32-50
- Time (travel time and on-time running): 66-78
- Customer care (helpful staff, responding to suggestions/complaints): 6-20
- Comfort (temperature, ventilation, comfortable journey, clean, crowding): 25-42
- Security (feeling safe and secure): 19-34
- Environment (effect on pollution, noise, congestion): 5-17

These figures demonstrate the importance of convenience related factors. For example, availability is the most important issue, even more than journey time whilst these two and information are more important than comfort and security and far more important than customer care, environmental considerations and ease of getting on and off...

As we have defined it here, convenience is an important aspect of the attractiveness of public transport. Let us give an example. A typical commuting journey might be made up of 30 minutes of in-vehicle time, with 5 minutes of access and 10 minutes of egress, added to which is 5 minutes waiting. At what might be deemed conventional values where out-of-vehicle time is double weighted, this amount to 70 minutes of generalized journey time of which the convenience element makes up 57%. If we added to this average lateness of one minute, with a multiplier of 3, and crowding conditions tending to add 25% to the value of time spent in-vehicle, then the proportion that convenience forms of generalized journey time is 63%. Other scenarios will yield other proportions but it is not unreasonable that convenience is a significant portion of the time element of travel. This will also be the case with regard to the generalized cost of travel. Once the money elements are included, convenience should reasonably form 25-50% of total generalized cost. Crowding alone forms 8-12% of GC for Tokyo commuters (Kato, 2014).

Convenience variables are significant features of public transport journeys and their relatively large values underpin a disproportionately large contribution to its attractiveness. Their importance also opens avenues for making public transport more competitive.

Firstly, as Krygsman et al. (2004) state, "Access and egress are the weakest links in a public transport chain and determine the availability and convenience of public transport. Initiatives aimed at improving access and egress hold potential to significantly reduce public transport trip time and are inexpensive options compared to the expensive infrastructure and vehicle enhancement alternatives frequently considered". Not only might it be possible in some circumstances to be more cost-effective to achieve overall journey time reductions by operating on OVT terms but the greater valuation of OVT savings ought to reap greater dividends.

Secondly, Litman (2014) provides interesting examples of how the travel time costs of transit can exceed those of the same car journey but, with incremental improvements in convenience due to the conditions in which the journey is made, can significantly improve the attractiveness of transit to be competitive with car without any reductions in the journey time itself.

Thirdly, if convenience is important to users of public transport, how much more is it an issue for non-users who do not use public transport precisely because they regard it to be inconvenient?

We can therefore conclude that convenience is a 'big issue', and if convenience is important to users and potential users, then it can be expected to have an impact on the financial bottom line of operators, and therefore be of concern to a broad range of stakeholders. Indeed, there are several indications that service quality improvements trigger larger demand responses than fare changes (see the resource papers by Anderson et al. (2013) and by Lee (2013)). Service quality management can affect the financial sustainability of public transport, particularly if accompanied by fare management.

Operators may regard convenience often as beyond their control, thereby introducing an unwelcome level of uncertainty. Train operators are faced with a fixed network and hence find it difficult to influence access and egress times and other costs that have a significant bearing on their attractiveness. Whilst bus operators can be more flexible in their networks, they suffer the vagaries of traffic congestion and buses can as a result be notoriously unreliable particularly at times when most people wish to travel.

Convenience is also an important issue for regulators that seek to incentivise operator performance. Contracts between authorities and operators that are based on indicators of convenience can lead to improved convenience. In the UK, for example, the Schedule 8 payments mechanism means that train operators and the infrastructure provider are fined and compensated according to the degree of delay that they cause or incur. In Transantiago, bus operators receive significant fines if the frequency offered per line is below that requested, and if headway variability exceeds a threshold. The STIF (the public transport regulator for the Ile-de-France region) recently signed a 4 year contract with the RATP and the SNCF (the public transport operators for the Central Paris area and the regional railway network respectively). If we limit consideration to the STIF/RATP contract, signed for the 2012-2015 period, the total financial envelope for the service provision and the investments planned is around 15 billion euros, among which 28 million are related to a bonus-penalty system, depending on the quality of the service provided to users (in the previous contract for 2008-2011, this amount was 21 million). Punctuality's weight within this bonus-penalty scheme is 50%, the information for users corresponds to 14% and the users' satisfaction with service quality forms 10%. The latter is now assessed through a survey of 120 000 users per year covering the three main issues of environment, accessibility and information. For the regional railway network (RER), users will be refunded (50% of the Navigo travel pass) if the service delivery becomes ‘unacceptable’.

A perverse incentive of some performance regimes has been the padding of timetables with additional recovery time. With regard to Dutch railways, Kroon et al. (2009) point out: “To increase the robustness of the timetable, we increased the running times, dwell times, and headway times by time supplements based on experience and expert opinions. Time supplements in the running and dwell times absorb small disturbances in the real-time operations, allowing trains to recover from delays. Time supplements in the headway times, also called buffer times, reduce the propagation of delays from one train to another.” A balance has to be struck between speed and reliability.

It is widely regarded that consumers have ever rising quality expectations in all markets and thus whatever importance public transport convenience currently has, and we would argue it is significant, it will become more of an issue in future, particularly in the light of increases in the attractiveness of car travel. Improving public transport convenience can be virtuous: it increases demand, revenue, public support and acceptability, helping to ensure its long term viability.

Finally, adding convenience to CBA can lead to appreciable increases in benefits. For example, the resource paper by Kroes et al. (2013) integrating the value of crowding in the socio-economic appraisal of the extension of RER line E increases total benefits by 6%. Similar orders of magnitude are found in studies for Japan, as were discussed in the presentation at the Roundtable by Kato.

2.3 Official Multiplier Values

In some countries, official values are specified to be used in the appraisal of transport investments and policies, particularly where public funding is involved. The primary focus of attention over the years has been valuation of in-vehicle travel time savings. We are, however, here concerned with recommended multipliers for the convenience factors set out in section 2.1.

Bickel et al. (2004) as part of the EU funded HEATCO project concerned with transport costing and project appraisal provided a useful summary of the state-of-play in Europe early in the 21st century regarding convenience multipliers. They stated:

> *“Four countries include guidance weights or values for the treatment of walk, wait and transfer times (Denmark, Sweden, Switzerland and the UK). Other countries, such as France and the Netherlands, make reference to the fact that walk, wait and transfer times may have different values from in-vehicle-time but do not suggest any weights. Denmark and Sweden weight walk-time the same as in-vehicle-time, but weight wait-time and transfer-time at twice the value of in-vehicle-time. For air trips Sweden values transfer-time at 1.7 times the value of in-vehicle-time. Switzerland also values transfer-time at twice the value of in-vehicle-time but does not give specific guidance on the treatment of walk-time and wait-time components. The UK values time spent*

> *walking at twice the value of in-vehicle-time, whilst time spent waiting at 2.5 times the value[3]"*

On the matter of crowding and reliability they added:

> *"Sweden, Denmark and the UK include valuations of travel time that is in excess of that expected (i.e. delay) for public transport trips only. Denmark and the UK value delays at the same as that spent waiting for public transport (i.e. twice in-vehicle-time for Denmark and 2.5 times in-vehicle-time for the UK). Sweden on the other hand uses a range of values (from 1.6 to 3.7 times in-vehicle-time) depending on the journey purpose (work/non-work) and the mode. French guidelines value travel in overcrowded conditions on public transport at 1.5 times the value of standard in-vehicle-time. The UK guidelines distinguish between passengers who sit in overcrowded conditions and those who stand. For non-work travel the values range from 1.1p/min to 30.8p/min which reflects a range of about 1.1 times in-vehicle-time to 4.5 times in-vehicle-time".*

The position some ten years ago was therefore that even in the developed economies of Europe there was limited recognition of convenience related variables in official recommendations.

The more recent Mackie and Worsley (2013) 'benchmarking' report extends coverage to some Non-European countries but with fewer European countries included, and we drew on this material in collating the official values contained in Table 1. We also asked Roundtable participants if they were aware of official multiplier values relating to public transport as well as approaching academics and organisations in Canada, Italy, South Korea, Spain, Switzerland, Portugal and Chinese Taipei.

The current situation regarding official multiplier values is, to the best of our understanding, that few countries worldwide have them. Indeed, no country has recommendations for all the convenience variables of interest here. For those that have official values, walk and wait multipliers are the most common followed by reliability and crowding. We are not aware of official values relating to displacement time.

We do not here comment on the official recommendations but defer it to a broader discussion within the review of empirical evidence in section 4. But we note that official appraisal values do not tell the whole story for the following main reasons:

- Some countries differ quite markedly in their approaches to appraisal and to forecasting;
- In several countries, sub-national organisations and operators provide guidance;
- Specific schemes and policies, and invariably major ones but even more routine ones, have developed bespoke models to support forecasting and appraisal;
- Partly as a result of these points, and also because of academic investigation, there is now a wealth of evidence on the subject.

3. It is elsewhere in the report stated "In Germany only in-vehicle time is included within an appraisal - thus interchange time and time spent waiting for a public transport service is excluded

Appraisal and Forecasting

Several countries differ quite markedly in their approaches to appraisal and forecasting, as we have pointed out in notes to Table 1. In Chile, no distinction is made between different elements of travel time in appraisal but demand modelling uses walk time and wait time multipliers of 3.6 and 1.9 respectively along with a transfer penalty of 7.5 minutes. Reliability and crowding are not explicitly included but are assumed to be discerned by mode specific constants.

Appraisal in the Netherlands also uses door-to-door time where the value of time does not distinguish by the type of time, although reliability is accounted for. However, the national model (LMS) does distinguish between different components of time.

Table 1. **Official Multipliers for Public Transport Convenience Terms**

	Walk	Wait	Headway	Reliability	Crowding	Interchange
Australia	1.4 1.2 < 5min 1.8 > 20min	1.4 2.0 Congested 1.2 Transfer		3.0 Late 6.0 Late at stop 1.5 Late in-vehicle	1.0 LF < 70% 1.1 Seat 1.4 Stand LF=100% 1.3 seated 2.0 stand Crush	5 within mode 7 between mode 10 different facility
Chile[A]	1.0	1.0			1.0	
Denmark	1.5 Transfer	2.0 1.5 Transfer	0.80	2.0 Late		6
France	2.0	1.5		[B]	Seat $1+0.08PM^2$ Stand $1.25+0.09PM^2$	
Germany[A]	1.0	1.0			1.0	
Japan	1.25 Transfer on flat 1.65 Transfer upstairs 1.53 Transfer downstairs 0.89 Transfer using escalator	1.0		1.0 Late	1+0.027LF[C] (LF<100%) 0.9442+0.0828 LF (100%<LF<150%) 0.8+0.179LF (150%<LF<200%) -0.22+0.690LF (200%<LF<250%) -1.37+1.15LF (250%<LF)	2.0 (multiplier approach) or 10 min per transfer
Norway	1.0 Access < 50km 1.36 Access > 50km	Based on headway	As Sweden	RR[D] 0.67 PT<50km RR 0.42 Bus>50km RR 0.54 Train>50km	[E]	2-10 <50km 10 >50km
Sweden	1.36 Access 2.5 Transfer	2.5 Transfer	< 100km 1.13 <10m head 0.92 11-30 head 0.45 31-60 head 0.28 > 61-120 head 0.13 > 120 head > 100 km 0.51 < 60m head 0.26 61-480m head 0.21 >480m head	3.5 Late	1.0-3.0 depending on crowding	
Netherlands[A]	1.0	1.0		RR 0.4 Commuting RR 1.1 Business RR 0.6 Other		

Table 1. **Official Multipliers for Public Transport Convenience Terms (contd)**

	Walk	Wait	Headway	Reliability	Crowding	Interchange
New Zealand	1.4 Access 2.0 Transfer	2.0 Transfer		3.9 Late 5.0 Late at Stop 2.8 Late En Route	1.4	
United Kingdom	2.0 for Non EB 1.0 for EB	2.5 for Non EB 1.0 for EB	Full:Reduced Tickets[F] 1.0:1.0 ≤15m head 0.95:0.85 20m head 0.87:0.70 30m head 0.65:0.45 60m head	Lateness 2.5 RR[G] 1.4	1.0 LF < 70% 1.0-1.05 Seat 70%<LF<100% 1.06-2.12 Seat 1-3 PM[2] 1.45-2.80 Stand 1-3 PM[2]	[H]
United States	2.0 for local travel and Non EB	2.0 for local and Non Business				

[A] In Chile, the Netherlands and Germany, appraisal deals in door-to-door time, thereby not using multipliers for other elements of time.

[B] Complicated functions for late time are implied according to the base share of the journey affected by lateness and the amount of delay time.

[C] In Japan, the load factor (LF) is defined as the number of passengers relative to the seating capacity plus the space for standees.

[D] RR denotes reliability ratio, the ratio of the value of the standard deviation of time to the value of time.

[E] Values exist for standing but they are in monetary units and the implied multipliers are not clear.

[F] Official railway industry values.

[G] Here RR is defined as the standard deviation of lateness relative to mean lateness.

[H] Official railway industry penalties exist but they are not pure transfer penalties but also include the consequences of not premium weighting the amount of time spent transferring.

In Germany, rail investments at the national level include transfer time in the travel times and in appraisal the various components of time are given the same weight. These are different to the weights used in forecasting which tend to be unpublished. For public transport investment at the local and regional level, walking, waiting and transfer times are calculated and included with a weighting of one.

British official multiplier values until recently related only to walk and wait time, whereas the railway industry in its standard forecasting procedures has for over 25 years been using headway, interchange, crowding and reliability multipliers (ATOC, 2013).

Sub-National Recommendations

Table 1 does include some values that originated in railway administrations and there are some significant regional organisations and operators that provide guidance on multipliers for use in transport investment, planning and policy appraisal.

Transport for London has its Business Case Development Manual (Transport for London 2013) which involves a mix of Department for Transport standard recommendations but with, as we shall see below, a significant amount of detail added to cover station and train crowding, the precise walking and waiting conditions, and a wide range of information provision.

In the Ile-de-France, STIF use multipliers of 2 for waiting time, access/egress walking time to public transport and transfer time. For reliability, STIF value a 5% improvement in reliability as equivalent to 4.6 minutes of travel time saving. The current ANTONIN model uses a multiplier of 2.5 for transfer walking time and 2 for waiting and access/egress walking time (Kroes et al., 2006).

In Hong Kong, MTR use multipliers for walking and waiting of 2 in their rail demand forecasting, but there are no specific multipliers for the other elements of convenience covered here, whilst Metrolinx in Ontario has used walk and wait multipliers ranging from 1.5 to 2.5 with transfer penalties ranging from 2.5 to 10 minutes.

In New York, MTA and NYCT have a range of models available to them. The assignment model weights, across all purposes, walk time by 1.5, wait time by 1.25 and uses a transfer penalty of 1 minute. The weighting of time at 100% capacity at 1.15 is though recognised to not fully reflect the discomfort of crowding. As for MTA's Regional Transport (Mode Choice) Forecasting Model, walk, wait and transfer multipliers of 1.5 are used with a transfer penalty of around 5 minutes. Road access to rail has a multiplier of 2, rising to 2.5 for accessing transit. Their 'Best Practices Model' covering the journey to work weights wait time and transfer time for rail at 2.6 for wait times of 7 minutes or less and at 1.42 for more than 7 minutes; the reasoning being at higher headways people are more likely to consult the timetable. Walk time has a multiplier of 3.36.

