Support to UK Tram

Activity 7 Work Group

"Benefits Involved in Appraisal Process"

Analysis of Quantitative Research on Quality Attributes for Trams

By: Institute for Transport Studies

University of Leeds

pteg cpt TRAMS LRT FORUM

UK Tram

Title: Support to UK Tram Activity 7 Work Group Benefits Involved in Appraisal Process – "Analysis of Quantitative Research on Quality Attributes for Trams" by: Institute of Transport Studies – University of Leeds.

Customer: UKTram Ltd

Authors: Daniel Johnson, Pedro Abrantes & Mark Wardman

Reviewed By: UKTram Steering Group

Approved By : UKTram Board

Contents

Tables

Disclaimer

1. This document is made available without any representations or any kind of warranty (whether express or implied by law) to the extent permitted by law. In particular, UKTram Ltd gives no warranties as to the accuracy of the Content or its fitness for your purpose, or that the Content does not infringe third party rights. UKTram Ltd does not accept any liability for error or omission in the Content.
2. UKTram Ltd is not responsible for how the Content is used, how it is interpreted or what reliance is placed on it, whether by you or by any other party.
3. Under no circumstances will UKTram Ltd be liable for any losses or damage (whether foreseen, foreseeable, known or otherwise) including, but not limited to: (a) loss of data; (b) loss of revenue or anticipated profits; (c) loss of business; (d) loss of opportunity; (e) loss of goodwill or injury to reputation; or (f) losses suffered by third parties however arising (including under negligence).

Intellectual Property

4. If you use Content from this document, you may not remove any copyright notice or any other proprietary notice. If you use part of any Content then you must acknowledge the copyright owner as the source of the extracted material

General

5. These terms shall be governed by and interpreted in accordance with the laws of England and Wales

UKTram Ltd
Windsor House
42-50 Victoria Street
Victoria
London
SW1H 0TL

22th April 2009

Analysis of Quantitative Research on Quality Attributes for Trams

1. Introduction

The overall purpose of this study is to identify the important quality attributes which comprise a measure of quality of journey experience on trams, making it distinct from other modes. This study has three main aims:

- Firstly to identify the extent of modal preference for tram over other modes captured in the mode specific constant.
- Secondly, where possible to identify the importance of the various components of the modal preference.
- Thirdly to identify gaps in knowledge and suggest possible avenues for future research.

We class quality attributes as those which are not captured in time or cost related estimated parameters from Stated Preference (SP) or Revealed Preference (RP) exercises.

Our findings are aimed at promoters, funders and operators of rapid transit schemes in the UK and include:

- A critical review of the available literature on public transport quality attributes, and the approaches used to collect the valuations of these.
- Analysis of the Tram Modal constants available from a range of relevant studies, segmented where appropriate
- A ranking of quality attributes and a discussion of those quality attributes identified as being significant contributors to modal preference
- Comparisons of valuations with those from studies into Bus Rapid Transit type schemes.
- Insights into the possibility that the quality attributes of UK Tram proposals have been under or over-stated.
- Consideration of whether appropriate modelling exercises have been undertaken.
- A summary identifying gaps in the evidence base and limitations in the analysis and recommendations for future work to address these gaps and limitations.

Given the focus on quality attributes is a relatively recent phenomenon, and the lack of coverage of these factors in earlier studies, we have focused on studies from the year 2000 onwards.

The number of suitable studies from which to draw on, although far from trivial, precludes the reliance on a traditional meta-analysis approach where some quantitative relationship is estimated between the available modal preference evidence and the range of socio-economic, modal and trip characteristics that might influence them. In addition the range of disparate valuations renders a meta-analysis very difficult.

Pertinent quality attributes associated with Tram schemes include the following, although the list is not meant to be exhaustive and there is clearly some overlap:

- waiting environment; provision of seating and quality of shelters, security issues, adequate signage and information provision;
- staff and security; helpfulness of staff, safety and security throughout the journey;
- service reliability, including reliability at the origin (wait time) and at the destination (late time);
- vehicle quality; smoothness of ride, accessibility, multi-door boarding, on board facilities, cleanliness; level of crowding, air conditioning, CCTV;
- ticketing systems, including simplified fares schemes;
- other factors such as perception of permanence.

In addition to evidence on relevant attributes, we will also discuss:

- evidence on the factors that distinguish Tram from other modes and their relative importance;
- the mode specific constant for Tram relative to other modes;
- variations in the value of time according to the type of vehicle;
- the extent to which Tram demand forecasts have turned out to be accurate;
- consideration of the validity of SP methods.

It must be borne in mind that, more than the other parameter estimates of mode choice models, these constants are subject to influence by a range of factors:

- model mis-specification
- unavoidable correlations between the constant and other coefficient estimates and patterns in the errors of individuals' responses.
- the influence of service and system attributes not explicitly modelled
- inadequate market segmentation leading to a model which does not accurately reflect observed choices
- poor experimental design or inadequate data

For the above reasons, the evidence relating to mode specific constants can be expected to be much more volatile than value of time estimates and hence will be much harder to explain and any derived relationships will be inherently 'less convincing'.

It is important to determine the extent to which individual valuations are the subject to package effects. Package effects occur where the sum of individual interventions applied in isolation may exceed a value of a package of the same measures.

Section 2 of the report outlines the context to this study, Section 3 discusses the relevant methodological approaches, and Section 4 critically appraises the literature on tram studies and presents a synthesis of the factors identified as important in studies. Section 5 presents quantitative findings on the tram constant found in the studies. Section 6 concludes.

2. Background

2.1 Context of this Study

At the present time there are eight tram schemes in operation in Britain:

- Croydon Tramlink
- Centro (West Midland Metro)
- Nottingham (NET Tram)
- Manchester Metrolink
- Sheffield Supertram
- Blackpool Tram
- Docklands Light Railway
- Nexus (Tyne and Wear Metro)

The latter two run partially underground so are officially considered metros or subways.

Trams have many benefits over existing PT modes, when used in the appropriate context. Whilst trains are suited to moving lots of people quickly over a long distance, trams are more flexible, low cost and frequent. Buses are suited to moving smaller numbers of people over shorter distances but trams are faster and more reliable. Also:

- Trams are environmentally friendly – travel by tram produces 1/3 the amount of CO2 as travelling by car (Defra, 2007). They can also reduce congestion in city centres.
- Trams are popular and can improve the image of a city
- Trams are quiet and safe.

The UK has fewer trams than other countries than Europe. In March 2000 the Department for Transport suggested that funding would be available for up to 25 new trams around the country, but by 2005 Ministers decided buses would be more cost effective and withdrew funding for a number of schemes including Leeds Supertram, South Hampshire and Liverpool.

Only one new scheme is currently being developed, Edinburgh, scheduled to be completed by 2011. Work is also currently underway on extensions to Manchester Metrolink (Manchester to Oldham Mumps is expected to open in autumn 2011 and onwards to Rochdale in spring 2012). There are two extensions currently in development on the NET Tram network, they are Chilwell via Queens Medical Centre & Beeston and Clifton via Wilford.

At the current time, alternatives for the future of transport in our cities is being discussed, particularly Bus Rapid Transit schemes, which are perceived as delivering benefits of trams systems with lower capital costs. In the light of this it is important to try and establish the benefits that tram systems confer, and how these benefits compare to those from other competing modes. Alongside the ‘typical’ time and cost attributes covered in modelling exercises to establish values for Public Transport systems, appropriate valuations and understanding of Tram quality attributes could play an important part in appraisal and demand forecasting.

2.2 Existing Levels of Tram Patronage

The Government’s own statistics on Light Rail (DfT, 2008) presents figures on forecasted patronage from the initial surveys and the actual levels of patronage of 8 tram systems. Promoter's expected patronage figures are taken to be when system reaches maturity, usually five years after opening.

Sheffield Supertram is performing well below its forecast, despite being almost 15 years old. Similarly, West Midland Metro is underperforming against expectations. Conversely, both Croydon and Manchester Metrolink performed better than expectations. Copley and Vaughan (2001) provide more detail on the Metrolink figures which seem to suggest that whereas the aggregate forecast looks accurate, ‘it was the result of inaccurate forecasts [of

different parts of the network] cancelling each other out’. The underlying assumptions as to fares, parking charges, bus service rationalisation and tram frequencies were not realised and exogenous factors were also different. They re-run their forecasting models with the outturn factors in place and get improved estimates which they claim justifies the modelling process.

Table 2.1 Forecast and Actual Patronage

	DLR	Croydon Tramlink	Nexus (Tyne & Wear Metro)	Centro West Midland Metro	Nottingham NET Tram	Altram Manchester Metrolink	Stagecoach Supertram	Blackpool tram
1997/98	21		35			13.8	9.2	4.7
1998/99	27.6		33.8			13.2	10.4	4.4
1999/00	31.3		32.7	4.8		14.2	10.9	4.3
2000/01	38.4	15	32.5	5.4		17.2	11.1	4.1
2001/02	41.3	18.2	33.4	4.8		18.2	11.4	4.9
2002/03	45.7	18.7	36.6	4.9		18.8	11.5	4.5
2003/04	48.5	19.8	37.9	5.1	0.4	18.9	12.3	3.7
2004/05	50.1	22	36.8	5	8.5	19.7	12.8	3.9
2005/06	53.5	22.5	35.8	5.1	9.8	19.9	13.1	3.6
2006/07	63.9	24.6	37.9	4.9	10	19.8	14	3.4
2007/08	66.6	27.2	39.8	4.8	10.2	20	14.8	2.9
Forecast		25		8		18	22	

Most services exhibit strong growth after their inception, with the exception of West Midlands Metro and Blackpool (which is of course long established).

3. Modelling Approaches

3.1SP Modeling

An SP study collects information about individuals preferences based on a series of choices, where individuals are forced to make trade-offs between different attributes and through that reveal their underlying preferences. In order to introduce variability into the explanatory data a number of levels of these attributes in the survey should be used. However this can create problems as, from a statistical point of view, a high number of levels imply that a very large sample is needed to reach a sufficient confidence about the results. If not enough levels are used the results will not accurately reflect respondent's actual marginal valuations of changes of attribute levels.

All the studies covered use discrete choice modeling techniques to elicit valuations from the collected SP data, whether to elicit within-mode time or service quality related valuations or through a mode choice exercise to additionally elicit values for modal constants. The logit model which is used to analyse choices at the disaggregate (individual) level is based on the assumption that each individual chooses that alternative from the n on offer which yields the maximum utility (U) or satisfaction. Thus, individual *i* chooses alternative 1 if:

$U_{i1} > U_{in}$ *for all n, n≠1*

Overall utility for each alternative is composed of part-worth utilities associated with a range of explanatory variables. However, the analyst cannot possibly accurately observe all influences on individual's choices. An error term (ε_i) is therefore introduced to represent the net effect of unobserved influences on an individual's choices. The studies conventionally assume that individual *i* bases decision making on what might be termed random utility, which for each alternative *k* is made up as:

$$U_{ik} = V_{ik} + \varepsilon_{ik}$$

where V_{ik} is the observable component of utility, termed deterministic utility. In a simple example of a choice between *n* options with different costs (C) and travel times (T), the deterministic utility associated with option 1 for individual *i* could be represented as:

$$V_{i1} = \propto T_{i1} + \beta C_{i1}$$

Utilities for other options can be specified analogously. Clearly, in only observing V_{ik}, this ignores the influence of the unobservable components of utility. It is not certain that alternative 1 is preferred if V_{i1} is the highest, yet the analysis must proceed on this basis.

The way forward is to specify the problem as one of explaining the probability of an individual choosing a particular alternative. We would expect the likelihood of choosing alternative 1 to increase as its overall random utility increases. The probability that an individual chooses alternative 1 from the *n* on offer can be represented as:

$P_{i1} = Pr[(V_{i1} + \varepsilon_{i1}) > (V_{in} + \varepsilon_{in})]$ for all *n,n ≠1*

By assuming a probability distribution for the ε_{in}, the probability of alternative 1 can be specified as a function of the observable component of utility. Assuming the errors have a type I extreme value distribution and are independently and identically distributed yields the familiar multinomial logit model (MNL):

$$P_{i1} = \frac{e^{V_{ik}}}{\sum_{k=1}^{n} e^{V_{ik}}}$$

Where choices are made amongst just two alternatives, this simplifies to:

$$P_{i1} = \frac{1}{1 + e^{(V_{i2} - V_{i1})}}$$

Maximum likelihood estimation ensures the best explanation of individuals' discrete choices.

In models of mode choice, modal preference over the *m* modes is captured by *m-1* modal constants, which give preference relative to the omitted mode. The modal constant represents all the features of a mode that affect its level of attractiveness but cannot be explained by any of the other attributes used in the model. Large modal constants are often indicative of poorly specified models – the purpose of including information on quality attributes is essentially to reduce the value of this modal constant and identify more explicitly the sources of attractiveness of the Tram mode.

The estimated coefficients denote the relative importance of the variables. A negative sign parameter indicates a variable which is disliked more as it becomes larger, such as cost and travel time. A positive value of the tram constant as compared to the base of bus suggests that, all else equal, there is a preference for tram over bus.

The logit model produces standard errors for each of its coefficient estimates, allowing t ratios and confidence intervals to be derived. These are interpreted in the same manner as for the more familiar multiple regression analysis. The critical values is taken to be two, however coefficients with lower t ratios are often kept in the model if they are expected to influence choice and are plausible, even if not precisely estimated.

The ρ^2 statistic measures goodness of fit, analogous to the more familiar R^2 of regression analysis. However, the interpretation of what is a reasonable figure is somewhat different. Louviere et al (2000) state that "Values of ρ^2 between 0.2 and 0.4 are considered to be indicative of extremely good model fits. Simulations by Domencich and McFadden (1975) equivalence this range to 0.7 to 0.9 for a linear function". ρ^2's of around 0.1 are typical of the goodness of fit obtained in standard SP travel choice models.

Standard logit model depends on the Independence of Irrelevant Alternatives (IIA) assumption. This holds where an improvement in the attributes of one alternative draws proportionately from all other alternatives. However, in the application of models to a number of different choices including a mix of PT and non-PT options, this may not be appropriate. More specifically the introduction of a tram option may draw more proportionally from the more similar alternative of bus, rather than car. In such situations it is appropriate to use a nested logit model, which is capable of dealing with different correlations between alternatives. In this example it would be appropriate to estimate a model with two nests, ie a public transport nest, where IIA holds within the nest but not across nests.

In other words, an improvement in the attributes of tram draws proportionately from other alternatives in the PT nest, but disproportionately from private transport options outside the nest.

The standard logit model assumes that unobserved influences on choice are independent. However, it is likely that, because each individual performs multiple choices, there will be a degree of correlation in the errors within the choices made by each individual. As a consequence, the t ratios will be higher than they should be and thereby we will be given a false indication as to the precision with which the coefficients are estimated.

In estimating models with constants, sufficient segmentation must be undertaken to avoid the ecological fallacy. This arises where modeling leads to the incorrect interpretation of data - where inferences about the behavior of individuals are based on aggregate statistics for a group to which individuals belong. For example it is wrong to assume that just because a modal constant suggests there is a preference for tram over bus, all individuals will prefer tram over bus. Within the population of the sample there will be a distribution of preferences.

More sophisticated estimation techniques, such as random parameters logit (mixed logit), allow estimated parameters to have a distribution across the sample rather than assuming them to be fixed across all individuals. These models are often applied in situations where the ecological fallacy may be a problem. Similarly, some estimation techniques allow more flexible forms of utility function to be directly estimated.

Monetary valuations

The valuation of an attribute denotes the monetary equivalence of the change in utility brought about by a change in that attribute. For example, the value of time is the monetary equivalent of a reduction or improvement in travel time. It therefore represents the most that an individual is prepared to pay for a time saving or the minimum compensation that would be required in the event of a time loss. This is termed as the willingness to pay (WTP) for an improvement of any of the attributes. Values are typically expressed as per minute for the time parameters, but per journey for constants.

The marginal value of a variable is defined as the ratio of the marginal utility of that variable and the marginal utility of money. In the example here, the marginal value of time is simply the ratio of the travel time coefficient and the cost coefficient (α/β). In this case the monetary value is constant, and the average and marginal values are the same.

The larger amount of random error in a model, then the smaller the coefficient estimates will be. In turn, forecast shares will tend to equal shares, which in the extreme case implies random choices.

Using SP models for forecasting

The issue of scale, or the amount of random error, of the model is not a problem in calculating relative values, since they are derived as ratios of coefficient estimates, so the scale cancels out. However, for accurate forecasting of real world behavior, a necessary condition is that the errors in an SP model are representative of the errors that influence actual behavior. This is unlikely to be the case given that respondents are not committed to behave in accordance with their stated preferences. The widely held view is that SP models should, for forecasting purposes, have their coefficients rescaled to be consistent with actual choices.