The Barcelona metro places multipliers of 1.5 on walking access and egress time, 1.5 to 2 on waiting time, 1 on headway, and between 2 and 4 on interchange time.

Bespoke Scheme Evidence and Other Research Outputs

There is now a considerable amount of evidence, as our review below demonstrates, into multiplier values for convenience variables, and much of this comes from models developed to address specific projects, issues and unknowns rather than informing national policy.

Summary

It was the view of Roundtable participants that the use of the GC measurement, as proposed here, by operators and authorities is generally poor in practice, although better in some European metros than elsewhere.

It was felt that considerable benefit could be obtained by making use of the evidence that exists or deriving local evidence.

3. MEASURING AND VALUING CONVENIENCE

There are two ways that improvements in convenience can come about. One is essentially customer focused, responding to what travellers want, and the other is product led, driven by investment and replacement, new technology and external factors such as competition and policy directives. In both cases, it is essential that we can measure the changes that will be experienced by travellers and that we can place a value on them. In this regard, the Anderson et al. (2013) resource paper usefully points out:

> *"To make public transport services more convenient and therefore attractive to passengers, public transport operators and authorities should be keen to ensure a high quality of service on the public transport system. This may require an improvement in service quality, which can only be achieved by a clear understanding of travel behaviour and consumer needs and expectations. Therefore, it becomes essential to measure the level of service in order to identify the potential strengths and weaknesses of the public transport system. This can provide clues to public transport management in the process of evaluating alternative service improvements aimed at enhancing user satisfaction and increasing market share".*

We first consider issues of measurement prior to discussing how valuations are obtained

3.1 Measuring Convenience

Three approaches can be adopted here:

- Measure perceptions and attitudes;
- Measure the strategic key performance indicators;
- Measure the detailed elements of an 'extended generalised cost' expression.

Measure Perceptions and Attitudes

Without doubt, measuring how public transport users and indeed non users perceive public transport convenience, and their attributes to it, would yield important insights for key stakeholders, and indeed it is hard to envisage that it would be absent from a customer focused approach to investment decisions and planning. As Anderson et al. (2013) state:

> *"However, developing accurate and valid measures of service quality is a complex task, since it deals with perceptions and attitudes. Hence, gaining a better understanding of consumers' perceptions of the quality of the service provided by public transport is important"*

Whilst the measurement of perceptions and attitudes is now quite widely used to provide important management information in its own right, it also has a long history of use in enhancing demand travel models.

In an early study (Paine et al., 1969), "an attempt was made to provide a more comprehensive coverage of significant variables affecting mode choice decisions", recognising that at the time it was not atypical that mode choice models contained only the two terms of time and cost. Importance and satisfaction ratings were used to evaluate a wide range of attributes relevant to mode choice.

Another early attempt to extend beyond the simple time and cost mode choice models by using survey based psychometric rating scales to represent the effect a broader range of measures, including convenience is provided by Spear (1976). He derived importance scores and satisfaction ratings for 14 attributes, almost all of which related to convenience such as, arriving at the intended time, avoiding long waits, avoiding leaving early for work, avoiding long walks, journey time and having a choice of departure. A convenience index was constructed and used to enhanced mode choice model. The goodness of fit was significantly better than a model based solely on time and cost.

Early models based on RP data did tend to be weak in terms of convenience variables, largely due to data, computing and sample size limitations, although inclusion of convenience terms was certainly not absent and as is apparent from the review material covered below.

It was though the advent and widespread acceptance of Stated Preference (SP) data that meant that convenience terms could be routinely and successfully included in behavioural models as objectively measured terms. This again becomes apparent from the review discussion below.

The advances in choice modelling, which benefitted RP as well as SP approaches, meant that it is not necessary to rely on psychometric measurement, and the ability to use objectively measurable terms in analysis and forecasting for the convenience variables of interest here has clear advantages.

Where psychometric approaches still have considerable attractions is in the valuation of comfort rather than convenience related variables. This is because comfort variables, covering issues such as ride quality, noise levels, seat comfort, rolling stock, safety and security, cleanliness and décor, often have no natural units or else have natural units which cannot be meaningfully used. If we are to generalise from categorical approaches, based on the valuation of specific attributes such as leather seats or a particular type of train which are not inherently transferable, then use must be made of psychometric scales. This becomes even more critical if we want to understand the psychosocial factors that drive people's travel behaviour (Ellaway et al. 2003). However, this is not the case here. We can objectively measure almost all convenience terms and we can value them and hence we can extend the generalised cost term beyond the simplistic time and cost representation.

Admittedly, some convenience factors, such as information acquisition and the ease of obtaining tickets, are not so easily measured in an objective fashion and instead survey based rating methods are required.

Measure the Strategic Key Performance Indicators

The Anderson et al. (2013) resource paper provides considerable detail on how public transport operators measure their performance, including various convenience related terms. These tend to be in the form of key performance indicators (KPIs) which have particular attractions for monitoring how well an operator is performing, and might be important for contractual, regulatory and strategic reasons.

Without the right indicators, operators, planners and transport authorities cannot determine accurately the level of convenience they are providing to their customers. And as the old adage goes, "what gets measured, gets managed". Common convenience related KPIs include the number of passengers affected by delay, the percentage of rolling stock available for service, the percentage of ticket machines and escalators in operation, the number of occasions when passengers exceed the maximum capacity of stations or the proportion of peak services above some seating capacity threshold, the percentage of passengers delayed by X minutes or more, and such like. The problem with some KPIs is that they tend to be strategic, aggregate or categorical in nature and hence not readily used alongside valuations in appraisal. Some are collected because they are easy to collect.

However, some KPI information can be operationalised with valuation data, such as mean load factors and excess journey times. Nor is it essential for operators to measure how they deliver on their objective using a GC approach; they can use more direct measures of service quality such as the percentage of passengers arriving on time or who have to stand. And as data systems get better and more granular, operators and planners will have much more data to turn into information on how convenient their services are. Smartcard and mobile phone data will provide much more detail on journey times and their variability, train weighing systems will improve crowding data and GPS information will increase the accuracy of bus reliability information. These performance indicators are not always well measured today, but technology will allow them to be better measured and managed. Such data will provide valuable management, performance and regulatory information in its own right, and will be more suited for inclusion within the GC expression that underpins the appraisal of schemes and to which we now turn.

Measure Detailed Elements of the Generalised Cost Expression

Our central approach here is to use an enhanced GC approach to cover more convenience terms. This was essentially the approach advocated many years ago by Hensher and McLeod (1977) who sought explicit rather than attitudinal representation of convenience (as well as comfort and effort) and reported (RP) models to this effect that contained the convenience terms of walk time, wait time, number of transfers and seat availability amongst a range of other factors. They did not have the benefit of large amounts of SP data to explore the issue, but nonetheless demonstrated how what they termed variables measured in 'policy sensitive units' can replace the reliance on 'attitudinal schema'. We might usefully summarise this position in terms of Hensher and McLeod (1977) stating:

> "*There is a growing literature on the use of various attitudinal measurement techniques in identifying the influences on travel choices, yet this useful work falls short of meeting the requirements of a policy-sensitive model.*"

Way Forward in the Context of Valuing Convenience Variables

We are not here arguing that KPIs do not have a role, nor that measuring perceptions and attitude is irrelevant. They both have important roles to play in:

- Alerting operators and authorities of the need for action;
- Informing operators and authorities of the consequences of any action;
- Providing valuable management information for benchmarking, contractual and funding purposes.

The KPIs can provide very important management information, but then one KPI cannot be directly compared with another without converting to some 'common currency' such as GC or else applying 'political' weights to different aspects of convenience. If we are to extend the GC expression to cover a broader range of terms, then it seems natural to measure these variables, and not just for the appraisal of specific schemes but more broadly in managing and evaluating performance. These variables can be measured in objective terms and do not need the expense and difficulty in application of psychometric approaches. Some of the KPIs typically recorded are difficult to apply within the extended GC approach but improvements can be expected with technological developments in monitoring and measurement,

3.2 How Do We Value Convenience?

By value we mean how much an individual is prepared to per for a 'one unit' improvement in some convenience variable. Thus if someone is prepared to pay €1.20 to save 15 minutes of walking time, then the money value of walking time savings is 8 cents per minute. Convenience attribute values are typically expressed as multipliers to IVT. If therefore the money value of wait time is 20 cents per minute and the money value of IVT is 10 cents per minute, wait time is valued at twice the rate of IVT and the multiplier is two.

Transport planning practice the world over has invariably represented the overall attractiveness of a public transport mode (or indeed any mode) as being composed of a range of time, cost and other factors each expressed in common monetary units using the weights described in the previous paragraph. This is termed the Generalised Cost (GC) of travel which we could illustrate as:

$$GC = P_I + P_O + \lambda(IVT + \alpha A + \beta E + \gamma WT + \delta D + \theta C + \mu T) \qquad (1)$$

P_I and P_0 denote the prices for in-vehicle and out-of-vehicle travel. The remaining terms are weighted to convert them to common monetary units. So λ is the value of IVT and α, β, γ, δ, θ, μ and ω are multipliers to be applied to the λ to represent in money terms the additional 'unattractiveness' of access time (A), egress time (E), wait time (WT), expected delay time (D), mean crowding (C) and the number of transfers during the journey (NT), and the benefits of information (I)

It is quite straightforward to have variants upon this term. So where journeys are planned, and travellers do not arrive at random for their journey, wait time might be replaced with headway, although wait time involved in transfers is still relevant, whilst where there are restrictions on the actual time of travel, then it would be more appropriate to enter terms explicitly relating to the inconvenience of not being able to travel at the desired time. As we shall see, alternative representations of reliability are possible.

Additional terms could be included to cover comfort variables, transaction costs, safety and such like, although care needs to be taken to ensure they are independent effects. As terms become more subjective, and are less easily measured or indeed have no natural units of measurement, the GC term might include ratings to reflect how well a travel option performs in terms of factors such as internal noise, ride quality, seating comfort, décor or perceived safety. Even then though, it would be necessary in an enhanced GC term to attach weights to these rating terms in much the same way as for the terms in equation 1 to convert them into equivalent money units. We shall discuss examples of such models in section 4

The overall attractiveness of a means of travel as represented by equation 1 could be expressed in time units, the so-called Generalised Time (GT), by dividing through by the value of time (λ).

Note that the various parameters can vary across different travellers and types of journey. As examples amongst many types of possible variations, we might expect the value of time for business trips to be somewhat higher than for non-business trips, reflecting the benefits to employers of being able to use saved time productively, whilst those with higher incomes can be expected to have higher money values as can those travelling in less pleasant conditions.

Nor is the function necessarily linear-in-parameters; the value of time and the other multipliers might depend on the levels that the variables take, so that say a minute of IVT saved on a 60 minute journey has a different value to a minute of IVT saved on a 10 minute journey. In particular, we might expect a given increase in occupancy to have a larger impact at higher levels of crowding. There might also be interactions between variables (as opposed to interactions with socio-economic and trip characteristics defined above) so that, for example, the value of time is lower where the fare is higher because travellers are less willing to pay for time savings where the service is deemed to provide poor value for money. It is widely regarded that the inconvenience of unreliability can be reduced by the provision of good information.

The various transport system variables in equation 1 can be objectively measured by some means or another, although there might be a divergence between the actual times and costs and what individuals perceive. So, for example, there might be improvements to public transport convenience but some travellers remain unaware of them, whilst it is not unknown that non-users regard public transport to be less convenient than it actually is. But what about the other components of equation 1; how are its various parameters estimated?

The valuations are relative terms expressing the satisfaction obtained from improvements in one attribute relative to improvements in some other. This is why they are sometimes termed relative valuation. A willingness to pay €0.80 to save 10 minutes means that the traveller is indifferent between the current travel situation and one where the cost is €0.80 more but with a 10 minute lower journey time[4]. In this context the value of a travel time saving relative to money is €0.08 per minute. The same reasoning applies to being prepared to walk 5 minutes longer to access a through service and save 15 minutes journey time. Obtaining estimates of how much travellers are prepared to trade-off one attribute against another is dependent upon information on their choices when confronted with such trade-off situations. Mathematical models can be estimated to explain the choices made in such trade-off situations from which the implied valuations can be obtained by comparing the rate travellers are willing to trade-off.

The first sorts of models to be estimated in order to yield relative valuations, in the 1960s and 1970s, were based around the travel choices people actually make, so-called

4. Values might be derived as a willingness to pay to save time, a willingness to pay to avoid a time loss, the willingness to accept compensation in place of a time saving and the willingness to accept compensation in the event of a time loss.

Revealed Preference (RP) methods. These were usually mode choice models although route choice models also feature. Economists in particular are keen to base empirical analysis and inferences on what people do in the real world.

In the late 1970s, methods based upon hypothetical scenarios, imported from the marketing research literature and particularly experience in the United States, started to attract attention and grew in popularity through the 1980s to the extent that what are termed Stated Preference (SP) approaches have been for many years, and certainly since the 1990s, the principal means of obtaining valuations in the transport market. These methods mimic the real market conditions we ideally want for valuation purposes by offering people multiple choices that require them to trade-off one relevant attribute against another.

RP methods are attractive because they are based upon what travellers actually do, and in well-defined choice contexts where travellers are familiar with the travel alternatives confronting them and their characteristics and where large samples can be obtained, they can yield important insights. However, they can struggle to provide robust estimates where travellers are unfamiliar with the choice context, where there is insufficient reliable information on how travellers perceive the choices confronting them, where sample sizes are small, and where there is limited variation in some variables, high correlation between others or poor trade-offs. Indeed, RP methods cannot provide evidence on variables and travel options that do not currently exist.

The reliability of values obtained from SP methods is critically dependent upon respondents doing what they say they will do, and in particular the absence of strategic bias where respondents exaggerate their responses to, say, time savings or cost increases in order to influence policy makers. Other problems can arise, due to unrealistic designs or choice contexts, failure to bear in mind real-world constraints or simply finding the exercise too difficult, whilst the very nature in which SP information is presented breaks the habit effects that exist in the real world.

The evidence on whether values obtained from SP exercises are robust is mixed. Whilst SP is 'the only show in town' for aspects of comfort, that is not the case for the convenience factors of interest here. Its advantages in this context are that it can be based around real-world choice contexts, thereby achieving a greater element of realism than otherwise, it can achieve much larger sample sizes, and it can control the trade-offs that are offered to respondents thereby increasing the quality of the data. SP methods are now dominant on the grounds of cost-effectiveness, statistical efficiency and particularly the ability to examine issues that are not possible in real markets. Nonetheless, we counsel caution since it not unknown that such methods can provide results that are not entirely credible whilst some of the evidence reviewed below indicates that discrepancies can exist between the multipliers implied by the two methods.

We should also point out in passing that an additional set of concerns surround SP model when used directly for forecasting. However, we are not here advocating such use but are concerned primarily with valuation.

4. REVIEW OF EVIDENCE

We here provide an account of current understanding regarding multipliers for walk and wait time, service headway and displacement time, interchange, reliability, crowding and information. This is based around existing review material supplemented with evidence from specific studies where appropriate.

At the outset, we recognise that multipliers might vary across countries, although they are inherently more transferable than monetary based valuations. And variations are not restricted to cultural differences, but may stem from different standards and expectations, operating practices, travel conditions and socio-economic composition of the travelling (and sampled) public.

4.1 Walk and Wait Time Multipliers

Although somewhat different in nature, these two attributes form part of the OVT associated with public transport and were the first multipliers to receive detailed attention. They can be expected to be valued somewhat more highly than one on the grounds of the inconvenience, effort and frustration they cause. Indeed, the widely used convention of applying a weight of two to walk and wait time is one of the oldest and most common of transport planning practices worldwide and seems to stem from the UK Department of the Environment's pioneering Mathematical Advisory Unit Note 179 (McIntosh and Quarmby, 1970).

Summary of Official Walk and Wait Multipliers

The multipliers recommended as official values in Table 1 and used by public transport operators in major cities take on a large spread. On the one hand, some countries treat all types of time the same, as door-to-door time, and implicitly the multipliers are one. This will also be the case for business travel for the vast majority of countries who use the Cost Savings Approach to valuation since all types of travel time are implicitly unproductive and any time saved, of whatever form, is assumed to be transferred into productive effort.

For countries that have explicit multipliers of walk and wait time, even here a large spread can be observed for both walk and wait time; walk varies between 1.2 and 2.0 with 2.5 at transfers whilst wait varies between 1.4 to 2.5, with a lower bound of 1.2 at transfers. Indeed, there seems to be no consensus on which is the larger.

It could be argued that the access time multipliers are lower than for walk time, presumably because access involves modes less strenuous than walking, whilst waiting time at transfer seems relatively high, which might be because here waiting cannot be avoided whereas in other cases wait time might be proxying for headway inconvenience but the effect is dampened insofar as people do not turn up randomly.

Walk and Wait Multiplier Review Evidence

There is now a large amount of evidence on walk time and wait time values, not least because they are an essential feature of mode choice models. Although it is common that headway replaces wait time, offsetting this is that wait time is a feature of interchange that sometimes features in such models.

An early review of walk and wait time multipliers (Goodwin, 1975) pointed to multipliers in excess of two. McKnight (1982) reviewed evidence from 17 studies covering the United States, United Kingdom, Australia and France on the relationships between the values of walking, waiting and IVT. The mean walk time multiplier was 1.85 but the wait time values had a larger mean of 2.40. Of the ten disaggregate studies providing walk and wait time values covered in a review of international evidence (TRRL, 1980), walk time was on average valued close to twice IVT and, excepting a study with a very high valuation, wait time was valued around three times IVT. A large scale review of international evidence (Waters, 1992) concludes that "Several studies have shown that time spent waiting is valued more highly than time travelling, of the order of two to one or more" whilst Ortúzar (1994) reviewed 10 mainly revealed preference (RP) Chilean studies conducted between 1983 and 1993 and, on average, walk and wait time were valued at 2.4 and 5.4 times IVT.

Miller (1996) reported what at the time was an extensive review of international evidence on walk time multipliers. It covered 18 from 7 countries yielding 34 multipliers. The mean ratio was 2.28 with a standard error of 0.17. Steer Davies Gleave (1997) in their review of their own and also some European evidence concluded that, "Walking time is usually valued at between 1.8 and 2.4 times in-vehicle time. An average of 2.0 is recommended for simplicity" and "Waiting time is sometimes valued higher than walking time, up to 4.5 times higher than in-vehicle time. A ratio of 3 times is recommended."

Turning now to more recent evidence, what emerges, both in Britain and elsewhere, is a *prima facie* challenge to the convention of valuing walk and wait time at twice the rate of IVT which is at odds with the earlier RP based evidence.

Bickel et al. (2005) provided a major review of the state-of-the-practice in transport project appraisal in Europe. It summarises official guidance but it adds no insights on the evidence base over and above that here provided.

A number of large scale reviews of UK evidence, primarily focused on the value of time but with insights into time multipliers, have been provided by Wardman (2001, 2004) and Abrantes and Wardman (2011). For example, the findings of Wardman (2004) were used to increase the UK Department for Transport's recommended value of wait time multiplier to 2.5[5]. Most recently, Wardman et al. (2013) extended the work to cover Europe. The multipliers implied by these studies are reported in Table 2.

5. This was based on the RP element of the evidence.

Table 2. **Walk and Wait Time Multipliers**

	Wardman (2001)	Wardman (2004)	Abrantes and Wardman (2011)	Wardman et al. (2013)	
				UK	Non UK
Walk	1.66:0.06:140	1.68:0.05:183	1.65:0.04:296	1.62:0.05:272	1.93:0.10:68
Wait	1.47:0.09:34	1.76:0.10:62	1.70:0.09:90	1.68:0.10:77	1.93:0.09:59
Transfer Wait				1.72:0.11:11	1.93:0.16:15
Access	1.81:0.10:52	1.77:0.10:60		1.57:0.07:102	1.95:0.14:42
OVT	1.46:0.10 64		1.43:0.09:73		

Note: Mean, standard error of the mean and number of observations reported.

As far as the UK values are concerned, they do not vary greatly across the different data sets. What are noticeable though are that the UK numbers fall short of 2, and sometimes by a considerable margin, and certainly less than the 2.5 for wait time in official recommendations, and the UK values are around 15% lower than the Non UK European values.

The figures in Table 2 though mask some important variations. For example, Abrantes and Wardman (2011) report RP multipliers for walk and wait time of 1.84 (0.15) and 2.32 (0.18) in contrast to SP figures of 1.62 (0.04) and 1.43 (0.07) respectively whilst for European wide evidence Wardman et al. (2013) report RP multipliers of 2.01 (0.18), 1.88 (0.16), 2.22 (0.14) and 2.03 (0.31) for walk time, access time, wait time and transfer wait time respectively, with the corresponding SP values always being lower at 1.63 (0.04), 1.55 (0.07), 1.60 (0.07) and 1.82 (0.11). It would therefore seem that RP based figures are somewhat higher and not inconsistent with multipliers around 2.

The RP explanation could be behind the divergence between UK and Non UK values, on the grounds that the UK evidence places greater reliance on SP evidence. Wardman (2013) reported a meta-model estimated to a wide range of multipliers, covering 12 attributes and 1389 observations drawn from 244 studies and 18 European countries. The UK walk and wait multipliers were found to be 22% lower even after accounting for RP walk and wait time multipliers being valued 20% more highly.

However, given that the differences are not particularly large, the following discussion is based upon the entire UK and Non UK data set as providing the largest set of multiplier evidence. Furthermore, Table 3 splits the values by country, for all the OVT terms combined, and the variation is not large. Noticeably Denmark with a low average multiplier also places more emphasis on SP data.

Table 3. **OVT Multipliers by Country**

Country	
Denmark	1.64:0.07:45
Netherlands	2.02:0.17:14
Norway	1.87:0.15:30
Sweden	2.00:0.13:28
Switzerland	2.14:0.39:11
Spain	2.16:0.19:12
UK	1.62:0.04:468
All Other	2.11:0.13:44

Note: Mean, standard error of the mean and number of observations reported.

Proceeding therefore with the combined European data set, the meta-model reported in Wardman (2013) can be used to 'predict' walk and wait time multipliers. The walk time multiplier varied by mode whilst it and the wait time multiplier varied by purpose and distance, the latter because the money value of time increases with distance at a stronger rate than the money values of walk and wait time. There was also a trend reduction of around 1% per year apparent whilst RP multipliers were larger. The multipliers predicted by the model for 2011 and based on RP evidence are set out in Table 4. These figures would suggest multipliers of 2 should be regarded as upper limits.

Table 4. **Walk and Wait (RP) Multipliers Implied by Wardman (2013) Meta Model**

	BUS				TRAIN			
Distance (Km)	5	25	100	250	5	25	100	250
WALK								
Commute	2.05	1.98	1.91	1.87	1.80	1.73	1.68	1.64
Business	1.85	1.79	1.73	1.69	1.62	1.57	1.52	1.48
Other	2.18	2.10	2.03	1.99	1.91	1.84	1.78	1.75
WAIT								
Commute	1.80	1.73	1.68	1.64	1.80	1.73	1.68	1.64
Business	1.62	1.57	1.52	1.48	1.62	1.57	1.52	1.48
Other	1.91	1.84	1.78	1.75	1.91	1.84	1.78	1.75

Note: Transfer Wait and Access have the same multipliers as Wait.

Returning to the raw data, Tables 5 and 6 sets out the OVT multipliers split by journey purpose and mode for the European wide evidence in Wardman (2013).

We observe that there tends to be relatively little variation by journey purpose, particularly when the sample size is large. If anything the leisure multipliers are largest and the business travel multipliers the lowest, consistent with the meta-model predictions in Table 4.

Table 5. **OVT Multipliers by Journey Purpose**

Attribute	All	Commute	Leisure	Business	Other
Walk Time	1.68:0.04:344	1.69:0.07:119	1.70:0.09:81	1.52:0.25:7	1.65:0.07:137
Access time	1.68:0.07:144	1.68:0.13:34	1.82:0.14:46	1.66:0.17:17	1.55:0.11:47
Wait Time	1.80:0.07:138	1.83:0.11:56	1.76:0.14:37	1.54:0.32:5	1.84:0.11:40
Transfer Wait	1.84:0.10:26	1.59:0.12:11	1.99:0.27:5	1.28:0.0:1	2.12:0.16:9

Note: Mean, standard error of the mean and number of observations reported. Other here includes combinations of purposes.

As for mode, the segmentations are according to whether the multipliers vary by mode used and mode valued. The samples reported are bus users valuing bus OVT, rail users valuing rail OVT and car users valuing any public transport option. Since there are combinations of modes used and valued, the figures cover only a portion of the full data set. The main difference between bus and rail users is that access time is somewhat lower for rail, presumably because rail often involves modes of access that have a lesser disutility than walking which will be typical for bus. Whilst car users might be expected to have higher values of the OVT variables, since they are less accustomed to it and indeed it may be one of the reasons why they choose car, there is no support for this. In general, the modal variations are fairly minor, in line with the findings of the meta-model reported in Table 4.

Table 6. **OVT Multipliers by Mode**

Attribute	All	Bus	Rail	Car
Walk Time	1.68:0.04:344	1.64:0.12:29	1.65:0.12:17	1.47:0.08:98
Access time	1.68:0.07:144	1.62:0.12:8	1.29:0.14:12	1.45:0.13:21
Wait Time	1.80:0.07:138	1.74:0.13:25	1.49:0.17:17	1.75:0.25:10
Transfer Wait	1.84:0.10:26	1.92:0.20:8	1.83:0.25:5	1.64:0.08:2

Note: Mean, standard error of the mean and number of observations reported.

A review has recently been completed of public transport values of time and other attributes in Australia and New Zealand (Wallis et al., 2013). 21 studies yielded 48 walk time multipliers averaging 1.3, with little variation by time of day. As an average, this seems to be on the low side. However, it was pointed out that:

> *"All but two of the studies were SP surveys and in this regard it is worth mentioning a potential problem in getting respondents to hypothesise a different location for a bus stop or train station they normally use. The exceptions were two Sydney RP studies (Fox et al. 2010; Hague Consulting 1996) in which the value of walk time was estimated cross sectionally based on household travel survey data. These two revealed preference studies estimated a higher valuation of walk time of 1.5".*

Not only does this pattern of results accord with the results presented above, but the explanation is similar to that offered in those studies in terms of the realism of varying walk time.

From 6 Australian studies and 15 multipliers and 1 New Zealand study and 1 multiplier, Wallis et al. (2013) found wait time at transfer to average 1.25. Again this seems low and again SP evidence dominates and its inability to represent realistic wait time variations may be a contributory factor. In a resource paper for this Roundtable Lee (2013) reports mode choices models where the OVT multipliers varies between 1.01, 1.05 and 1.7 across three models.

One of the issues discussed in the Roundtable was the level of detail that is provided by the available multiplier evidence, and in particular we might expect multipliers to vary not only according to person type but also according to the conditions in which the walking and waiting time is spent. The weather, the travel environment and facilities, perceived safety, the degree of crowding and the amount of effort involved will impact on these multipliers. Indeed both might be non-linear, so that the unit values depend upon the amount of walking or waiting time. All these possible sources of variation might be why the OVT multipliers have been observed to vary somewhat.

There is not a large amount of evidence on influences on the walk and wait time multipliers. Transport for London's Business Case Development Manual (Transport for London, 2013) provides an unusually high level of detail in its recommended appraisal parameters, although the evidence underpinning it and its strength is not immediately apparent. Nonetheless, some entirely plausible relationships are specified.

For waiting for trains or lifts in acceptable, uncongested conditions a multiplier of 2.5 is used. However, this is increased on crowded platforms. The wait multiplier (WT) is then a function of the congestion factor (CF) as:

$$WT = 2.5 + CF$$

Walking in unimpeded conditions (WK) has a multiplier of 2, but is also allowed to vary with the degree of congestion:

$$WK = 2.0 + \frac{CF}{2}$$

CF is related to passengers per m^2 (P) as:

$$CF = 0.667(P - 0.5)^2 \; for \; 0.5 \; \leq P < \; 2$$

$$CF = 1.50 \; for \; P \; \geq 2$$

$$CF = 0 \; for \; P < 0.5$$

Illustrative multipliers for WK and WT are given in Table 7 below for vary degrees of congestion (P).

Table 7. **Transport for London Walk and Wait Multipliers and Congestion**

P	WK	WT
0.5	2.00	2.50
1.0	2.08	2.67
1.5	2.33	3.17
2.0	2.75	4.00
2.5	2.75	4.00

Both multipliers start at UK official recommended values with notable increases with congestion, particularly for waiting time.

In addition, Transport for London have a whole range of additional, entirely sensible, modifiers of:

- Walking upstairs: 4.0

- Walking downstairs unimpeded: 2.5
- Waiting to get to ticket office window or machine: 3.4
- Transaction at ticket office window or machine: 2.5
- Queuing at a PASS agent: 3.0
- Transaction at a PASS agent: 2.0
- Delay at Ticket Gates: 4.0
- Travelling on escalators: 1.5
- Travelling in lifts: 2.0

For bus journeys, the weights used are simply 2.5 for waiting and 2.0 for walking.

As is apparent from Table 1, the Japanese CBA manual for rail allows variations in the walking time multiplier according to whether the walking is upstairs, downstairs, on the flat or on an escalator (Kato, 2014). We note though that the recommended Japanese multipliers are relatively low for walk and wait time. This is backed up in the Tokyo rail route choice RP models of Morichi et al. (2001) where across commuting, business and leisure journey purposes the access/egress multipliers vary between 1.18 and 1.35 and the transfer time multipliers vary between 1.19 and 1.46.

Douglas Economics (2006) provides interesting insight into the impact of crowding on platforms and in access areas and entrances on walking and waiting time multipliers. Table 8 reports their estimated multipliers for different degrees of crowding defined in terms of passenger per square metre (PM^2). Some very large variations in the multipliers can be observed, somewhat larger than used by Transport for London.

Table 8. **Impact of Crowding on Station Walking and Waiting Times**

Crowding	<0.2 PM^2	0.2-0.5 PM^2	0.5-2 PM^2	>2 PM^2
Wait	1.9	1.5	3.2	5.5
Walk	2.2	2.2	3.5	6.2

A piece of research discussed at the Roundtable is interesting from, amongst other perspectives, the similarity of effects between two somewhat different cities and for casting more light of detailed valuations, particularly interchange which we return to below.