When pooling data across SP exercises, differences in scale, (as a result of differences in random error), could result in drawing erroneous conclusions about attribute value variation which are attributable to differences in scale across the exercises which deal with specific features rather than to genuine differences in attribute values.

3.2 Revealed Preference Modeling

SP models may not predict travel decisions accurately. By its very nature, SP data only gives an indication of what people say they would do in a given hypothetical situation. RP data on the other hand are based on what people did in actual real-life situations. Clearly research of the nature on transport systems not yet in existence will to some extent have to rely on SP data.

For reasons mentioned above, SP models are generally not used for forecasting unless some attempt to re-scale the model is undertaken. This can be done using data on actual travel behavior to develop a hybrid RP/SP model which has sensitivities based on actual choices.

Clearly the situations where this is appropriate are limited given the fact that many studies are based in areas where tram schemes do not exist. Re-scaling in these situations may be done at a higher level, which includes the choice between car and public transport.

RP modeling is difficult, even where data exists. In SP we can vary the patterns of attribute levels offered in choices so that we maintain independence between the explanatory variables and avoid the problems of multicollinearity. However, it is very difficult with RP data to find sufficient variability in the data and isolate the explanatory variables in order to robustly estimate models.

3.3 SP and Response Bias

There are a number of different approaches taken to modelling quality factors. Modelling quality attributes alongside other fare/time related attributes requires considerable care. Putting all attributes into one SP exercise will mean a very complex SP design and can lead

to overly burdensome SP questionnaires. This can result in bias through not understanding the trade-offs or simply becoming bored.

Study 1 (SDG, 2008) offers some guiding principles to minimize bias in hypothetical responses

- Avoid, whenever possible, choices between an existing service and a proposed improved service. In situations with hypothetical services, 'the fact that none of the presented alternatives is immediately associated with a service that the respondent is well-familiar with considerably reduces the chance that the respondent chooses the other, unfamiliar alternative simply because it seems more exciting and new'.

- They also recommend an alternative that can be seen as more innovative (e.g. a tram) is defined such that some of its features are at the basic level.

- The two key attributes - fare and travel time – should be present in all scenarios to reduce the chance that cost implications are ignored when considering improvements. ‘It also helps keeping the responses from different parts of the survey at a uniform scale.’

In order to simplify the complexity and cognitive burden of the task modellers typically undertake a two stage process to the analysis. Firstly a within-mode SP identifies the WTP of different quality attributes. However, in deriving the overall valuation of a package of quality improvements, a simple addition of the separately identified WTP values of the individual attributes is not appropriate, as the marginal value of an improvement in an attribute tends to fall as the total number of improvements increase, until a point where further improvements do not increase the WTP. This is what is commonly referred to as the ‘package effect’.

In a situation where a number of quality attributes are considered, it is thus appropriate to scale their impact. This can be done either by:

- A separate SP exercise which values packages rather than individual attributes or
- A transfer price exercise, where individuals are asked directly how much they would be willing to pay for a package of quality improvements.

These values of the packages elicited from this are then used to scale the individual WTP appropriately so they sum to the total value of the package. If such precautions are not taken we may see the values of any observed quality measures lead to negative values for the remaining unobserved factors making up the modal constant.

The modal preference for tram depends on how the model is specified particularly whether the model has mode specific or generic parameters, and degree of market segmentation. When mode specific parameters are used, modal constants are generally not significant, suggesting generic models mask the importance of individual attributes

4 Literature Review

4.1 Introduction

Table 4.1 below presents all the studies considered in this review.

Table 4.1 Studies Considered

Study	Client	Reference	Date of survey	Tram MSCs	WTP Values for Quality Factors	Attitudes to Quality Factors	'Performance' of Tram
1.New Generation Transport in Leeds	Metro	SDG(2008)	2007	Y	Y		
2.Croydon Tramlink: SP Working Paper	TfL	Faber	2001	Y	Y	Y	
3.West London Tram Project		MVA		Y			Y
4.Edinburgh Tram	Tie LTD	SDG	2006	Y			
5.Leeds LRT:SP Surveys	LCC	SDG	2001	Y			
6.South Hampshire Rapid Transit SP Survey	SHRT	SDG	2003	Y			
7.Mersey Tram	Mersey travel	SDG	2002	Y			
8.Midland Metro Extension	CENTRO	MVA	2007	Y			
9. Sheffield and Rotherham Bus Rapid Transit Study	SYPTE	MVA/Arup	2008	Y		Y	
10.Multi-modal SP Study	TfL	SDG	2007		Y		
11. Midland Metro MS	CENTRO	Faber	2001	Y	Y	Y	Y
12. Valuation of Station Facilities	GMPTE	SDG	2004		Y		

Ten of these studies all report values for the Tram constant against Bus, and/or Car, and in some cases other forms of Public Transport. The exceptions here are Studies 10 and 12 which focus on presentation of WTP estimates for quality factor improvements and do not present modelling results. Studies 1, 2 and 11 also report WTP estimates for quality factor improvements.

Three of the studies, 2, 9 and 11 investigate attitudes to service quality attributes, although this is in the form of attitudes to public transport in general.

Studies 3 and 11 provide some measure of the performance of tram against other modes.

In the cases of Studies 10 and 12 the lack of detail of some of the modelling results has meant it is impossible to derive values in terms of minutes, so our results are presented in monetary units.

In this Section 4.2 we will examine the tram studies which looked explicitly at WTP for tram quality attributes, Section 4.3 covers the remaining studies which looked at attitudes to quality attributes and Section 4.4 covers the remaining studies which just reported values for the tram MSC. Section 4.5 looks at some information from overseas tram studies and Section 4.6 looks at the studies which considered RP models. Section 4.7 look at findings from other PT modes. Section 4.8 attempts to synthesise the results examined.

4.2 Studies reporting WTP for Service Quality Improvements

Studies 2: Croydon Tramlink, (Oscar Faber, 2000) and 11 Midland Metro Monitoring Survey, (Oscar Faber, 2001)

Studies 2 and 11 take a similar two-stage approach to the modelling of quality attributes. Modelling all quality and time and cost related attributes in one SP experiment would be extremely problematic. If each attribute was varied sufficiently there would be too many choices for a respondent to deal with. Instead the approach here is to model mode choice and service quality valuations separately. The first stage uses a mode choice stated preference design to examine how well SP replicates behaviour and to provide a basis for examination of modal preference. The second stage, a service quality SP, examines the relative importance of different service quality attributes of different modes, and these are linked back to main mode choice model through inclusion of journey time, enabling results to be scaled to values of time in the main model. The choices are made within mode to avoid confounding mode choice issues.

Both studies used two model designs – car available including car, bus and tram, and non-car available with bus and tram. The mode choice designs involved a choice between car (where available) bus, tram, Would not travel, with Study 11 also considering train. Each mode was described in terms of in-vehicle time, cost, access/egress time and service headway. Three different distance bands were included to customize the SP scenarios. Both designs have each variable at 3 levels producing a design with 27 scenarios split into three subsets giving 9 presented to each respondent.

Respondents were asked to state how important each of the following variables were on a semantic 1-5 scale. These variables together with importance ratings are reported below.

Table 4.2: Importance of Public Transport Quality Attributes for Studies 2 and 11

	Study 2 Importance rating (/5)	Study 11 Importance rating (/5)
Feeling of personal safety in the vehicle	4.8	4.7
Personal security where you get the vehicle	4.7	
Ease of getting on/off vehicle	4.2	3.8
Waiting environment	4.2	3.8
Staff attitude	4.1	
Ease of getting information	4.1	3.8
Comfort	3.9	4.1
Visibility of staff	3.9	
Door to door journey time reliabilty	3.8	4.2
Environmentally friendly	3.7	3.9
Availability of seats to you	3.6	3.9
Publicity	3.6	
Ride quality	3.6	3.5
Noise level inside vehicle	3.3	3.5
Image	3.2	2.6

Clearly, personal safety is the most important attribute in both studies, but aside from this there are many differences in the figures and rankings. Given the lack of information on the distribution of the figures it is difficult to say confidently whether these differences are significant, or whether for example journey time reliability is significantly more important in Study 11 than Study 2. It would appear that ride quality, noise level and image are factors not considered as important as the other factors across both studies.

In addition respondents were asked about the importance of environmentally friendliness, ease of understanding of the network, image and publicity, which were useful factors for identifying importance but could not be sensibly varied within an SP choice context. They were then asked to select how different modes, including tram, currently perform, by choosing from four levels, for example in the case of ride quality, from ‘Very smooth ride’ to ‘A lot of movement and jerking’.