Raveau et al. (2013) used survey data to examine metro users' actual route choices in both London and Santiago. The range of attributes explaining behaviour was very similar in the two locations, with OVT multipliers varying with time of day, purpose and, in the case of walk time, being higher for women. In London the waiting time multiplier ranged between 1.59 and 2.26 whereas for Santiago the range was 1.53 to 1.99. As for the walking time multiplier, it ranged between 1.24 and 2.90 in London and 1.91 and 3.98 in Santiago. Note that these figures would tend to indicate multipliers above the SP based evidence above and notably it was derived from RP data.

Conclusions on Walk and Wait Time

There is now a lot of evidence on walk and wait time multipliers, and indeed there has been for a long time. The evidence seems to be indicating that RP based multipliers are larger than their SP equivalents, and it has been speculated that this might be because of difficulties in conveying realistic valuations in walk and wait times in SP exercises.

It can be seen that the multipliers vary quite a lot. This was noted in the early review of walk and wait time multipliers by Goodwin (1975) and repeated some 30 years later by HEATCO (Bickel et al., 2005). Apart from the RP-SP dimension, this could be because the conditions in which walk and waiting time are experienced vary somewhat, along with possible non-linearities. Having said that, variations by purpose and mode do not seem large.

We have uncovered sensible variations in multipliers according to the degree of crowdedness. These provide an important element of detail. Going forward, it would be informative to add to such level of detail by quantifying other influential factors.

Bearing in mind the heterogeneity within the evidence, there is no doubt that a premium should be attached to walking and waiting time relative to IVT, and one could interpret the results as indicating that multipliers of 2 in normal conditions can be regarded to be upper bounds.

There was limited evidence to suggest the walk and wait time multipliers were falling over time, although it is conceivable that there are confounding effects here.

4.2 Departure Time Convenience

Being able to make a journey essentially without the constraints imposed by timetabled departures is often cited as one of the key features of car convenience. Two attributes are relevant here. One is the service headway and the other is displacement time. As public transport services become more frequent, travellers tend to turn up at random at the station or stop and the inconvenience of not being able to travel at the precise desired time is reflected in waiting time. As services become less frequent, there is the inconvenience not only of departing at increasingly more undesirable times but also the costs involved in obtaining information and planning. In the latter case, displacement time is relevant, indicating the disutility incurred as a result of not departing at the preferred time.

Headway can represent both the wait time and the displacement time effect, and this as we shall see is a cause of some ambiguity in interpretation. Alternatively, it is possible to directly estimate displacement time reflecting the inconvenience of not being able to depart at the desired time.

Headway might also have ‘correlated’ benefits such as providing a degree of flexibility independent of any inconvenience issues whilst more frequent services are likely to be less crowded and be beneficial when there are service disruptions.

Summary of Official Headway and Displacement Time Multipliers

As is apparent from Table 1, we have not identified official values relating to displacement time. Nonetheless, such values are used in practice; for example, the railway industry in Britain constructs its recommended frequency penalties using displacement time multipliers (ATOC, 2013).

Sweden offers official headway multiplier recommendations which have been adopted in Norway whilst in the UK the railway industry has nationally recognised values. What is noticeable about these values is that they fall as headway increases, reflecting the movement from largely random arrivals at high frequencies to largely planned arrivals at low frequencies.

Review of Headway and Displacement Time Multiplier Evidence

There is less by way of review evidence on the value of headway and departure time shift. The largest conducted, covering UK and European evidence, is reported by Wardman (2013) and Wardman et al. (2013).

A feature of the review evidence is that it does not distinguish the random and planned arrival elements surrounding headway. Estimated headway multipliers are invariably constant regardless of the level of headway. Table 9 reports European wide headway and displacement time multipliers obtained from Wardman (2013). The headway values are quite variable across countries and this might reflect different balances of planned and random arrivals. The displacement time values largely comes from UK studies, but the vast majority of the other 28 observations are not greatly different.

Table 9. **Headway and Displacement Multipliers by Country from Wardman (2013)**

	Headway	Displacement
Denmark	0.59:0.07:19	-
Netherlands	0.36:0.05:6	0.52:0.07:18
Norway	0.89:0.22:15	0.52:0.09:8
Sweden	0.45:0.07:13	-
Switzerland	0.53:0.06:25	-
Spain	0.53:0.10:18	-
UK	0.76:0.03:225	0.67:0.06:79
All Other	0.40:0.09:8	0.36:0.21:2
All	0.71:0.03:329	0.63:0.05:107

Note: Mean, standard error of the mean and number of observations reported.

Wallis et al. (2013) find the headway multiplier to average 0.66 across 22 studies yielding 63 observations but a little lower at 0.48 across 8 New Zealand observations from 5 studies. These are not out of line with the European evidence.

If headway represented purely random arrival effects, then we would expect the value of headway to be half the value of waiting time. A mean headway multiplier of 0.71 is therefore broadly consistent with the waiting time multiplier given that the latter seems to be at most two and headway will not simply represent random arrivals. Indeed, Kroes et al. (2006) stated that, "The percentage of passengers aiming for a specific train is strongly related to the scheduled frequency of service: for train services with headways of 15 minutes or longer around 80% of all passengers aim for a specific train, whereas for services with headways of 5 minutes or less only around 20% aim for a specific train".

If headway represented a pure displacement time effect, then given uniformly distributed desired departure times, a given headway will on average translate into a quarter as much displacement time. Clearly, the mean multipliers for headway and displacement time are not consistent with this. We note that studies rarely give the departure times associated with a given headway do not make the link with displacement time. In any event, the headway, displacement and wait time multipliers can be consistent depending upon the proportion of planned and random arrivals.

Table 10 disaggregates the Wardman (2013) displacement and headway multipliers by journey purpose. It also distinguishes between displacement time that involves travelling earlier than desired, later than desired or where no distinction was made.

The headway multipliers are remarkably similar by journey purpose. Displacement time seems to be more highly valued for later than desired departures, although not by much and not for leisure trips. Commuters as might be expected dislike departing later more than departing earlier given arrival time constraints at work whilst leisure travellers might not want to get up sooner to set out on their journey and have fewer arrival time constraints. Confounding factors here though are direction of travel and/or time of day which might be expected to affect relativities but which studies typically do not control for or report on. Given the absence of the latter distinctions, and that the differences are in any event not large, it might be sensible to use a single value for displacement time that does not vary by earlier or later departures. Observing the row for all displacement time multipliers would seem to justify larger values for commuting and lower for leisure, although again purpose effects may confound with other effects.

Table 10. **Headway and Displacement Time Multipliers by Journey Purpose**

Attribute	All	Commute	Leisure	Business	Other
Headway	0.71:0.03:329	0.67:0.05:68	0.71:0.04:95	0.74:0.07:37	0.71:0.05:129
Displace Early	0.56:0.07:44	0.59:0.14:18	0.63:0.22:8	0.50:0.06:7	0.50:0.02:11
Displace Late	0.65:0.08:47	0.74:0.017:19	0.43:0.08:9	0.64:0.14:7	0.67:0.11:12
Displace Both	0.74:0.14:16	1.63:0.87:2	1.00:0.0:1	1.00:0.00:1	0.55:0.08:12
Displace All	0.63:0.05:107	0.72:0.11:39	0.55:0.11:18	0.60:0.08:15	0.58:0.05:35

Note: Mean, standard error of the mean and number of observations reported. Other includes combinations of purposes.

Table 11 provides multipliers by mode, where the car multipliers are for motorists but relating to public transport. Very much smaller headway penalties are apparent for rail, presumably due to lower frequencies and hence more trip planning. This might also underpin the larger displacement multipliers for rail than for bus users but it may simply be that it is less of an issue for bus users.

Table 11. **Headway and Departure Time Shift Multipliers by Mode**

Attribute	All	Bus	Rail	Car
Headway	0.71:0.03:329	0.76:0.10:40	0.42:0.03:43	0.80:0.05:92
Displacement	0.56:0.07:44	0.35:0.14:2	0.77:0.09:26	0.60:0.07:14

Note: Mean, standard error of the mean and number of observations reported.

The meta-model reported in Wardman (2013) can be used to provide implied displacement time and headway multipliers. These were found to vary by purpose, distance and mode for headway and whether the journey was inter-urban for displacement time. There is also a slight variation between earlier and later displacement times. Table 12 contains illustrative figures.

There is a strong reduction in the headway values with distance, presumably proxying for the different balance of planned and unplanned journeys. Business travellers find headway most important, which is to be expected. The headway multipliers now seems to be more important for train users, and presumably the previous results were being confounded by the strong declining distance effect given that the bus data is almost entirely for urban travel. As for displacement time, this is much more of an issue for inter-urban journeys, thereby explaining the difference between train and bus apparent in Table 11 which now disappears[6]. As with Table 10, commuters have the largest displacement time multipliers although the variations are relatively small.

Table 12. **Multipliers Implied by Wardman (2013) Meta-Model**

	BUS				TRAIN			
	5	25	100	250	5	25	100	250
Headway								
Commute	0.65	0.47	0.35	0.29	0.83	0.60	0.45	0.37
Business	0.76	0.54	0.41	0.34	0.97	0.70	0.52	0.43
Other	0.65	0.47	0.35	0.29	0.83	0.60	0.45	0.37
Displace Early								
Commute	0.48	0.48	0.80	0.80	0.48	0.48	0.80	0.80
Business	0.37	0.37	0.61	0.61	0.37	0.37	0.61	0.61
Other	0.37	0.37	0.61	0.61	0.37	0.37	0.61	0.61
Displace Late								
Commute	0.55	0.55	0.92	0.92	0.55	0.55	0.92	0.92
Business	0.42	0.42	0.70	0.70	0.42	0.42	0.70	0.70
Other	0.42	0.42	0.70	0.70	0.42	0.42	0.70	0.70

Note: Metro and LRT headway values would be 28% larger. Presumably this reflects the greater degree of random arrivals given the generally higher frequencies involved.

Conclusions on Departure Time Shift and Headway

There is a large amount of headway multiplier evidence, which at an aggregate level is consistent with the wait time multipliers reviewed in the previous section. There are only slight variations by journey purpose but, as expected, headway becomes less important for longer journeys. The headway multiplier is larger for train. Displacement time seems to be more of an issue for inter-urban travel, where planning is commonplace.

It is noticeable that the multivariate analysis provides different results to the simple tabulations with regard to how the multipliers vary mode, and this is presumably because the latter are confounded with the distance effects.

Whilst service frequencies can be readily observed and hence their use in GC based applications is straightforward, this is not the case for displacement time where surveys are needed on desired departure times to convert timetabled departures into displacement time.

Two words of caution. There is an element of ambiguity in the headway multipliers. We might expect them to fall as the balance between planned and random arrivals moves in favour of the former as headways increase. The evidence does not distinguish direction of travel or time of day, although we suspect the outward journey will have dominated, and we might expect displacement time multipliers to depend upon these. The differences between earlier and later displacement times would seem to relate to the outward journey but are in any event slight enough to be ignored.

6. This is an advantage of the multivariate approach of meta-analysis rather than the simple tabulations that are common in more conventional literature reviews.

Railways in the UK get around the problem of the headway value representing two different effects. They use a displacement time value for those who plan their journey, with a greater proportion planning as headways increase. This indicates the inconvenience of not being able to travel at the desired time. For those who arrive at random, which is more likely at more frequent services, headway is converted into waiting time and a wait time multiplier used to represent the inconvenience. However, there is little evidence of how travellers choose between planned and random arrivals.

4.3 Interchange

We have already covered the wait and walk time involved in interchange. Here we consider the fixed penalty involved in having to transfer between vehicles. This arises because of the hassle and risks involved independent of any walking and waiting time. Thus there is a risk that the next service is missed whilst any activities being undertaken will have to be interrupted.

Summary of Official Interchange Penalties

Official values are comparatively rare for transfer penalties. They are 10 minutes or less with variation by type of interchange. The penalties used in New York City and Toronto fit with this range whilst Transport for London (Transport for London, 2013) uses a 3½ minute penalty for transfer between underground services and 5 minutes for transfer between underground and rail.

Review of Interchange Penalty Evidence

There are three components to an interchange; walking between services, an amount of waiting and a fixed penalty for the inconvenience and risks involved. Wallis et al. (2013) stated that, "Many studies on transfers do not clearly distinguish between these three transfer components" which limits the amount of usable information available.

Wardman (2001) also recognised this problem in the literature. He distinguished between studies which estimated a pure interchange penalty independent of time effects, those that simply estimated an interchange variable without any separate connection time and those that estimated an interchange penalty and allowed for connection time but without any additional weighting of the latter. The latter two were, as expected, larger than the pure penalty and averaged around 30 minutes whereas the 8 observations relating to pure penalties were found to average 17.6 minutes. A meta-model was developed on 1116 money values of a range of variables, including 47 interchange values. It found interchange values to vary with purpose and region. The implied pure transfer penalties are set out in Table 13.

Table 13. **Implied Transfer Penalties (Wardman, 2001)**

Kilometres	5	25	100	250
Commute	6.9	5.8	5.0	4.5
Commute SE	5.0	4.2	3.6	3.3
Other	13.7	11.5	9.9	9.0
Other SE	10.0	8.4	7.2	6.5

The time multipliers fall since the money value of time increased with distance but the money values of the pure interchange penalty did not. Those in the South East (SE) have lower values, presumably due to a greater familiarity with the rail network as a result of greater usage whereupon the risks and uncertainties involved in interchange will be less whilst the more frequent onward

Wallis et al. (2013) cover 17 Australian studies and 63 values but only one New Zealand study yielding one value. Most studies estimated an interchange 'effect' containing the wait time and this was removed to leave a pure penalty. However, the approximations involved in this should be borne in mind.

The peak interchange penalties were 4 minutes for the same mode and 9 minutes between modes. The corresponding off-peak figures were 12.5 for the same mode and 17 minutes for different modes. It is plausible that the penalty is higher between modes. As for the high off-peak values, this might be because travel time in the peak has a higher disutility, passengers in the peak are frequent users and hence interchange will be more familiar, and the higher frequencies in the peak mean the risks associated with interchange are less.

Douglas and Jones (2013) review 17 interchange studies covering Australia and the UK. These largely overlap the Wallis et al. (2013) and Wardman (2001) reviews. What is particularly noteworthy about this study is providing more detail of how the interchange penalty might vary. The reported penalties are contained in Table 14 for bus users and train users. The penalties tend to be larger for longer distance. As expected, rail users find a cross platform interchange to be less onerous than an 'up and down' transfer to another platform. Bus users are more averse to rail interchange, perhaps due to unfamiliarity. Similarly, rail users have a larger dislike of bus interchange than do bus users. However, even bus users have quite large bus interchange penalties perhaps because transfer is relative uncommon by bus.

Table 14. **Transfer Penalty Variations (Douglas and Jones, 2013)**

Transfer	Bus Short	Bus Medium	Bus All	Rail Short	Rail Medium	Rail All
Rail Cross Platform	9.0	13.7	12.5	6.8	7.2	6.9
Rail 'Up and Down'	11.3	13.6	12.9	9.5	9.3	9.3
Bus to Rail	11.1	16.6	15.1	15.8	19.3	17.5
Bus to Bus	14.8	14.6	14.5	18.1	28.6	23.3

Wardman and Shires (2000) report a joint RP-SP model to explain the three components of interchange. The penalty was found to vary with journey duration, flow type and whether it was the first or second transfer. The second transfer had a smaller effect than the first. However, there was no difference according to whether the connecting train was on the same platform or another. Noticeably, they found some evidence that SP based transfer penalties were larger than those obtained from RP data. The interchange penalties implied by their model are reported in Table 15. Unsurprisingly, penalties are lower in the dense South East network, where frequencies and familiarity are high. For suburban journeys, the penalties are in line with other evidence.

Table 15. **Implied Transfer Penalties (Wardman and Shires, 2000)**

Journey Duration	Inter Urban 1st change	South East 1st change	Inter Urban 2nd change
30 minutes	9.1	7.5	5.8
60 minutes	11.1	9.1	7.0
120 minutes	15.1	12.3	9.4
180 minutes	19.1	n/a	11.9
240 minutes	23.1	n/a	14.3
300 minutes	27.1	n/a	16.8

The Raveau et al. (2013) metro route choice models for London and Santiago discussed at the Roundtable provide interesting insights into variations in transfer penalties. Even though in principle these penalties are independent of the amount of transfer time, there does seem to be variation with the amount of effort involved. Nonetheless, the variations with effort are slight; we would be surprised if they were large. The penalties for peak travel fit with other evidence and again off-peak travellers are found to have higher values. Similar results were found by Navarrete and Ortúzar (2013) for the multi-modal transit system in Santiago.

Table 16. **Metro Transfer Penalties (Raveau et al., 2013)**

	London		Santiago	
	AM Peak Commute	Off Peak Non Commute	AM Peak Commute	Off Peak Non Commute
Ascending Assisted	6.08	12.36	8.72	13.49
Ascending Semi-Assisted	7.11	14.46	n.a.	n.a.
Ascending Unassisted	7.70	15.66	10.30	15.95
Descending Assisted	5.24	10.65	5.84	9.05
Descending Semi-Assisted	6.28	12.76	n.a.	n.a.
Descending Unassisted	6.86	13.95	7.43	11.51

Note: Assisted means that an escalator or elevator can be used for all changes of level whereas they can only be used for part of the change of level under semi-assisted.

Conclusions on Interchange Penalties

Litman (2014) states that "transfers are estimated to impose penalties equivalent to 5-15 minutes of in-vehicle time". This is expected to be at the lower end where good information and comfortable waiting conditions are provided and there is a minimum of insecurity, stress and effort. We concur with this statement in the light of the evidence covered here and note the consistency between the evidence based and official and used transfer penalties.

There is evidence that commuters have lower transfer penalties than other travellers and this might be through a familiarity effect which was apparent in other findings. The evidence on the distance effect is not consistent, but it is very limited. There is evidence that shows worse transfers have larger penalties, as is the case for between modes.

4.4 Reliability

Reliability is, unlike the other convenience factors covered here, as much an issue for car travel as it is for public transport. As such, a considerable amount of evidence relates to car. Nonetheless, this is an area where there is a relatively large amount of public transport evidence, and much of it is comparatively recent.

Another aspect in which reliability is different to the other convenience attributes is that it has been measured and valued in a number of different ways. These are:

- Mean lateness on schedule, which was the first measured employed. Rather than offer a range of times, as is now customary, this method typically stated that the service would be X minutes late one in Y times.
- Schedule delay early (SDE) and schedule delay late (SDL). These are, across n arrival times, the mean level of earliness and lateness relative to the preferred arrival time.
- The standard deviation of travel time (SD), expressed across n arrival times. The ratio of the value of the standard deviation of travel time and the value of mean travel time is termed the Reliability Ratio (RR)[7].

Summary of Official Reliability Values

Official values for public transport are either based around mean lateness or the RR. The former exhibits a large range, from 1.5 to 6 but is generally between 2 and 4. The RR tends to be in the range 0.4 to 0.7, but with the 1.4 for the UK an exception.

Review of Reliability Multiplier Evidence

Wardman (2013) reports evidence on reliability related values covering Europe. An immediate issue with the scheduling (SDE and SDL) and mean-variance (RR) terms, originally pointed out by Tseng (2008), is that some models specify either the scheduling variables or the standard deviation of travel time whilst others include both. In the latter case, the effect attributed to the scheduling variables and to the variance will obviously be less than in the former case where the effect is not 'shared out'. The issue does not arise with the late time variable.

Table 17 provides multipliers for SDE, SDL and RR when the scheduling variables and the spread variables are specified on their own (Alone) and also when both term are specified (Both). Since we simply cannot report the average values across the Alone and Both model specifications, because this is neither one thing nor the other, the subsequent tabulations provided here are therefore for models which specified either the scheduling terms or the spread (Alone). This would be most appropriate for practical forecasting where accommodating just one reliability variable provides enough challenges let alone two!

It can be seen that, as expected, the multipliers for the Both observations are somewhat less than for the Alone observations

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7. To add confusion, this approach has traditionally been referred to as the mean-variance approach.

Table 17. **Reliability Multipliers by Model Specification**

Attribute	Alone	Both	All
SDE	0.86:0.07:48	0.35:0.04:6	0.81:0.07:54
SDL	1.94:0.14:54	1.31:0.16:16	1.80:0.12:70
RR	1.02:0.13:31	0.66:0.14:14	0.91:0.10:45

Note: Mean, standard error of the mean and number of observations reported.

Bates (2001) demonstrated the following relationship between the RR and the parameters of the scheduling approach:

$$RR = \frac{\beta}{\alpha} ln\left(1 + \frac{\gamma}{\beta}\right)$$

ɑ relates to mean travel time, β to SDE and γ to SDL. Although strictly speaking this relationship is only applicable where the traveller has a continuous choice of departure times, it is nonetheless illuminating to consider whether this theoretical relationship between the mean-variance approach and scheduling approaches holds in practice.

Taking ɑ to be one and with average values for β and μ of 0.86 and 1.94 from Table 17, the implied RR is 1.02. This is exactly the figure reported in Table 17 for the mean value for RR of 1.02.

Table 18 illustrates how the reliability multipliers vary across the European countries covered. We have combined the SDL and late multipliers on the grounds of sample size. There is considerable variation across countries, much more than for the other convenience variables, and this might be because of the inherently greater challenges involved in valuing reliability. In particular, the UK seems to be an outlier with the irrational mean SDE value and the very large SDL/Late values which may well be due to the dominance of mean lateness in the latter sample. We note that the late values were often obtained from SP exercises that specified one service X minutes late one in Y times. However, uncertainties surrounding how respondents interpreted lateness for the (Y-1)/Y occasions could well have led to inflated valuation estimates.

Table 18. **Reliability Multipliers by Country**

	SDE	SDL/Late	RR
Denmark	-	2.02:0.10:8	-
Netherlands	0.97:0.09:26	1.52:0.19:23	0.85:0.26:2
Norway	0.72:0.29:4	2.43:0.30:13	0.20:0.06:3
Sweden	0.77:0.19:5	2.88:0.56:10	0.59:0.19:3
UK	1.20:0.46:4	3.70:0.44:19	1.21:0.16:22
All Other	0.52:0.07:9	1.28:0.17:8	0.98:0.0:1

Note: For SDE, SDL and RR valuations estimated 'Alone'. Mean, standard error of the mean and number of observations reported.

Table 19 demonstrates some large but not entirely consistent variations by journey purpose. For mean lateness, leisure travellers have the highest values which is also the case for RR whereas commuters have the largest value of SDL and business travellers are particularly averse to arriving early.

Table 19. **Reliability Multipliers by Journey Purpose**

Attribute	All	Commute	Leisure	Business	Other
Late	3.24:0.39:27	3.53:0.75:6	4.95:0.97:7	2.33:0.58:3	2.23:0.32:11
SDE	0.86:0.07:48	0.82:0.09:26	0.68:0.11:8	1.18:0.22:9	0.77:0.23:5
SDL	1.94:0.14:54	1.91:0.10:25	1.83:0.39:11	1.49:0.30:9	2.61:0.27:9
RR	1.02:0.13:31	1.27:0.25:6	1.34:0.28:10	0.67:0.35:2	0.71:0.15:13

Note: For SDE, SDL and RR valuations estimated 'Alone'. Mean, standard error of the mean and number of observations reported. Other covers a mix of purposes.

Table 20 is based on mode users valuing the mode they used. It reveals that the values do not vary greatly between rail and bus, with the possible exception of SDL, but the limited sample sizes should be borne in mind.

Table 20. **Multipliers by Mode**

Attribute	All	Bus	Train
Late	4.10:0.44:37	3.63:0.09:3	3.88:1.05:7
SDE	0.86:0.07:48	0.59:0.41:2	0.53:0.10:7
SDL	1.94:0.14:54	3.03:0.44:6	2.17:0.28:9
RR	1.02:0.13:31	0.96:0.30:5	0.77:0.16:3

Note: For SDE, SDL and RR valuations estimated 'Alone'. Mean, standard error of the mean and number of observations reported.

The meta-model reported in Wardman (2013) estimated to a very large data set of multipliers contained around 200 reliability observations. It took account of the 'Alone' and 'Both' effects discussed above. It found the reliability values to fall with distance, and we can well understand that unreliability is expected, accepted and allowed for more for longer distance journeys. A strong positive effect was found for the late multiplier for leisure travel. Although reported in Table 21, we would be inclined to ignore this quite extreme effect, possibly attributable to the lack of clarity on arrival times for the (Y-1)/Y times the service is not late. Otherwise the multipliers seem sensible.

Table 21. **Implied Reliability Multipliers for Train and Bus (Wardman, 2013)**

Distance	5	25	100	250
LATE				
Non Leisure	3.59	2.82	2.30	2.00
Leisure	6.71	5.28	4.30	3.75
RR				
All	0.80	0.63	0.51	0.45
SDE				
All	1.02	0.80	0.65	0.57
SDL				
All	2.17	1.71	1.39	1.21

Note: For SDE, SDL and RR valuations estimated 'Alone'.

The values so far cover European experience, but there have been a number of reviews that cover broader international evidence.

The Wallis et al. (2013) review covered 4 New Zealand studies yielding 4 values of mean lateness and 6 Australian studies yielding 6 values. No distinction is made between bus and train, or between lateness at the stop or final destination, although the authors point out that there is some uncertainty as to whether the late time relates to the origin or destination arrival. The mean lateness figures were 2.7 for New Zealand and 3.6 for Australia.

With regard to the reliability ratio, Bates et al. (2001) stated that, "values around 1.3 appear plausible for car travel; somewhat higher may be appropriate for scheduled public transport but values above 2 are unlikely".

Carrion and Levinson (2012) conducted a worldwide review of reliability evidence. This is based on the RR, covering 17 studies and yielding 68 observations that were entered into a meta-analysis, although it is not restricted solely to public transport. The RR averages 1.2 across studies, although this varies enormously from 0.10 to 3.29. The meta-analysis specified variables to represent time of day, data type, choice dimension, region and whether the reliability values was from a model that allowed for unobserved heterogeneity. No significant effects of note were obtained.

Tseng (2008) also conducted a worldwide review of reliability evidence covering 16 studies. This study and the Carrion and Levinson (2012) review have 9 studies in common, although this study additionally covers values of SDE and SDL.

The RR was found to average 1.33 with a standard deviation of 0.68 across 74 observations. This varies between 1.46 in the 59 cases where no scheduling terms were specified in the estimated model to 0.81 in the 15 cases where they were. The former figure of 1.46 is higher than the 1.02 of Table 17 although the pattern of results is similar.

The mean value of SDL was 1.65 with a standard deviation of 1.39 across 67 observations, with the corresponding figures for SDE being 0.75, 0.40 and 69. SDE varied little between commuting and other trips and between public and private transport. For SDL, we find the commuting value to be somewhat larger at 1.99 from 44 observations than the 1.01 from 23 observations for other trips. This is not surprising although not apparent in the European evidence reviewed above. Similarly, private transport had a mean SDL value of 1.83 from 48 observations somewhat larger than the 1.20 from the 19 public transport observations.

It was also found that the figures depended upon whether the estimated model contained another reliability variable. Where SDE and SDL were specified on their own, their mean values were 0.81 from 54 SDE observations and 1.77 from 55 SDL observations. These fall to 0.53 from 15 SDE observations and 1.13 from 12 SDL observations when other reliability terms entered the model. This pattern of results, and particularly the multipliers where there is no standard deviation term, are highly consistent with the European evidence discussed above.

Meta-models were estimated to the RR, SDE and SDL observations. Explanatory variables were data type, choice type, mode, purpose, utility specification, and travel time measurement. The models were somewhat more successful than those of Carrion and Levinson (2012) in recovering significant effects. The values implied by the model exhibited considerable variations.

Based on RR or SDE/SDL being the only variables specified, RR was 1.71 for all trips and purposes (where the model did not specify terms for purpose and mode). This is very much larger than the implied RR multipliers in Table 21 based on the Wardman (2013) meta-analysis.

The implied values of SDE and SDL for public transport commuting were 0.51 and 3.37. These fell to 0.41 and 2.41 respectively for other trips. Again, these are not entirely consistent with the implied SDE and SDL multipliers in Table 21 based entirely on European evidence.

Wardman and Batley (2014) review British evidence on the late time multiplier. Whilst it covers much of the material considered in Wardman (2013) the two are not identical in terms of British evidence. The meta-model estimated to 41 late time multipliers implied values of 3.42 for inter-urban non-commuting, 3.92 for suburban commuting and 2.26 for suburban non-commuting.

Finally, we cover recent work conducted in the Netherlands which had a strong emphasis on the valuation of reliability. Table 66 of their report (Significance et al., 2012) provides an interesting comparison of their RR estimates against other evidence. Much of the latter is covered in other reviews here so we report their new evidence along with the 'expert workshop of 2004' evidence they cite. The results are reported in Table 22.

The expert opinion multipliers are probably heavily influenced by UK evidence, and we noted in Table 18 above that the UK RR evidence is somewhat out of line with other evidence. If we take the implied multipliers of Table 21 for the shorter journeys as more appropriate for comparison, then these new Dutch values, at least for commuting and other, would seem consistent with the European meta-analysis evidence.

Table 22. **New Netherlands Reliability Ratio Evidence**

	Train	Bus/Tram	Car
New Study			
Commuting	0.4	0.4	0.4
Business	1.1	1.1	1.1
Other	0.6	0.6	0.6
Expert Opinion	1.4	1.4	0.8

Conclusions on Reliability Evidence

There have been three measures of reliability used in valuation. The one that is the most straightforward to apply is the multiplier for mean lateness on schedule. This has been widely used in the UK and underpins the regulatory mechanism, driving fines and compensation payments on operator and infrastructure providers. The issue here though is that it does not allow for different distributions of lateness or the fact that regularly late trains can to some extent be anticipated and hence the consequences are less.

The standard deviation of travel times or the standard deviation of lateness on schedule can be objectively measured so they too could be readily incorporated in policy and planning decision making. Indeed, both late time multipliers and RR form the basis of official valuations.

However, approaches based around SDE and SDL are less easily implemented given that they require information on preferred arrival times which cannot be readily measured and instead requires survey based evidence.

It seems that the reliability evidence is more diverse than for other attributes, even though there is quite a lot of it, and we attribute this to the inherently greater difficulties in estimating values of reliability terms and perhaps also because it can be a contentious issue which might attract protest responses in survey based evidence. We note that empirical evidence relating to reliability is almost entirely SP based.