Three of nine quality variables were selected at random and presented as a choice of vehicle A vs Vehicle B together with IVT.

Stated preference studies were administered on a cross section of areas with different demographic/socio-economic characteristics, with the interview based on a specific trip made from a household. For Study 2 there was a total sample of 824 interviews, 560 car available, 264 non-car available. Study 11 collected 893 interviews, 516 of which were car available and 377 non-car available.

Three different distance band designs were produced for short, medium and long time periods.

This quality model was linked to the modal constant from the mode choice variables in a number of stages. Firstly, coefficients for each of 4 levels for quality aspects for bus and tram were generated from the SP experiment. These are reported in the table below (although only the values from the worst to highest levels).

Table 4.3: WTP values for changes in Quality Attributes for Studies 2 and 11

	Study 2	Study 11 Bus Users rating of Metro	Study 11 Car Users	Study 11 Metro users
Personal safety in the vehicle: From Very unsafe to Very safe	26			
Personal security where you get the vehicle: From Very unsafe to very safe	63	22	27	42
Ease of getting on/off vehicle: From Very difficult to easy	38	17	12	13
Waiting environment: From very unpleasant to very pleasant	11*	13	12	11
Staff attitude: From very unhelpful to very helpful		20	7	2
Ease of getting information: from very easy to very difficult		4*	5	4*
Comfort: From feel very uncomfortable to feel very comfortable	12*	9	16	7
Visibility of staff: from rarely to very visible many staff		2*	5	9
Journey time reliability: from very unsure as expected to unsure	23	8	10	5
Availability of seats to you: from stand for all journey to ample seating	16	11	8	16
Ride quality: from lot of movement/jerking to very smooth ride	13*	5	6	12
Noise level inside vehicle: from extremely noisy to very quiet	5	12	15	4

*Indicates insignificance

The individual values cannot be taken at face value, as they are subsequently scaled, but do give an indication of strength of preferences. It is clear that a high level of personal security is valued the most. Ease of access and personal safety (in study 2) are also valued highly. Ease of information, staff visibility and noise level inside vehicle are not valued as highly.

Secondly, for each vehicle type and quality variable, the perceived performance level was replaced by the coefficient for that level from SP- for each user the various tram and bus quality coefficients were totalled to produce an overall perceived performance score for tram and bus. These performance scores were included in the mode choice SP to determine impact of perception of mode on mode choice. These are only reported for Study 11, and shown below

Table 4.4: Performance ratings of Public Transport Quality Attributes for Study 11; (1=good, 4=bad)

	Bus	Car	Metro
Feeling of personal safety in the vehicle	2.0	1.5	1.8
Personal security where you get the vehicle	2.0	1.4	2.0
Ease of getting on/off vehicle	1.6		1.4
Waiting environment	2.3		2.1
Staff attitude	2.3		1.9
Ease of getting information	2.1		1.8
Comfort	2.2	1.4	1.8
Visibility of staff	2.9		2.8
Door to door journey time reliability	2.4	2.0	1.7
Environmentally friendly	2.5	2.5	1.5
Availability of seats to you	1.6		2.0
Publicity	2.3		2.1
Ride quality	2.4	1.9	1.5
Noise level inside vehicle	2.2	1.8	1.9
Image	2.1	1.8	1.9

This shows that for the attribute adjudged most important in Table 4.2 above, car users feel most safe and bus users least safe. Car has the highest value for feeling safe on the mode and tram performs worse than bus. Tram performs better than bus on most of the attributes, but particularly so for ride quality and reliability.

Having combined these quality variables into a composite quality variable it is possible to estimate a parameter for the composite quality variable. These quality variables impact on the modal constants and the goodness of fit of the models.The measures of quality appear right sign, significant.

Study 2 developed models for the following market segments:

- Car available commuters
- Car available shoppers
- Car available other purposes
- Non-car available commuters

Additionally models are run for generic and mode specific parameters.

Study 11 develops hybrid RP/SP models for car available and non-car available segments but does not include the quality variables in these models, for reasons not made clear. This is described in more detail in Section 4.5. The table below shows the overall generic models for both studies, with and without the quality variables so their effect can be seen.

Table 4.5: Unsegmented Results for Study 11 (Midland Metro)

	SP Model			SP with Quality Variables		
	Coeff	T value	Value p/min	Coeff	T value	Value p/min
Cost	-0.006197	20.8		-0.006219	20.9	
In Vehicle Time	-0.054022	14.3	8.7	-0.05386	14.2	8.7
Headway	-0.047270	11.0	7.6	-0.04697	11.0	7.6
Access/Egress	0.003791	0.5	-0.6	0.004003	0.6	-0.6
Bus MSC	-0.57	8.4	-92.0	-0.3872	4.2	-62.3
Tram MSC	-0.1232	2.3	-19.9	0.2829	3.3	53.0
Rail MSC	-0.9229	5.6	-148.9	-0.9577	5.8	-20.4
Bus Quality				0.09825	3.0	
Tram Quality				0.1176	6.0	
Rho-sq	0.0834			0.0857		

Table 4.6: Unsegmented Results for Study 2 (Croydon Tramlink)

	SP Model			SP with Quality Variables		
	Coeff	T value	Value p/min	Coeff	T value	Value p/min
Cost	-0.01158	12.6		-0.0118	12.6	
In Vehicle Time	-0.04351	13.0	3.8	-0.0472	13.7	4.0
Bus Headway	-0.02971	4.8	2.6	-0.0302	4.7	2.6
Tram Headway	-0.02827	3.7	2.4	-0.0323	4.1	2.7
Bus Type	0.08102	1.4	7.0	0.0822	1.4	7.0
Access/Egress time	-0.03676	4.5	3.2	-0.0417	4.9	3.5
Bus MSC	-1.15300	11.6	-99.6	-0.3171	2.9	-26.9
Tram MSC	-0.67690	7.4	-58.5	-0.1388	1.4	-11.8
Bus Quality				0.2416	20.2	20.5
Tram Quality				0.1777	14.8	15.1
Rho-sq				0.0967		

With the inclusion of the quality variables, as expected, the tram and the bus MSCs drop significantly, but other valuations remain constant. However, Study 11 now has a positive MSC for tram over car which has not been found in other studies. In Study 11, for both models the access/egress time coefficients were wrong sign but headway was significant. The explanatory power of the model for both studies also improves.

Study 11 showed how the perception of tram and bus varied across these attributes, and provided the proportional weight of the average quality factor making up the overall service quality modal values, as shown below. This is the only study which provides an ‘unpacking’ of the constant in this way, although the same exercise was undertaken in Study 2 but not reported.

Table 4.7: Perception of Mode by Tram Users from Study 11 (Midland Metro)

Proportional Weight of Average Quality Factor by Tram Users	Perception of Tram Av. value	% of total	Perception of Bus Av.value	% of total
Personal security where you get your vehicle	20.7	30%	15.8	26%
Waiting environment where you get your vehicle	4.9	7%	6.9	11%
Ease of getting on and off the vehicle	4.8	7%	1.1	2%
Availability of seats for you	6.1	9%	0.8	1%
Vehicle Ride Quality	5.1	7%	3.8	6%
Noise Level inside the vehicle	2.2	3%	4.6	8%
Comfort	3.0	4%	5.1	8%
Feeling personally safe in the vehicle	14.9	22%	9.1	15%
Door to door journey time	0	0%	2.7	4%
Visibility of staff	4.5	6%	1.6	3%
Staff attitude	0.5	1%	4.5	7%
How easy it is to get information	2.7	4%	4.3	7%
	69.3		60.2	

It is very difficult to interpret the value of the quality measure. A composite quality measure does not lend itself to meaningful marginal changes- what would a 1% change in the measure actually represent? Also including a composite quality measure for tram and bus there is the implicit assumption that the quality measure for car is zero, clearly car does have aspects of safety, comfort, security, ease of boarding which could have been valued by a similar exercise.

The two studies yield markedly different monetary valuations for all attributes, although consistently find tram to have a higher MSC than bus. Model 2 has much lower values for IVT and headway time (around 4 and 2.5 pence per minute respectively) than Model 11 (around 9 and 7.5 pence per minute respectively).

Study 2 continues to estimate a raft of models segmented by journey purpose and generic/specific specifications, with and without tram quality attributes. Results are far from clear, particularly for the mode specific models which yield many wrong sign coefficients and bizarre monetary valuations. It is very difficult to draw any strong conclusions from this work.The table below gives some indication of the variability of the results in terms of the estimation of the constants with and without the inclusion of the quality measures. Clearly the quality measures reduce the value of the constants, in many cases making them insignificantly different from zero.

Table 4.8: Tram MSCs From Segmentations from Study 2 (Croydon Tramlink)

Purpose	Specification	No Quality Bus MSC	No Quality Tram MSC	No Quality Tram pref	Quality Bus MSC	Quality Tram MSC	Quality Tram Pref
Overall	Generic						
Overall	ModSpec	-145	0	145	0	0	0
CA	Generic	-146	-77	69	-48	-25	23
NCA	Generic	0	0	0	0	0	0
CA	ModSpec	-210	0	210	0	0	0
NCA	ModSpec	0	0	0	0	0	0
CA Com	Generic	-144	-85	59	0	-46	-46
NCA Com	Generic	0	0	0	0	0	0
CA Com	ModSpec	-281	0	281	0	0	0
NCA Com	ModSpec	0	0	0	0	0	0
CA Shop	Generic	-172	-93	79	-63	-31	32
NCA Shop	Generic	-20	0	20	0	0	0
CA Shop	ModSpec	-384	-171	213	-174	0	174
NCA Shop	ModSpec	0	0	0	0	0	0
CA Oth	Generic	-112	-45	67	-75	0	75
NCA Oth	Generic	0	0	0	0	0	0
CA Oth	ModSpec	0	0	0	0	0	0
NCA Oth	ModSpec	0	0	0	0	0	0

Study 1: New Generation Transport in Leeds (SDG, 2008)

Study 1 was undertaken as part of demand forecasting work for an as yet unspecified major urban public transport scheme in a large city and assessing its business case. Integral to this was an SP model to estimate how travellers choose their travel mode and their willingness to pay for various attributes. Selection of these attributes was based on focus groups.

Whilst introducing a wide variety of attributes into the modeling, these attributes are described using the smallest 'reasonable' number of levels, in many cases two only. The authors argue that it is 'easier for respondents to understand the choice tasks (hence it leads to more reliable valuations). The main disadvantage of this approach is that when the valuations are later used for forecasting, they need to be adjusted to account for the fact that the improvement is more modest than that presented in the questionnaire.' Exercises with a small number of levels may not introduce enough variability to capture the complexities of individuals' preferences.

The SP exercise requires respondents to complete 4 different exercises, each of which is selected from 2 at random (giving a total of 8 exercises), in order to break up the coverage of the attributes. The first two exercises were pairwise mode specific choices intended to elicit the willingness to pay for certain service attributes and facilities. The third exercise deals with reliability and the final one a mode choice exercise. For car users there were variations in the mode used for a Park and Ride service. Four modes were used, standard bus, very modern bus (similar to FTR), trolleybus and tram.

Service quality attributes included:

- Lighting at the bus stop - 2 levels
- Shelter at the bus stop - 3 levels
- Passenger information at the stop and on board - 2 levels
- CCTV surveillance cameras at the stop and on board - 2 levels
- Space for luggage on board - 2 levels
- Whether a ticket machine is available at the stop - 2 levels

Reliability was included in terms of lateness and earliness at origin and destination, implemented via a range of possible arrival and departure times.

For car users, service quality attributes are not included but the following Park and Ride service components are included:

- Drive time to (entire journey in the car option, but only the journey to car park in the P&R option) - 4 levels
- Type of public transport vehicle (bus, trolleybus, tram, FTR) (P&R option only) - 4 levels
- Time on board the public transport vehicle (P&R option only) - 3 levels
- Return fare for the public transport vehicle (P&R option only) - 3 levels
- Cost of parking (car option only) - 3 levels
- Frequency of PT service from car park (P&R option only) - 3 levels

Other attributes included:

- Fare;
- Journey time (in-vehicle only)
- Frequency of service - 3 levels
- Walk time to stop -3 levels
- Vehicle Type (old style, modern bus, or FTR style bus) - 3 levels
- How the ticket is sold (by the driver or by a conductor) - 2 levels
- Type of ticket (paper ticket or electronic card) - 2 levels
- Level of crowding on board - 3 levels

Full models for choice are estimated for public transport users and car users, by pooling all the information from the 4 separate SP surveys. No consideration appears to be made of potential scale differences across the different SP studies that are pooled. Specification includes service attributes as different types of improvements, relative to a base, and interaction terms are used to model differences between journeys for different purposes. Time related attributes, reliability and crowding measured per minute, others measured as a one-off penalty per journey.

The first survey collected responses from 1,378 bus users and second one, from 262 car users. Significantly more females than males responded. The model for bus users yielded the valuations detailed in the table below, which correspond to the coefficients from the estimation. All estimated coefficients were found to be right sign significant, with exception of ticket sales by a conductor variable. The availability of ticket machine was found to be insignificant and dropped from the model. The model did not include constants for trolley bus and tram which did not add anything to the model. They claim this as an indication of the success of the model in that it has explicitly accounted for the various service attributes. This is a rather dubious claim given potential modal differences in ride quality, safety, comfort and noise levels amongst other attributes that were not included. This implies that they would not be significantly different to an Old bus type, which is the base here. The perception of these characteristics between bus and tram users in Study 11 was found to vary across these attributes as shown.

Table 4.9: Willingness to Pay for Various Attributes (NCA) for Study 1 (NGT)

Attribute	**Commuting trips**	**Trips on the employer's business**	**Other trip purposes**	**Value is in pence per…**
In-vehicle time when there is sufficient space to stand	-2.75	-6.33	-3.11	minute
In-vehicle time when standing in densely crowded conditions	-3.55	-7.33	-4.02	Minute
In-vehicle time when there are plenty of seating spaces	-2.41	-5.92	-2.73	Minute
Walk time	-3.13	-3.89	-3.55	Minute
Headway	-3.98	-4.94	-3.08	Minute
Lighting: from 'poor' to 'good'	25.57	-18.68	28.95	Journey
Shelter: from 'flag only' to 'new shelter with lots of space and nice design'	33.75	41.85	38.21	Journey
Shelter: from 'flag only' to 'standard shelter'	30.69	38.05	34.74	journey
Ticketing: from 'sold by driver' to 'sold by conductor'	-10.13	-12.55	-11.46	journey
Ticketing: from 'paper-based' to 'electronic ticket'	11.18	13.86	12.66	journey
Information: from 'like now' to 'advanced electronic display at stop and on-board'	24.57	30.46	27.81	journey
CCTV: from 'none' to 'CCTV at stop and on-board'	27.56	34.17	31.20	journey
Space for luggage: from 'none' to 'plenty'	9.44	11.70	10.69	journey
Mean earliness at the origin	-6.37	-21.02	-7.21	Minute
Mean lateness at the destination	-13.22	-16.39	-11.36	Minute
Bus type: from 'old' to 'very new'	13.39	16.60	15.16	Journey
Bus type: from 'old' to 'FTR'	10.01	12.42	11.34	Journey

Differences in shelter type and CCTV give the highest WTP values. But there is an issue with high WTP for these factors. For example if all improvements offered for other CA passengers, with bus type as well, amounts to over £1.60. Would people really be willing to pay 29 pence per journey for a better lighting? (Does the fact survey carried out in winter have any bearing on this?) This indicates that some sort of scaling of the package of quality attributes may have been appropriate.

The reliability of the service, the level of crowding on board, the level of lighting at the stop, and the information provided to passengers were also found to be important characteristics of the service.

The ticketing facilities available, the age of the vehicle and the availability of space for luggage on board contribute to the choice of a public transport service but to a lesser extent.

They found ‘strong evidence that whether the service is provided by a bus, trolleybus or tram is less important to travellers than other characteristics of the service. This adds considerably to the power of our models as a forecasting tool, since the outputs are not dependent on generic mode-specific constants.’
For car use models, following WTP values were derived.

T**able 4.10 WTP Values (CA) from Study 1 (NGT)**

Attribute	**Non-business trips**	**Business trips**	**Value is in pence per…**
In-vehicle time	-4.61	-8.6	minute
Headway	-6.00	-11.2	minute
Bus-based P&R constant with respect to car)	123.4	231.3	journey
FTR-based P&R constant (with respect to car)	95.3	178.6	journey
Trolleybus-based P&R constant (with respect to car)	107.1	200.7	journey
Tram-based P&R constant (with respect to car)	98.3	184.3	journey

Here the alternative specific constants have a bigger role as a full list of service attributes is not included. They suggest that constants for the various types of P&R journeys are positive, indicating the natural tendency is to prefer a journey by car. Values for travel time and headway by car users is higher than that of bus users and business travellers are twice as sensitive to these as those on other purposes.