Nonetheless, it is clear that late arrivals are important, and are most likely the largest multipliers of all the convenience terms. Litman (2014) recommends that, "each minute of delay beyond the published schedule should be valued at 3-5 times the standard in-vehicle time". This perhaps extends to too high values but it would seem the late time multiplier exceeds the walk and wait time multipliers of 2 and the crowding multipliers discussed in the next section, even if they contain an element of protest. We should also point out that we would expect mean lateness to be less than the value of SDL, on the grounds that SDL is always lateness whilst, as a result of scheduling constraints, lateness on schedule could actually move some people nearer to their desired arrival time!

It is encouraging to have found a high degree of consistency amongst the mean estimated RR and that implied by the SDL and SDE values. Whilst the evidence on the RR across studies is quite variable, it does seem to be less than the figure attributed to it by 'expert opinion'.

Finally, we point out that much of the empirical work relates to late arrivals at the destination. The official Australian and New Zealand values distinguish between lateness at the destination and lateness at the point where public transport is accessed but this is a neglected aspect.

4.5 Crowding Convenience[8]

Crowding is a feature of public transport commuting journeys the world over, whether by train or bus. In some cases, particularly major metropolis and also in regional centres, standing is a common occurrence on buses but especially trains and metros. Whilst the inconvenience of standing can be readily appreciated, and can be expected to increase the value of travel time appreciably, crowding will also impact on those seated to the extent they will also incur an increased inconvenience and discomfort which will lead to higher values of time.

Traditionally, the measure used to represent crowding was load factor. This is fine for the inconvenience incurred by seated passengers as occupancy increases. However, a superior means of representing crowded conditions for those having to stand is in terms of passengers per metre squared. Trains can have high load factors but, because of a small amount of seating and ample standing space, the crowding conditions are not as bad as the high load factor might imply.

The common convention in this area is that although penalties on seated passengers can occur before a train is full, and a figure of 70% seems to be when the inconvenience is felt to start, standing penalties are not relevant at load factors less than 100% since if anyone chooses to stand when there are seats free then they are not particularly averse to standing.

Summary of Official Crowding Multipliers

8. Some might regard crowding to be more a comfort than a convenience factor. We do not wish to get into semantics here, and indeed crowding does impact on the comfort dimension. However, the view of the Roundtable was that it is clearly inconvenient to have to stand; it was extensively discussed at the Roundtable and hence is covered here. Crowded conditions also extend walking times, in-vehicle times and make waiting time more onerous.

There are some small multipliers for seated time between around 70% and 100% load factor. However, when seated there seem to be two different views of the world. In some countries, even in very crowded conditions, the multiplier for crowding when seated would be less than 1.5. In the UK, it could be over 2. As far as standing multipliers are concerned, there is a wide range, from around 1.4 to over 2.5 in crush conditions. As with reliability, this is an area where there is a wide range of multipliers.

Review of Crowding Multiplier Evidence

Wardman and Whelan (2011) report the most extensive review of crowding multipliers, albeit exclusively based around British evidence. They covered 17 UK studies spanning 20 years and yielding 208 valuations. From the meta-analysis model estimated, the crowding multipliers were found to vary with load factor and journey purpose. The implied multipliers are set out in Table 23 and can be very large. Presumably the multipliers are lower for commuters since they are more resigned to crowding!

Table 23. **Implied Crowding Multipliers (Wardman and Whelan, 2011)**

Seated Multiplier			Standing Multipliers		
LF	Commute	Leisure	LF	Commute	Leisure
50%	0.86	1.04			
75%	0.95	1.14			
100%	1.05	1.26	100%	1.62	1.94
125%	1.16	1.39	125%	1.79	2.15
150%	1.27	1.53	150%	1.99	2.39
175%	1.40	1.69	175%	2.20	2.64
200%	1.55	1.86	200%	2.44	2.93

The railways in Britain have now moved to the superior means of representing crowding conditions in terms of passengers per metre squared. The PDFH values (ATOC, 2013) for standing are largely driven by the work of MVA (2008) and Whelan and Crockett (2009) who conducted an innovative SP exercise involving trade-offs between time and crowding where crowding levels were clearly set out graphically and in written explanation. They recommended the crowding penalties set out in Table 24. Values did not vary by purposes but did vary by flow type. It is commonly argued that those in London and the South East are more accustomed to crowding and hence their values are lower whilst for the generally somewhat longer inter-urban journeys crowding will be more unpalatable. It can be seen that some large multipliers are implied even for sitting when there are high levels of crowding.

Table 24. **Estimated Crowding Multipliers**

Pass/m²	London and SE		Regional		Inter Urban	
	Sit	Stand	Sit	Stand	Sit	Stand
0.0	1.00	1.43	1.00	1.34	1.00	1.77
0.5	1.05	1.50	1.12	1.48	1.06	1.79
1.0	1.09	1.56	1.24	1.61	1.11	1.81
1.5	1.14	1.63	1.36	1.75	1.17	1.83
2.0	1.18	1.69	1.48	1.88	1.23	1.85
2.5	1.23	1.76	1.60	2.02	1.29	1.87
3.0	1.27	1.82	1.72	2.16	1.34	1.89
3.5	1.32	1.89	1.84	2.30	1.40	1.91
4.0	1.36	1.95	1.96	2.43	1.46	1.92
4.5	1.41	2.02	2.08	2.57	1.52	1.94
5.0	1.45	2.08	2.20	2.70	1.57	1.96
6.0	1.54	2.21	2.44	2.97	1.69	2.00

Wallis et al. (2013) found only a limited amount of Australian and New Zealand evidence. They report 2 Australian observations from seated in crowded conditions with a mean multiplier of 1.23. This increases to 1.62 for 6 Australian observations for standing in crowded conditions, with the corresponding figure of 1.49 across 4 New Zealand observations, with a mean multiplier of 2.0 for 3 observations relating to standing in crush conditions.

Haywood and Koning (2013) report on a contingent valuation exercise, discussed at the Roundtable meeting, where travellers on the Paris metro could forego travel time in return for less crowding. Seven levels of crowding were presented. The multipliers for the different levels of crowding are presented in Table 25.

Table 25. **Time Multipliers on Paris Metro**

Pass/m²	Multiplier	Multiplier Morning Peak	Multiplier Evening Peak
0	1.00 (0.91-1.08)	1.02 (0.93-1.12)	0.93 (0.78-1.08)
1	1.00	1.00	1.00
2	1.05 (0.97-1.13)	1.06 (0.96-1.15)	1.06 (0.91-1.21)
2.5	1.18 (1.07-1.28)	1.19 (1.07-1.31)	1.18 (0.99-1.36)
3	1.26 (1.13-1.39)	1.24 (1.10-1.38)	1.29 (1.05-1.53)
4	1.40 (1.25-1.56)	1.52 (1.33-1.71)	1.31 (1.06-1.56)
6	1.57 (1.35-1.80)	1.46 (1.20-1.73)	1.67 (1.27-2.06)

Note: 95% confidence intervals in brackets. The 2-6 pass/m² figures relate to standing and the 0-1pass/m² relates to seating.

There are some, but generally slight, differences between the time multiplier in the morning and evening peaks. The figures are somewhat lower than those so far discussed.

Kroes et al. (2013) provided a resource paper as part of this Roundtable, reporting the findings of an extensive study of crowding in Paris. This covered rail, metro, tramway and bus. Two SP exercises were used; one based around the idea of catching the first but crowded arrival or waiting for a less crowded train, and the other offering a trade-off between two options with different travel times and crowding levels. In addition, there was experimentation with SP methods.

Although the best model was one that specified a fixed effect per trip rather than a time multiplier, for practical reasons a model with crowding multipliers was developed. The multipliers split by mode are reported in Table 26.

The multipliers for seated, which here largely relate to commuters, bear a reasonable resemblance to those in Table 23. However, the standing multipliers are somewhat lower and very much in line with the other Paris values in Table 25.

Table 26. **Paris Crowding Penalties (Kroes et al., 2013)**

Load	**ALL**		**METRO**		**TRAIN+RER**		**BUS+TRAM**	
	Seat	Stand	Seat	Stand	Seat	Stand	Seat	Stand
25%	1.000		1.000		1.000		1.000	
50%	1.000		1.000		1.000		1.000	
75%	1.000		1.000		1.000		1.000	
100%	1.083		1.077		1.073		1.102	
125%	1.165	1.289	1.155	1.270	1.145	1.261	1.204	1.342
150%	1.248	1.394	1.232	1.362	1.218	1.358	1.307	1.467
200%	1.330	1.499	1.309	1.453	1.290	1.456	1.409	1.593
250%	1.413	1.604	1.386	1.545	1.363	1.553	1.511	1.718

Li and Hensher (2011) provide a review of willingness to pay evidence relating to crowding but it does not add to what is covered elsewhere here.

Finally, we are aware of evidence from a country famous for its sometimes very high degree of rail overcrowding. Valuations from the Japanese CBA Manual for Rail, as discussed in the resource paper by Kato (2014), and a rail route choice RP model for commuting trips (Morichi et al. 2001) are presented in Table 27. The values from these two Japanese sources are not only very similar but are broadly in line with the Paris evidence.

Table 27. **Japanese Crowding Multipliers**

	Multiplier	
Load Factor	CBA Manual	Morichi et al. (2001)
110%	1.04	1.11
140%	1.06	1.13
170%	1.10	1.27
200%	1.16	1.37
230%	1.37	1.49
260%	1.62	1.62

Note: The load factors are defined with regard to seating and standing capacity and so will be lower than the more usual definition relative to seating capacity.

Conclusions on Crowding Multipliers

The evidence on crowding values in line with the official values is bimodal. Some evidence points to crowding multipliers that would imply that standing rivals late time in terms of inconvenience whilst other evidence points to lower multipliers somewhat less than the value of 2 commonly ascribed to walk and wait time. From a theoretical perspective, we could argue that crowding multipliers ought to be high, on the grounds it can reasonably be expected to be worse than walking and waiting, but we could also argue that we travellers are observed to stand even when seats are available. One thing is for sure though; the crowding multipliers unequivocally increase with the degree of crowding!

Litman (2014) concludes that the value of transit travel time is doubled when standing and further doubled when standing in a crowded bus or train. Our view is that this is not supported by the evidence.

Kroes et al. (2013) concluded in their study of crowding penalties in Paris:

> *"It is clear that more value of crowding studies, conducted in similar and different contexts, are needed before more definitive and more general conclusions can be drawn with respect to the value of crowding in public transport"*

It would be hard to argue with this. Well focused and large scale RP exercises and observations of actual behaviour might be able to cast more light on the issue. In this regard, we note the Japanese RP based crowding penalties are relatively low.

4.6 The Convenience of Information

The presence (absence) of information adds to (diminishes from) public transport convenience in several respects. Travellers do not like uncertainties surrounding how to use and pay for public transport, what to do when there are alternative possibilities or when things go wrong, and not knowing the causes of any irregularities in service. Information can reduce the stress of waiting or interchanging and allow travellers to make better use of their time. There might be a value for the existence of information, even if it is not used, since it provides reassurance in the event it is needed. In the extreme, lack of information about a public transport product inevitably means it will not be purchased[9].

Those who are unfamiliar with public transport, or at least with the particular journey being made, can be expected to benefit most from the availability of suitable reliable information, as might those who are making complex inter-modal journeys, whilst in this digital age there are ever increasing expectations that information is not only of a high standard but is easily accessed. In recent years, there has been considerable investment in improving the information available to public transport users (Litman, 2014), in large part due to technological developments.

There are different means by which public transport users can obtain information. Some has to be actively sought, such as that available via the internet and mobile phones, from travel information centres and phone hotlines, and email and text alerts, either prior to starting a journey or during it, whilst other information is routinely present in the course of a

9. In some cases there are benefits (to operators) from the absence of information. For example, price discrimination is more effective if, say, low cost sensitivity business travellers are not fully aware of the presence of tickets targetted at more price sensitive segments of the market.

journey, such as real time information displays, signage, information points, staff, posters, announcements, departure boards and printed matter. The information can relate to a range of different aspects of a journey, such as how to access and egress public transport and system navigation, timetable details, prices and how to pay, what facilities are present during the journey and what to do when things go wrong.

There might well be interactions between the valuations of different information sources. For example, the presence of mobile information may well reduce the value of information from station staff, signs and displays, whilst providing information on-vehicle may reduce the value of information provided at stations and stops.

Summary of Official Information Values

Table 1 contains the official multiplier evidence we have identified for the time related aspects of convenience. We are not aware of official guidance in the context of information convenience. This is partly because of the diverse nature of information and partly because it is not a prominent feature of scheme appraisal. However, what is in our understanding the most extensive set of information values in use in transport scheme appraisal, as recommended by Transport for London, is considered below.

Review of Information Valuation Evidence

There have been a large number of SP studies which have covered some aspect of information provision. We have inevitably made extensive use in this document of review material, but we are not aware of a comprehensive review of the valuation of information provision. To some extent this is because of the more diverse nature of the improvements being valued, although the fact that some developments in information provision are quite recent and will form a more modest proportion of generalised cost than other aspects of convenience are also contributory factors. Litman (2014) discusses a variety of real-world improvements in information provision and travellers' favourable responses to them.

There is little evidence on valuations of some aspects of information, such as on how to pay and what to do when journeys are disrupted. The evidence tends to relate to the valuation of real time arrival information and timetable information.

Information is different to the other attributes we have here covered. Whilst it undoubtedly influences the convenience of using public transport, it does not always operate as a multiplier on the value of time in the same way as an interchange penalty. In many circumstances it is more of a fixed benefit, although not necessarily independent of journey length, such as might be expected of information on departure times, routes and fares, but it can interact with other valuations in a multiplier fashion, such as when arrival or performance information reduces the stress of waiting time and anxieties of travel time.

Of particular relevance here is the possible presence of a 'package' effect. It is not uncommon that the information is considered alongside a wide range of other 'soft factors' and that the sum of the valuations of the separate attributes exceeds the valuation of all attributes estimated as a package (Jones, 1997). This might be because of: interactions, as mentioned above; halo effects, whereby improvements in one attribute are taken to imply improvements in another; budget effects, where travellers are prepared to pay for improvements to some attributes but not all to the same pro-rata extent; or simply an artefact of the artificial nature of SP experiments in what is a challenging valuation context and one that might attract strategic responses.

Given the absence of review material, and because values have often been obtained in money units which are less transferable than the time multipliers considered previously, we here consider a selection of illustrative empirical evidence from the wide range available before turning to Transport for London's extensive set of recommendations which seem to be the most comprehensive of any transport authority in the world.

Hensher and Prioni (2002) developed a service quality index for use in evaluating the overall performance of bus operators. In the SP exercise undertaken to create parameters to populate the index, 13 variables were simultaneously covered in each of three bus options offered. The attributes ranged from time and cost through to on-board safety and the friendliness of drivers. One of the attributes covered related to information; whether there was timetable information or timetable information and a map at the bus stop. The results obtained were counter-intuitive, with the former valued at 9.25 minutes and the latter at 6.15 minutes relative to no information. Whilst this might have been due to what appears to be a highly complicated SP exercise, nonetheless even the lower of these two valuations seems implausibly large.

Laird and Whelan (2007) report valuations of information for bus journeys after a package effect had been estimated. The implied valuation of up-to-the-minute bus arrival time information was 3.97 minutes per journey for leisure travellers and 1.97 minutes for commuters. Again such values seem rather large.