Study 10: TfL Multi-Modal SP Study (TfLMMS), (SDG 2007)

Study 10 undertakes an SP exercise based on within-mode preferences for various quality attributes for a whole range of PT modes. Each respondent was given four pairwise SP exercises, three of which were 'attribute' exercises where respondents were asked to evaluate attributes specific to a given theme, and a fourth a 'factor' exercise where respondents chose between improvements to packages of attributes, including cost. Using the monetary valuations for the packages and the relative individual priorities, WTP estimates are derived for individual factors. The fieldwork was undertaken on 217 existing Tram users. Two Tram packages were included in the SP based on Tram Waiting & quality and the Tram Environment. The attributes included in the SP exercises were selected to be those expected to be of higher value to respondents, so far as we could judge in advance. Before the 'Attribute' SP exercise, each of the attributes was introduced. Respondents were asked to state what the level of provision was for each attribute on the particular journey that they described. The number of levels for each attribute varied between two and four.

Table 4.11 Tram Package Valuations - WTP(p) from Study 10 (TfLMMS)

Package	Attribute Level	Level - from	Level - to	WTP (p)
Tram Environment	Ventilation	Opening windows giving ventilation to some passengers	Air conditioning, circulating cool fresh air throughout the tram	2.4
		Opening windows giving ventilation to some passengers	Opening windows giving ventilation throughout the tram	1.3
	Wheelchair and buggy space	Dedicated area for wheelchairs and/or buggies or up to six people standing	Large dedicated area for wheelchairs and/or buggies or up to ten people standing, with fewer seats elsewhere	0.0
		Dedicated area for wheelchairs and/or buggies or up to six people standing	Dedicated area for wheelchairs and/or buggies or up to six people standing, with fewer seats elsewhere	-0.5
	Noise	Tram often produces intrusive rail noise during journey	Tram rarely produces intrusive rail noise during journey	2.9
Tram Quality and Waiting	Smoothness of driving	Jerky ride causing those standing to worry about losing their balance	Very smooth ride - no jerkiness	3.2
		Jerky ride causing those standing to worry about losing	Fairly smooth ride	2.9

	their balance		
Likelihood of being able to board tram	One day out of five you will not be able to board your tram	You are always able to board your tram	3.8
	One day out of five you will not be able to board your tram	One day out of twenty you will not be able to board your tram	0.4
Infrastructure	No separate lane (traffic on all sections)	Separate lane all of the time (no traffic)	3.2
	No separate lane (traffic on all sections)	Separate lane most of the time (traffic on some sections)	3.2
Service frequency	Trams run every 20 minutes	Trams run every 5 minutes	4.9
	Trams run every 20 minutes	Trams run every 10 minutes	4.3
Crowding	No seats available and very little standing room	Seats available	4.5
	No seats available and very little standing room	No seats available but plenty of standing room	2.2

The willingness to pay for changes in noise, service frequency, infrastructure, seating availability, smoothness of ride and boarding likelihood provide the highest values in this study.

<u>Study 12: Valuation of Station Facilities (VSF), SDG (2004)</u>

As part of recommendations for appraisal procedures for GMPTE, Study 12 establishes WTP on a number of attributes of station facilities for Bus, Rail and Tram. The initial list of priority attributes for each mode were identified by committee and then were taken forward in the form of two SP exercises for each respondent. Within each attribute various levels were identified. A third SP exercise to identify the capping value of the upper limit of the WTP estimates.

Respondents for the 3 different modes examined were recruited in areas where there were services running. There were a total of 448 bus, 116 rail and 135 tram respondents.

Responses to each of the first two SP exercises were analysed to provide estimates of within mode valuations of the attributes. The third SP located the upper cap limit, and the WTP values from the first two exercises were re-scaled so they totalled the maximum willingness to pay. An additional scaling was also undertaken, in proportion to the difference between the average fares in the sample and overall average fares for the region sampled. The following recommended WTP valuations were derived for tram

Table 4.12: WTP (p per journey) values for Quality Attributes for Study 12 (VSF)

Attribute	Attribute level	WTP per trip	WTP capped
Waiting Facilities	Basic shelter to Enclosed shelter	4.6	1.5
	Basic shelter to Continuous canopy shelter	12.7	5.3
	Basic shelter to Continuous canopy shelter with nearby kiosk	29.9	11.2
Station Car Park	None to Station car park, guaranteed space, free of charge	39.1	14.5
	None to “Secure” car park, guaranteed space, free of charge	40.3	15.2
	None to “Secure” car park, guaranteed space, £1 per day	35.7	13.3
Security Cameras	None to Recorded CCTV	49.5	18.2
	None to Recorded and Monitored CCTV	71.3	26.5
Service information	Poster timetables to Poster timetables and information point	10.4	3.9
	Poster timetables to Poster timetables and electronic display	21.9	7.9

4.3 Studies reporting Attitudes to Service Quality Factors

<u>Study 9: Sheffield and Rotherham Bus Rapid Transit Study (SRBRT), (MVA, 2008)</u>

Study 9 undertakes a similar approach to studies 2 and 11 in that mode choice is estimated in one SP and then another exercise seeks to identify the key ‘within’ mode attributes. This exercise was actually carried out with respect to BRT. This looked at just internal appearance, power supply and payment method, along with headway and IVT attributes. The resulting model implied payment to a ticket machine as opposed to a person is valued negatively to an additional 3.77 IVT minutes. Internal appearance of a French Light Rail vehicle was worth 2.15 IVT minutes compared to a First Group FTR interior and a Bombardier Metro vehicle. An electric power supply was valued positively by 3.46 IVT minutes over a diesel.

Additionally, and more usefully, individuals were asked to rate the importance of the following eight attributes of public transport systems on a one to ten scale. Reliability was rated as the most important factor in their decision making process, with frequency of service, journey time and fare considered to be important attributes. Internal appearance, comfort and power supply were of less importance, and external appearance was considered least important. There was a considerable sample size of between 440 and 538 respondents.

Table 4.13. Ranking of Ratings of Public Transport Attributes (N=440 to 538) from Study 9 (SRBRT)

Attribute	Ranking
Reliability	1
Frequency	2
Time	3
Fare	4
Internal appearance	5
Comfort	6
Power Supply	7
External appearance	8

Study3: West London Tram Project (MVA,2005)

The objective of this study was to 'derive up-to-date boarding penalties for Tram, articulated bus and conventional bus, in terms of generalised minutes relative to (conventional) bus, in a fixed and variable form'.

This took the form of two SP surveys amongst existing tram, conventional and articulated bus passengers in two areas, : Croydon – Wimbledon where both Tram and (ordinary) bus operate; and Peckham – Lewisham where both articulated and conventional bus operate. A separate SP exercise was conducted in each corridor with existing passengers of both modes. The surveying yielded 308 completed questionnaires in the Croydon – New Addington corridor (tram vs bus). 187 completed questionnaires in the Wandsworth – Lewisham corridor (articulated vs conventional bus).

To check the SP model was reporting consistent information, a direct (non-SP) trade-off question between tram and conventional bus was asked. Where a preference was given, respondents were asked to explain why they preferred one mode over another. Results are shown below:

Table 4.14. Reason for choosing preferred mode – percentage of total responses from Study 3 (West London Tram)

Respondents who preferred Bus		Respondents who preferred Tram	
More comfortable	16.3%	More reliable	41.2%
Less crowded	16.3%	More convenient	11.1%
More direct	16.3%	More spacious	8.9%
Cleaner	14.0%	More comfortable	8.9%
Better view	11.6%	Smoother ride	8.9%
Personal safety	9.3%	Better access	8.6%
More convenient	4.7%	Cleaner	5.5%
Better access	2.3%	Personal safety	2.8%
Easy to board and alight	2.3%	More direct	1.2%
More stops	2.3%	Better for environment	1.2%
Other	4.7%	Other	1.5%

Reasons for preferred mode differed between tram and bus. Reliability is the key reason for choosing tram against conventional bus, with convenience, spaciousness, comfort, ride quality and access all similarly important. The reasons for choosing bus are more diverse, with crowding, comfort and directness being key influences. Clearly people's perceptions vary depending on a variety of factors and circumstances.

In order to provide a single boarding penalty (ie MSC), the sample was weighted in accordance with estimates for current mode share within the corridor of interest.

Table 4.15: Weighted SP model of Tram versus Conventional Bus SP exercise

Variable	Coefficient	Adjusted t-stat	Value	Coefficient	Adjusted t-stat	Value
Generic IVT (mins)	-0.083	-11.7				
Tram IVT			-0.075			
Bus IVT			-0.09			
Headway (mins)	-0.189	-20.9	2.27	-0.187	-25.1	2.27
Boarding penalty	0.719	10.3	8.7	0.464	6.6	6.2

Null Loglikelihood = -2218.3; Model Loglikelihood = -1648.0; Rho-bar squared = 0.257

The SP models provide both mode-specific in-vehicle time parameters and a boarding penalty. However, they develop a simplified SP model that 'fixed' the bus in-vehicle time parameter to be 1.2 times that of the tram in-vehicle time parameter. Such a specification fits in better 'for modelling purposes'.

Attitudes towards different modes may vary between different user subgroups, so tests were carried out to identify any significant differences in boarding penalties by:

Peak/Off-peak Travel: The difference in the boarding penalties for the model segmented by peak and off-peak users was statistically insignificant,

Car availability: Car available users show a much significantly stronger preference in favour of tram over non-car available users (14.3 vs 6.5 mins).

No statistically significant impact on the boarding penalty when segmented by journey time (as stated by the respondent) was apparent, Journey purpose does not appear to have been investigated, or found significant.

4.4 Other Tram Studies

<u>Study 4: Edinburgh Tram Stated Preference Report (SDG, 2004)</u>

This study was based on a stated preference survey interviewing car and bus users in Edinburgh, to provide estimates of behavioural parameters to be used in a model forecasting demand and revenue associated with the introduction of a new tram network.

There were two SP exercises, a first stage within mode exercise to elicit values of walk, wait time, in-vehicle time and interchange penalties for bus users and value of time for car drivers.

The proposed tram service was described and then illustrated with interior and exterior photographs. The second SP exercise for bus users offered respondents a choice between their current mode and one by tram differing by in vehicle time and cost for non-concessionary passengers. For existing car passengers the exercise was concerned with a comparison between a car journey into the city centre and a park and ride with tram option.

Demographic information was collected to see if valuation of attributes varied by segments.

Respondents were in scope for the computerized interview if they had made a trip on the bus or by car into Edinburgh city centre within the last month originating in areas within reasonable distance to the proposed tramlines 1 and 2. After cleaning the dataset there were 188 paying bus users, 111 concessionary bus users and 156 car users.

Table 4.16: Results from Study 4 (Edinburgh Tram)

	Bus			Bus concessionary		Car Park and Ride		
	Coeff	T-stat	Value (p)	Coeff	T-stat	Coeff	T-stat	Value (p)
IVT	-0.193	-8.4	4.5					
Bus IVT				-0.149	-8.3			
Tram IVT				-0.152	-10.5	-0.088	-7.39	6.97
Car IVT						-0.082	-4.22	6.48
Fare	-0.043	-9.4				-0.013	-6.35	
Tram ASC	0.463	4.3	10.8					
Wait/Car IVT						-0.013	-6.35	

The results seem at odds with other studies. They suggest a low ASC for existing paying bus passengers, and in the other two models where no ASC was estimable, the differences in mode specific values of time were not significant. A model for mode specific IVT was also estimated. Segmentations for journey purpose, time of journey, car availability did not yield any significant differences in valuations. However, respondents' current perception of tram did influence the results, with people who thought tram was a bad idea having higher values of time on the tram than the bus. With respect to current journey length for Car users they found the weight on wait time varied by the time of current journey.

Study 6: South Hampshire Rapid Transit SP Study (SDG,2003)
This study aimed to obtain current estimations of the value of in-vehicle time, walk and wait time and mode constants of light rail relative to existing modes in the areas of the proposed route for SHRT, ie Portsmouth, Fareham and Gosport.

Service Quality Attributes were included implicitly, through the description of the vehicle. Although final design ‘not decided’, the interior was to be ‘like a modern bus’ with mention of improved:

- Ride quality (ie quieter and smoother)
- In vehicle Information
- Noise level inside the vehicle
- Pavement level boarding
- Ticket machines

No mentions of differences in reliability or waiting environment were included.

This study uses a two-stage approach with a first stage uses a VOT SP exercise to elicit values of time, and secondly a Mode Choice SP exercise to derive Tram MSCs. There were two SP model designs – for existing Car users and PT users

Respondents were recruited from Portsmouth, Fareham and Gosport and categorised into trip type:

- Cross Harbour (CH) use ferry to travel cross harbour either to or from Portsmouth
- Those travelling on the peninsula between Fareham and Gosport and surrounding areas (P)
- Those travelling all the way round the harbour either to or from Portsmouth (RH)

The VOT exercise includes Time, Cost and a Ferry Constant, segmented by trip type A total sample of 568 interviews were collected including, 286 bus users, 282 car drivers. Primary quotas were for peak/off peak and Bus/Car with secondary quotas for trip type and trip length.

After the respondent had been familiarised with the tram scheme they were presented with the mode-choice SP exercise. The objective of the mode-choice experiment was to establish the value of walk time, headway minutes and relative weights together with mode constants.
The experiment was designed around a choice between an existing journey and an alternative involving the proposed tram system. Different experimental designs were devised for car and bus users. A separate design was used for car users travelling across the harbour (ie using ferry) as opposed to those travelling around the harbour

Interestingly there were many non-traders, ie respondents who always chose the LRT, 'since there is significant enthusiasm for the scheme in the area, thus it proved difficult to gain unbiased valuations of the scheme.'

As such, only 389 respondents remained in the mode choice analysis (219 bus and 171 car).
The pooled results obtained for car and bus users are shown below, the following utility specification was used. Again, the cross and round harbour designs were pooled together without consideration for different scales.

Table 4.17: Study 6 Results

	Car Users			Bus			
	Coeff	T-stat	Value (p)	Coeff	T-stat	Value (p) peak	Value (p) Off-peak
Journey time	-0.05	-6.7	8.9	-0.05	-3.7	3.3	1.9
Journey time (Peak)				-0.04	-2.3		
Cost	-0.56	-6.9		-2.55	-8.0		
Headway	-0.08	6.0	1.6	-0.05	-7.6	1.8	1.8
Walk time	-0.09	-7.6	1.7	-0.09	-10.8	3.4	3.4
Light Rail vs Bus	0.39	3.4	69.6	0.34	3.8	13.3	13.3
Bus vs Car/Ferry	2.26	7.6					
Bus vs Car	-0.63	-2.8					

Results indicate strong preference amongst car drivers for light rail over bus, around 70 p per journey, and a much lower, but significant value of 13p per journey for Bus users. Higher values of time were found in the peak.

Study 7: Mersey Tram Stated Preference Research (SDG,2002)

The objective of this stated preference (SP) exercise was to provide data on local travel preferences given the introduction of Merseytram in one or more corridors within Merseyside. A survey of Merseyside bus users and car users was undertaken to collect SP choice data and associated data on travellers and their journeys. A computerised questionnaire was presented to respondents in hall-based interviews. The data was analysed to provide estimates of the values of time and other mode choice parameters needed for demand forecasting.

The SP questionnaire was customised on a recent, in-scope, reference trip by bus or car. There were two SP exercises, a within-mode SP with simple trade-offs of time and cost and a mode choice SP where the existing mode was given as a competing option to the Tram with access and egress time, service frequency, in-vehicle time included as attributes. There were four different versions of the mode-choice SP exercise, with customised designs corresponding to the mode used in the reference trip (bus or car), whether they paid for their fare (bus travellers) and whether their trip was from within the walk catchment of the proposed Merseytram lines (car travellers).

Each stated preference exercise was introduced with a description of the context, the choice alternatives, and the attributes used in the description of each alternative. Photographs were used to illustrate the alternatives and certain attributes. The choice exercises were based on formal experimental designs which allow the relative importance of each attribute to be estimated.

In total 689 valid responses were garnered, with 161 for the paid Bus vs tram exercise, 82 for the concessionary fares exercise, 316 for the short distance car travelers exercise and 130 for the car park and ride exercise.

Results from the SP modeling are shown in Table 4.18. For both car models, there are relatively low (and insignificant in the case of Park and Ride) constant in favour of car over bus - The residual benefits of car over public transport have been reduced by the effects of respondents consistently refusing to pay higher parking charges.