The UK rail industry's Passenger Demand Forecasting Handbook's (PDFH) recommendations distinguish between on-train and at-station facilities, which includes information. Unfortunately, the recommendations for at-station facilities come in the form of demand uplifts. Matters are little better for on-train information. Although expressed as value of time multipliers, they only cover audibility of announcements and electronic displays and a number of assumptions are made in converting monetary values into time units, particularly given that the value of time depends upon distance.

Given the qualitative nature of many bus quality attributes, Douglas Economics (2014) conducted an SP exercise in New Zealand that offered trade-offs between two bus options described in terms of time, cost, service headway, bus vehicle quality and bus stop quality. The latter two were characterised by a 5 star system (similar to that used to rate films and restaurants) which included verbal descriptions of quality. The respondents' ratings of their current bus vehicle and bus stop quality were regressed on various relevant factors to determine what influenced them. Thus the valuations of the ratings in the SP model could be decomposed into the various influential factors. Whether the bus stop had a shelter, seating, real time information and a timetable influenced the ratings. The benefits of providing real time information and a timetable were found to be worth 1.7 minutes or 6% of fare. This increases to 4.3 minutes or 16% of fare when seating and shelter are provided.

This work built upon a previous study in Australia (Douglas Economics, 2006) which involved nine point scales for each of 46 rail service attributes. This was converted into a % scale and the ratings were linked to the rating of time variation, thereby allowing values to be obtained in time units. Table 28 reports time valuations for a range of train improvements. Information is not the most important factor but nor is it the least.

Table 28. **Value of Train Improvements from 60%-70% (minutes per journey) Source: Transport for London (2013)**

Improvement	Value
Train Outside Appearance	0.15
Ease of Train Boarding	0.22
Seat Comfort	0.07
Smoothness of Ride	0.10
Quietness	0.22
Heating and Air Conditioning	0.15
Lighting	0.13
Cleanliness	0.26
Grafitti	0.08
On-train Announcements	0.16
Layout and Design	0.38

The valuations of station improvements reported in Table 29 are far less than for train improvements, which is unsurprising given train travellers generally spend far longer on a train than at the station. Taking the three information related terms together, they are joint second in importance behind ticketing.

Table 29. **Value of Station Improvements from 50%-60% (minute per journey) Source: Transport for London (2013)**

Improvement	Value	Improvement	Value
Ease of Train On and Off	0.08	Grafitti	0.05
Platform Weather Protection	0.004	Toilets	0.01
Platform Seating	0.04	Safety	0.06
Platform Surface	0.07	Staff	0.09
Subway/Overbridge	0.01	Car Park	0.01
Station Building	0.10	Car Park Drop Off	0.01
Lifts/Escalators	0.03	Taxi	0.01
Signing	0.05	Bus	0.02
Station Announcements	0.05	Bike	0.02
Information	0.03	Telephone	0.01
Station Lighting	0.03	Retail	0.05
Cleaning	0.13	Tickets	0.16

This ratings based approach has attractions since otherwise diverse and categorical attributes not easily measured or defined cannot be valued within an SP exercise. Real life application requires that for an improvements that are planned then ratings of the before and after situation are required.

What seems to us to be the most extensive set of recommended valuations relating to information provision, and indeed to a wide range of other 'soft factors', is provided by Transport for London's Business Case Development Manual (Transport for London, 2013). This document "summarises the values which passengers place on a comprehensive list of key service attributes". Valuations of information are recommended for the underground, bus and train and for information provided on-vehicle and at stations/stops. In some cases, the valuations are based on ratings of information attributes whilst in other cases categorical information levels are specified.

We set out below the wide range of information related valuations recommended, partly as inspiration that valuations can be provided for a wide range of information attributes and indeed other soft, comfort-related, factors.

The valuations recommended in the Business Case Development Manual are in money units. To convert to time units, the recommended values of time are 14.7 pence per minute for the underground, 15.8 pence per minute for rail and 12.8 pence per minute for bus.

Values relating to the ticket hall are not time dependent. Those for on-train are based on a typical 15 minute journey whilst the average platform wait time is 3½ minutes with one minute on average of access time. These time dependent valuations should be amended where the average durations of these variables is different.

Some valuations are linked to the scores obtained from Mystery Shopper Surveys (MSS) or Staff and Information Surveys (SIS). These are reported in Table 30 for information provided to underground users in the station ticket hall, station access, station platform and on-train.

Thus an improvement in electronic displays in carriages that led the ratings to improve from 20% to 50% would be worth 1.641 pence. The valuations relating to on-train provision tend to be somewhat larger, as is to be expected given the relative amount of time spent on the train. Noticeably, information related to the next train and particularly to service disruption are highly valued.

Table 31 presents the recommended values for underground users for information provision represented in categorical form. Again, the benefits of providing information on service disruption and next trains are the largest. Definitions of each level for each type of information are given in the Business Case Development Manual Section E4.3

Table 30. **Underground Information Provision Benefits using MIS/SIS Scores (pence per passenger September 2013 prices) Source: Transport for London (2013)**

	Score	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Station Ticket Hall												
Clarity of the PA announcer's delivery	SIS	0.351	0.340	0.308	0.263	0.213	0.171	0.131	0.094	0.059	0.027	0
Usefulness of the PA messages	SIS	0.325	0.278	0.235	0.196	0.160	0.127	0.096	0.069	0.044	0.021	0
Directional signing	MSS	0.433	0.395	0.363	0.334	0.298	0.244	0.191	0.140	0.091	0.046	0
Clocks	MSS	0.241	0.234	0.215	0.189	0.160	0.130	0.100	0.072	0.045	0.021	0
System disruption information	MSS	3.610	3.551	3.311	2.934	2.465	1.953	1.447	0.962	0.547	0.229	0
Next train information	MSS	3.097	2.734	2.368	2.010	1.665	1.337	0.933	0.605	0.349	0.152	0
LUL information leaflets	MSS	0.380	0.372	0.344	0.305	0.260	0.211	0.163	0.117	0.074	0.035	0
Station Access												
Clarity of the PA announcer's delivery	SIS	0.384	0.372	0.338	0.288	0.233	0.187	0.143	0.102	0.064	0.030	0
Usefulness of the PA messages	SIS	0.356	0.305	0.258	0.214	0.175	0.139	0.105	0.075	0.048	0.023	0
Directional signing	MSS	0.474	0.433	0.398	0.365	0.326	0.268	0.209	0.153	0.100	0.051	0
Station Platform												
Clarity of the PA announcer's delivery	SIS	0.482	0.467	0.424	0.362	0.292	0.235	0.180	0.129	0.081	0.037	0
Usefulness of the PA messages	SIS	0.446	0.382	0.323	0.269	0.219	0.174	0.132	0.095	0.060	0.029	0
Directional signing	MSS	0.595	0.543	0.499	0.459	0.410	0.336	0.262	0.192	0.125	0.064	0
Clocks	MSS	0.266	0.261	0.242	0.215	0.183	0.150	0.116	0.084	0.053	0.025	0
Next train information	MSS	1.372	1.314	1.238	1.144	1.022	0.880	0.726	0.558	0.377	0.190	0
System disruption information	MSS	2.954	2.545	2.135	1.752	1.405	1.027	0.718	0.474	0.279	0.124	0
Train												
Clarity of driver's delivery over PA	SIS	3.478	3.396	3.274	3.120	2.938	2.731	2.503	2.173	1.491	0.765	0
Usefulness of PA messages on train	SIS	3.261	3.090	2.787	2.367	1.521	0.821	0.402	0.213	0.115	0.051	0
Interchange and next station information over train PA	SIS	3.261	3.090	2.787	2.367	1.521	0.821	0.402	0.213	0.115	0.051	0
Electronic displays in the carriages	MSS	5.175	5.050	4.809	4.398	3.830	3.168	2.538	1.974	1.376	0.697	0
Time of first PA announcement when a delay occurs	MSS	3.158	2.978	2.740	2.477	2.185	1.761	1.373	1.003	0.656	0.317	0
Frequency of PA announcements when a delay occurs	MSS	2.721	2.449	2.177	1.905	1.633	1.361	1.088	0.816	0.544	0.272	0

Table 31. **Underground Benefits**
(pence per passenger September 2013 prices)

	1	2	3	4
Station Ticket Hall				
Audibility of the PA system	0.351	0.035	0.000	0
Ease of seeing signs	0.326	0.160	0.000	0
Information available via the help points	0.461	0.000	0.000	0
Service disruption notices in the ticket hall	5.781	1.823	0.527	0
Information on planned station and line closures	6.193	2.451	0.321	0
Information button in help points – speed of response	0.361	0.000	0.000	0
Station Access				
Audibility of the PA system	0.384	0.038	0.000	0
Information available via the help points	0.634	0.133	0.008	0
Ease of seeing signs	0.440	0.305	0.000	0
Information button in help points	0.361	0.000	0.000	0
Station Platform				
Audibility of the PA system	0.446	0.104	0.000	0
Information available via the help points	0.959	0.335	0.020	0
Information on the outside of the train	0.613	0.000	0.000	0
Next train information on platform displays	5.948	0.456	0.000	0
Disruption information on platform displays	0.482	0.000	0.000	0
Ease of seeing signs	0.552	0.382	0.000	0
Information button in help points	0.361	0.000	0.000	0
Train				
Announcements of disruption on connecting lines	8.561	5.328	1.976	0

The recommended values for improvements to train, as opposed to underground, information are reproduced in Table 32. These largely relate to information on the next train and on service disruptions and as for the other modes these are quite highly valued.

Table 32. **Rail Improvements**
(pence per journey September 2013 prices) Source: Transport for London (2013)

Ticket Hall		
Information about Service Disruptions	No information in the ticket hall about service disruptions	0
	Hand-written notices in the ticket hall showing service disruptions	14.31
	Electronic display in the ticket hall showing service disruptions	17.31
Platform Facilities		
Next Train Information	No information about next train on the platform	0
	Electronic information about next train arrival time, destination and all stations where the train is stopping	14.83
Train Information		
Electronic Display	No electronic display in carriages	0
	Flat screen style display showing next station, final destination information and relevant service disruption information	11.71
PA Announcements	Public announcement impossible to hear, muffled or echoing	0
	Public announcement message able to be heard	11.32

Turning to bus users, Table 33 reports the wide range of recommendations for improvements to information provided at bus stops, bus stations, on buses and at bus-underground interchanges. These are all for discrete levels of information. The values of the improvements tend to be clustered in a fairly narrow range.

Table 33. **Bus Improvements**
(Pence per Journey September 2013 Prices) Source: Transport for London (2013)

Bus Stop Information		
Countdown signs	No Countdown sign	0
	Countdown displays up to the minute bus arrival times	3.35
	Countdown displays up to the minute bus arrival times, diversions and delays	4.11
Mobile phone real-time information	No information on phone about time of next bus or disruptions	0
	By typing in code shown on bus stop, receive information sent to phone about time of next bus	0.83
	By typing in code shown on bus stop, receive information sent to phone about time of next bus and any service delays	1.39
Spider Map	No diagrammatic map of bus routes serving the stop	0
	Stop with diagrammatic map of bus routes serving the stop	4.63
Local Map	No map of local information / services	0
	Stop with map of local information / services	4.52
Bus Station Information		
Public Announcement	No public announcements	0
	Public announcements that can clearly be heard	1.12
Staff providing bus service information	No staff at the station	0
	Member of staff walking around bus station	0.92
	Member of staff at information desk	1.25
Bus Service Information Displayed on Screen	No countdown sign	0
	Countdown displays up to the minute bus departure times	2.88
Finding way round bus station: signs	Unclear of badly located signing, difficult to find your way around the bus station	0
	Good signing, easy to find your way around the bus station	2.62
Finding way round bus station: maps	No display	0
	Displays showing location of the stop for your bus	6.08
Bus Environment		
Information provided inside bus	No electronic information inside the bus about the next stop	0
	Electronic sign and voice announcement of the next stop	2.34
	Electronic sign and voice announcement of the next stop and also connections that can be made with other transport services, plus nearby attractions that can be reached from that stop	2.54
Bus-Underground Interchange		
Visual information on bus service disruption	No service disruption information in Underground station for bus services	0
	Hand-written notices in Underground station about bus disruptions	6.55
	Electronic information in the Underground station about disruptions to bus services	8.62
Signage at Interchange	No signs to bus and Underground services	0
	Generally good signs between bus and Underground services, but additional signs would make it easier to find the way	3.52
	Excellent signs giving a direct route between bus and Underground services	6.92

Conclusions on Information Values

Although evidence relating to information levels is much more diverse than for other aspects of convenience, a large amount of evidence exists, although no review study as far as we are aware, and we have here considered some of the available evidence.

We feel it right to issue a word of warning in this context, since it is not unknown that values can be implausibly large. Whether this is due to unaccounted for package effects or simply strategic bias when the purpose of the relevant SP exercise is quite transparently to value information, care should be taken in estimation, interpretation and application. Care also needs to be taken to account for interaction effects[10].

Having said that, credible results do exist and approaches based around rating scales have proved popular because they allow transferability of results for variables which have no natural units of measurement.

The findings suggest, as would be expected, that on-vehicle information is more important than at-station or stop information. Information relating to disruptions seems particularly important, as does information on next services. We should point out though that large sums of money are being spent on real-time information on platforms and some bus stops, but increasingly less on more traditional information such as paper maps posted on stations and bus stops. Evidence is required to ensure that the appropriate policies are being followed.

The extensive recommendations provided by Transport for London, not only for information but a wide range of 'soft factors', should serve as an achievable aspiration more generally for practical transport appraisal and helping to ensure that authorities deliver best value to the travelling population and taxpayer alike.

4.7 Summary

We have above considered each convenience attribute in isolation. Whilst we return to the issue of interactions between valuations below, it is informative to summarise this individual evidence to determine what really matters most with regard to public transport convenience of use, not least because this is where operators and funders can focus attention on improvement.

Clearly, what matters most to individuals will depend on specific circumstances, such as the current levels of attributes, the type of journey being undertaken and the travel conditions, and of course cultural factors. Therefore in generalising the results, it seems that the most important convenience issues for public transport users are:

- waiting in crowded conditions;
- walking in crowded conditions;
- walking that involves more than normal levels of effort;
- travel time reliability.

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10. It is conceivable that some of the Transport for London valuations might interact with the provision of information by other means. For example, the value of next train information in ticket halls (on-platforms) might well depend upon whether the information provided on platforms (in ticket halls).

Poor performance on these can be a significant deterrent to public transport use where choices are available or else will impact appreciably users' wellbeing. The next most important aspects of convenience are:

- walking and waiting in normal conditions
- having to stand while travelling, although its inconvenience might be expected to exceed normal walking and waiting when there is severe overcrowding.
- displacement time and headway, with displacement time being more of an issue for longer journeys where planning is more commonplace and headway being more important for shorter journeys where there is less planning and perhaps an expectation of better frequencies.

The two variables that generally make the least contribution to convenience are:

- the penalty involved in having to interchange
- information provision

Our summary of the empirical evidence on the relative importance of the different convenience multipliers is set out in Table 34.

Table 34. **Summary of Importance of Convenience Multipliers**

CONVENIENCE TERM	INDICATIVE MULTIPLIER
Late Time	3.0-5.0
Walking with more than normal effort	4.0
Waiting in Crowded Conditions	2.5-4.0
Walking in Crowded Conditions	2.0-3.5
Walking and Waiting in Normal Conditions	1.75-2.0
Standing (depending on conditions)	1.50-2.0
Headway	0.5-0.8
Displacement Time	0.4-0.6
Interchange Penalties	5-15 mins
On-Vehicle Information	<< 1 min
Off-Vehicle Information	<< 1 min

5. THE RESEARCH AGENDA

There seem to be two aspects to a forward research agenda in the area of valuing public transport convenience

- Consolidating and particularly adding to the evidence base on convenience multipliers
- Monitoring, validating and ex-post analysis of the use of the convenience multipliers[11]

5.1 Adding to the Evidence Base

The Roundtable was of the view that there is insufficient use worldwide of convenience multipliers to understand and appraise public transport. In part this is because even in developed countries the cost-benefit analysis to evaluate transport investments, planning and policies is not always routine, but the absence or unawareness of relevant information cannot help matters.

The Roundtable also recognised that even where formal cost-benefit analysis procedures are in use, there is a need to add further detail. We might expect the walk and wait time multipliers to depend upon the conditions in which they are incurred. Whilst there are some notable examples of allowing for this, considerably more insight could be obtained here. So how do the various multiplier values covered here vary with the levels of the variables, with the degree of crowding, with the travel environment, with the length of the journey, with journey purpose and the like? The emphasis though must be on generating new evidence that can be readily applied rather than providing insights into influential variables, such as personal characteristics, that would be difficult or impossible to use in real world appraisal.

This research into conditions is important since it demonstrates how the 'time costs' of travel can be reduced by reducing the time weight rather than the amount of time and, as some studies have indicated, it might in some circumstances be more cost effective to reduce the time cost to achieve and effective time saving.

Another neglected area of research, although by no means confined to convenience related variables, is that of examining thresholds, non-linearities and interactions. It may be that target levels of convenience need to be achieved before, say, car users will entertain using public transport, or that there is little point in improving convenience if fares are unacceptably high. So convenience multipliers for one attribute might depend upon the levels of another attribute or in some way or another its own levels. Although probably more of an issue for comfort related variables, package effects might be present, whereupon the

11. Whilst this takes us into the world of forecasting, which was not the primary concern of this Roundtable, values are used in forecasting and hence this process might inform on the reliability of the multipliers.

introduction of various improvements has a larger impact than the sum of each introduced separately. The roundtable had the view that we can sometimes spend too much time looking at separate parts and not the whole. Evidence on these matters is scant, which is of concern if public transport 'retailers' have to get all aspects of their offering right.

There are some particular valuation related issues that need further attention. Headway values have typically not distinguished properly between the dominance of wait time at high frequencies and the dominance of displacement time at low frequencies. Late time values either explicitly relate to destination arrivals or else there is a degree of indeterminacy as to what they represent. The latter ambiguity does need to be removed in future work but in any event there is a need to distinguish between and value of late arrivals at the destination and the value of late arrivals at the departure point. Crowding values need to be grounded in occupancy rates up to 100% load factor and then passengers per square metre beyond that whilst displacement time multipliers must distinguish direction of travel and time of day. New research could usefully examine convenience aspects such as integration between modes, the acquisition of tickets and obtaining relevant information, and Lee (2013) demonstrates such issues to be able to influence public transport demand favourably. We have not covered these latter aspects of convenience here but our impression is that the evidence base is not large.

To these 'lists' we can add that there may be temporal variations in multipliers whilst concerns will remain regarding cultural transferability and there are clearly differences between 'users' and 'non-users' about which we do not know as much as we should. Changing expectations over time and an ageing population could lead to different multipliers over time whilst multipliers might be tempered by conditions, so for example, commuters in Tokyo might have somewhat greater tolerance to crowding than commuters in many other metro systems.

Conditional upon more widespread adoption of formal procedures to evaluate convenience improvements, and we have argued that the treatment of convenience really does matter, our review of evidence and in any event general impressions and expectations would suggest that it make sense to derive local values where possible. Of course, these can be benchmarked against broader review based material.

SP methods are traditionally used in a very detailed manner, to derive parameters that can then be used to populate a 'bottom-up' cost-benefit appraisal. A novel alternative, which could be regarded as 'top-down', would be to use SP in a more strategic fashion, as a sophisticated voting system, to determine the sort of public transport system and policies that people really want.

In addition to addressing research themes, there is also a need to embrace and exploit new and emerging sources of data and information that reveal people's choices, preferences, implied valuations and indeed deterrents. For example, mobile phone data for the Paris underground has recently been exploited to provide reliable insights into passenger behaviour (Aguiléra et al., 2013). The Roundtable identified promising new behavioural data sources as:

- check-in and check-out data can provide considerable insights into urban travel patterns and choices;

- mobile phone data contains a wealth of information from ultimate origin and destination details[12], through route choices down to even which carriages are boarded;
- CCTV data informs on train arrival and departure times, on escalator-stairs choice, on platform crowding, choice of seat and whether to stand and a range of other behavioural issues;
- mobile phone apps can be used to contact travellers during the course of their journeys regarding their ongoing experiences and also to undertake post-journey market research

These data could be particularly useful for the access and egress components of convenience, where operators have little control, and for inter-modal integration.

Finally, our view is that there are significant economies in pooling research efforts. In Britain, the 24 train operating companies and other organisations with railway responsibilities have voluntarily formed a 'research club' to pursue common research interests which is funded through subscription. At the other extreme, there is 'pan-country' funding of research, such as by the European Commission. We feel that opportunities are being missed for conducting more meaningful, significant and path-breaking research by transport operators and regional authorities through collaborative, well-focussed research to address the sort of common challenges that this document is concerned with. Opportunities to share knowledge, expertise and research findings should be fully exploited.

The view of the roundtable was that this is an area of considerable interest to many researchers and practitioners, so we can expect a considerable amount of further research (both published and unpublished) on this subject going forward. It would therefore be useful if some organisation established a central repository for travel time valuation (and also elasticity research), organised and categorised by subject area, similar to but expanded on the Bureau of Transport Economics Transport Elasticities Database Online (www.bitre.gov.au/tedb), perhaps along the lines of the resource provided by the Victoria Transport Planning Institute (eg, www.vtpi.org/elasticities.pdf) or indeed the UK railway's Passenger Demand Forecasting Handbook (PDFH) but with access to source material. This would require ongoing funding, and ideally would be housed and supported in a governmental agency much along the lines of maintaining physical libraries.

The PDFH provides a good example of how different parties, such as operators, government, infrastructure providers and other bodies, can work together to develop and agree a common, and evolving, evidence base in these issues, considering all the attributes together rather than each in isolation. It would make sense to take forward such an initiative on a much wider basis than just the UK, and indeed extended to cover not just the convenience issues here discussed but also cost, comfort and time.

There are also three highly complementary research themes that should be pursued, each of which could itself be the subject of a Roundtable. These are:

- The marketing of public transport convenience, and in particular what are the perceptions of the current situation and of changes and how can these be improved and what promotional measures can be taken to increase public transport use?

12. This is important given that the public transport operator provides only a proportion of the journey product and particularly because access and egress are important aspects of convenience.

- What is the most appropriate means of forecasting how changes in convenience impact on public transport demand?
- Measuring changes in convenience and monitoring their effects.

The former two issues are somewhat outside the remit of this study. The latter we cover amongst other issues in the next section.

5.2 Monitoring, Validating and Ex-Post Analysis

Whilst we have pointed out there is now a significant evidence base relating to convenience multipliers, there is also a need to appraise the methodologies used to obtained the valuation evidence and the findings themselves.

The Roundtable was of the view that a 'research protocol' needs to be established for monitoring and ex-post analysis of improvements to convenience. In this regard, Litman (2014) makes the following important points:

- *"Survey transit operators who have implemented various service quality improvements, such as reduced crowding and real-time information signs, to better understand their experience. In particular this research should attempt to identify:*

  The impacts of these improvements on patron satisfaction and transit ridership.

  How individual improvements are coordinated to maximize their effectiveness.

  How to avoid potential pitfalls."

Learning from the experiences of operators is often a neglected aspect of monitoring. In addition though there is a need for the more conventional form of behavioural monitoring. Litman (2014) adds:

- *"Perform detailed before-and-after studies of any transit service improvements. For example, before implementing service improvements collect appropriate baseline data through surveys and traffic counts as a basis for evaluating how they affect patron satisfaction, travel and operations"*

We might usefully add to this that operators can monitor changes in demand as represented in their sales of tickets and surveys must be conducted post-improvement to identify the reasons for behavioural change.

There is another, but indeed related, issue of validation that also needs to be addressed. This relates to the use of hypothetical questions to derive values and drive policy. The SP method has, for around 30 years, been a key part of the tool-kit available to transport planners and analysts. It has provided an enormous amount of evidence worldwide on parameters used in transport forecasting and appraisal, as is clear from our review. Despite this, there still remains an underlying unease about the SP approach, and not just amongst economists who traditionally favour methods based around individuals' actual behaviour. Indeed, we have reported what we regard to be convincing evidence that SP based multiplier values for walk and wait time seem to be too low. This appears to be on the grounds of realism rather than protest response. We are also aware that SP methods can provide what can be regarded to be inflated values for contentious issues such as late time and crowding, as well as comfort related factors, where exaggerated responses might influence policy.

We would therefore recommend, wherever possible, that SP values are given a firm basis in RP behaviour and that convincing evidence is provided that SP evidence is reliable. Of course, poor RP data and models serve no useful purpose in validating SP methods. But it is not beyond the bounds of reasonableness and ingenuity to identify RP choice contexts where we can obtain large samples of travellers with real and familiar trade-off choices between convenience attributes. Although there are those who are sceptical about building reliable RP models, we note the plausible and generally robust Raveau et al. (2013) RP results discussed at the Roundtable even without the benefit of very large sample sizes. Moreover, the resource paper by Kato (2014) reveals the emphasis on robust RP data in Japanese studies, often based around the choices presented amongst rival train companies and routes, although the unexploited potential of SP methods in that country is also pointed out. Concerted efforts to build robust RP models will, in our view, yield reliable parameters that can be used to evaluate comparable SP evidence.

6. POLICY IMPLICATIONS

The view of the Roundtable was that convenience is not generally covered as well as it should be in policy and project assessment, either because of the absence of official economic appraisal procedures or else because of limitations in coverage of existing appraisal methods. This is disappointing given the importance of convenience terms in the overall attractiveness of public transport.

Current transport evaluation methods tend to focus on speed and price and undervalue comfort, convenience and reliability. This skews planning and investment decisions. Some cost-effective transit improvement strategies are overlooked and undervalued, resulting in underinvestment in transit service quality makes transit less attractive relative to automobile travel. Opportunities for modal integration are overlooked, since many transit quality improvements involve improving walking and cycling conditions, or improving connections with other modes. This reduces the attractiveness of public transport in relation to use of the private car contributing to a cycle of increased automobile dependency and sprawl and reduced transit ridership and revenue.

The review findings should be a valuable resource to planners and policy makers, operators and funding bodies, facilitating access to a significant body of empirical evidence on travel quality attributes often overlooked. The findings also yield insights into methodological issues and provide a means by which the results of specific empirical studies can be interpreted in relation to a large amount of accumulated evidence.

By providing evidence on convenience multipliers and demonstrating the importance of convenience, this report aims to support the identification and evaluation of schemes that improve convenience to achieve broader transport policy and mobility objectives.

We have seen that factors related to convenience can form a significant proportion of the generalised cost of public transport. Addressing convenience is therefore an important part of improving wellbeing of public transport users, and attracting non-users to use public transport, and more generally a significant route to increasing welfare by reducing the costs of transport.

Litman (2008), reports that inconvenience and discomfort often double or triple average travel time costs. This underlines the need to take convenience seriously in project appraisal and planning and for planners and policy makers, operators and funding bodies to identify means of improving convenience.

The previous section sets out suggestions for further research into convenience multipliers. However, there is little point in authorities, planners and operators conducting further empirical research if there is no appraisal system in place to make use of the values.

Existing appraisal methods should be extended where necessary to appraise the full set of convenience measures. Incorporating convenience can clearly alter the outcome of cost-benefit assessments of projects and policies. For example, the Paris experience (Kroes et al., 2013) demonstrates that counting the benefits of reducing crowding added around 6% to the total benefits of the investment to extend RER line E[13].

Policy makers must also recognise that there is more to improving convenience than schemes to reduce walking times, reduce headways or improve crowding levels. A cost effective way forward might in some circumstances be to achieve an effective convenience improvement by reducing the penalty attached to the variables walk time and crowding. Thus reductions in generalised cost might be achieved more cost effectively by designing public transport interiors to facilitate standing safely and comfortably rather than by generally expensive increases in capacity. Similarly, improving facilities at bus stops, stations and at transfer points can reduce the cost attached to wait time and hence again effectively serve as a reduced waiting time.

Apart from the valuations themselves, there are issues of measurement and implementation. Quality measured is not always quality delivered nor quality perceived. There are significant challenges in measuring reliability and crowding, although possibilities are improving here with technology, noting that these vary across, for example, different departures and indeed within any given departure through the course of a journey. Different market segments will have different convenience multipliers, and the ability to more closely tailor provision with what people want and are willing to pay for requires more information than is currently available. Implementing improvements in the appraisal of convenience will place significant demands on measurement abilities. Measurement and valuation of convenience is important not just for the appraisal of schemes but also management and regulation and improvement of operations. Indeed, measurement of convenience is a pre-requisite to its good management, regulation and delivery.

The sorts of interventions that the valuations reported here could be used to evaluate investment, planning, pricing and policy options that cover:

- Measures such as longer and higher capacity trains, improved service frequencies and appropriate pricing incentives that reduce the degree of crowding, particularly on peak services;
- Providing more through services and where possible improving conditions and time transferring at interchange locations;
- Improving access to and from public transport and integration between modes;
- Pricing measures to encourage travellers to change their time of travel to off-peak periods;

13. This scheme also involves some direct travel time benefits because of a shorter route for some travellers. In other schemes without travel time benefits, the importance of incorporating the crowding benefits might be much higher.

- Operational and infrastructure measures to improve on-time performance and to provide reliable information to travellers on how trains and buses are running;
- Higher service frequencies, in terms of the impact of waiting time as well as the convenience effect;
- Providing better passenger information, both on-vehicle and at-stations/stops, on a wide range of issues such as service performance, next departure, disruptions, directions and obtaining assistance.

7. CONCLUDING REMARKS

The outcome of this roundtable has been, we would argue, the most extensive review so far conducted of valuations of public transport convenience, covering appraisal practice, the now extensive empirical evidence base and identifying policy implications and future research needs and directions. Valuations of in-vehicle time have dominated transport appraisal and a review of evidence on attributes that influence public transport convenience is timely, not least given the serious transport-related challenges that increased investment in and better planning of public transport is well suited to address.

Our hope is that this document will facilitate greater use of convenience valuations in the appraisal of transport investments and policies worldwide. There is no reason why, in principle, the 'best practice' adopted in some countries and by certain organisations cannot be adopted more widely. Whilst the valuations summarised here provide a valuable resource, ideally appraisal should be informed by local parameters and we would encourage their estimation as well as a greater level of detail as to how and to what extent the convenience multipliers vary across different circumstances.

And finally, we recognise that there are a wide range of comfort related variables which are also of importance in public transport provision and increasing its attractiveness. A similar assessment of their valuations is also long overdue.

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International Transport Forum
2 rue André Pascal
75775 Paris Cedex 16
itf.contact@oecd.org
www.internationaltransportforum.org