Table 4.18: Study 7 (Mersey Tram) Results

	Bus			Bus conc		Car Short Distance paid/free parking			Car Park and Ride		
	Coeff	T value	Value p/min	Coeff	T value	Coeff	T value	Value p/min	Coeff	T value	Value p/min
IVT (mins)	-.070	-7.0	Peak; 3, Off;2.4	-.104	-6.7	-0.109	-6.3	3.7 (paid) 4.3 (free)	-0.069	-4.4	6.3
Paid parking dummy (IVT)						0.055	2.4				
Walk	-0.077	-8.5	1.1	-0.196	-6.4	-0.149	-10.0	1.1 (paid) 1.4 (free)	-0.103	-5.0	1.5
Paid parking dummy (walk)						0.088	4.6				
Headway	-0.046	-5.9	0.7	-0.078	-5.6	-0.091	-4.5	0.9 (paid)	-0.044	-2.2	0.6
Paid parking dummy (headway)						0.043	1.8	0.8 (free)			
Cost	-2.905	-12.4							-1.097	-4.4	
Cost AM	0.604	2.6									
Merseytram (Over bus)	0.761	3.7	26 (p)	0.862	4.85	1.056	9.6	19.6(paid) 9.7 (free)	0.515	2.1	46.9
Car Constant (Over bus)						0.64 1	2.6	19.1(paid) 5.9 (free)	0.380	1.4	34.6

The extra benefits perceived in the Merseytram option relative to bus for Car users were lower than for other segments, with an average equivalent time-saving of only 7.5 minutes.

The value of times for the Car Park and Ride models were higher than those of the other models and a separate within-mode Value of time exercise. This is attributed to 'the competitive position of the mode being confounded with the mode constant…the relatively high value of time [that] would suggest that people were quite willing to pay for the extra speed of travelling by car.

The authors recommend that the value of time from the Value of Time exercise should be used, together with the relative weights of walk time and headway, and the constant for Merseytram. For the short-distance car exercise, they recommend the mode constant for car be calibrated so that the choice model as a whole produces estimates that are consistent with real modal market shares.

Conductors and Crowding SP exercise

An additional small SP exercise was conducted to evaluate preferences of conductors over ticket machines and of the dislike of crowding. Results showed the average traveller values a service with conductors rather than ticket machines as equivalent to a 2.6 minute journey time saving. They found much variance by age and gender, with more elderly females valuing a conductor as high as 10.1 minutes. As compared to a 125% seated loading, on average a 100% load would be worth a 5.3 minute saving, a 50% load an 8.6 minute saving and a 6% load a 9.5 minute saving. There was also oddly a constant for a faster alternative with an even higher load which was impossible to interpret given the confounding of two effects.

Study 5: Leeds Supertram Stated Preference Research (SDG, 2001)

This formed part of the work to undertake demand and revenue forecasts for the proposed Supertram scheme in Leeds. The objective was to provide generalised cost parameters for a series of mode choice models used to forecast transfer from existing modes (car, bus and rail) to the proposed tram service.

Computerised interviews were held with people who had made a recent journey by car, bus or train into Leeds City Centre from a variety of origins around the city. Over 900 completed interviews were collected. Each respondent completed within-mode SP exercise offering choices between two journeys by existing mode. A second SP mode choice exercise offered choices between modes they had used and an alternative mode, ie Supertram.

Supertram was described as having improved reliability, faster journey times and a good ride quality. Vehicles were described as clean, air conditioned and having room for buggies and wheelchairs. Street level boarding, tickets sold from machines and electronic displays at stops give times of next vehicle. Park and ride schemes were described as signposted from roads, assisted by a marshal with a short walk to a nearby tram stop.

Respondents were allocated to one of four mode-choice SP exercises:

- Bus vs Supertram (local)
- Car vs Supertram or Existing Bus (local trips)
- Car vs Park and Ride using Supertram (longer distance trips); and
- Rail vs Park and Ride using Supertram (longer distance trips)

Results are shown in Tables 4.19a,b and c.

Table 4.19a: Study 5 Results for Bus Users

	Bus users AM peak			Bus users interpeak		
Parameter	Value	T-Stat	Valuation	Value	T-Stat	Valuation
Access Time	-0.133	-5.7	5.03p/min	-0.118	-5.3	3.13p/min
Headway	-0.055	-1.2	2.09p/min	-0.144	-3.2	3.80p/min
Journey time	-0.098	-4.4	3.70p/min	-0.140	-6.7	3.72p/min
Fare	-2.64	-2.6		-3.78	-5.2	
Mode constant CA	-1.83	-3.4	19 mins	-1.11	-2.2	8mins
Mode Constant CNA	-1.88	-3.6	19 mins	-1.93	-3.9	14mins

Table 4.19b: Study 5 Results for Rail Users

	Railusers AM peak			Rail users interpeak		
Parameter	Value	T-Stat	Valuation	Value	T-Stat	Valuation
Walk Access Time	0.032	1.7		-0.034	-2.4	7.4p/min
Motorised access time	-0.045	-5.1	8.6p/min	-0.033	-2.4	7.2p/min
Headway	-0.039	-5.4	7.4p/min	-0.022	-3.2	5.0p/min
Journey time	-0.038	-5.2	7.2p/min	-0.033	-5.4	7.2p/min
Cost	-0.527	-7.9				
Egress time	-0.110	-7.0	20.8p/min	-0.452	-6.9	
Mode Constant	-1.24	-6.3	33 mins	-1.312	-6.7	40 mins

Table 4.19c: Study 5 Results for Car Users

	Car Local AM peak			Car Local Interpeak		
Parameter	Value	T-Stat	Valuation	Value	T-Stat	Valuation
IVT	-0.023	-1.1	5.6p/min	-0.032	-1.7	5.9p/min
Walk time	-0.044	-4.2	10.8p/min	-0.042	-3.7	7.9p/min
Headway	0.006	0.1	-			
Journey cost	-0.404	-10.8		-0.537	-9.8	
Car-PT constant	0.854	2.1	38 mins	0.542	3.5	17 mins
Bus-Tram Constant	0.342	1.9	15 mins	0.461	2.8	15 mins

<u>Study 8: Midland Metro Extension (MVA, 2007)</u>

This study investigated modal preferences between tram and BRT to inform the modelling and appraisal work for the Phase 2 Midland Metro schemes.

There were two designs for the experiments, one for fare paying public transport users and (pt using) car drivers and the other for non-fare paying public transport users. It seems strange that car drivers were not given car as an option. Respondents included 185 existing Metro users, 150 Bus users and 133 car drivers with recent public transport experience. For public transport users, SP exercises were presented as a number of pair-wise choices, pivoted around the existing journey. Analysis of the SP results was undertaken for five different market segments:

- Fare paying Metro users
- Non-fare paying Metro users
- Car drivers
- Fare paying bus users
- Non-fare paying bus users

The tables below detail the results.

Table 4.20a: Results from Study 8 for Non-concessionary travellers

	Metro fare payers			Bus fare payers			Car Drivers		
Parameter	Coeff	T-stat	Value	Coeff	T-Stat	Value	Coeff	T-Stat	Value
Existing Tram vs Bus	1.286	8.8	11.8 min	0.640	4.2	6.3min	1.48	8.8	9.9min
New Tram vs Bus	1.545	6.8	14.1 min	1.289	5.1	12.7min	1.673	6.7	11.2min
BRT vs Bus	1.120	6.9	10.3 min	0.424	2.8	4.2 min	0.405	2.9	2.7min
IVT	-0.109	-11.1	3.8p/min	-0.101	-9.2	2.4p/min	-0.149	-13.7	4.5p/min
Fare	-0.028	-8.7		-0.403	-10.9		-0.033	-9.5	6.7p/min
Headway	-0.182	-10.5	6.4p/min	-0.190	-9.5	4.5p/min	-0.224	-12.0	6.7p/min

Table 4.20b: Results from Study 8 for Concessionary travellers

	Metro non fare payers			Bus non-fare payers		
Parameter	Coeff	T-stat	Value	Coeff	T-Stat	Valuation
Existing Tram vs Bus	1.118	3.8	32.1min	-0.074	-0.2	
New Tram vs Bus	1.279	2.9	36.8min	-0.438	-0.9	
BRT vs Bus	0.005	0.0		0.580	2.0	7.3min
IVT	-0.035	-1.8		-0.079	-3.7	
Headway	-0.124	-4.4		-0.178	-5.2	

Although results vary across segments it seems clear that the new tram has a consistently higher MSC than existing tram and BRT. Highest values for constants are found amongst the Metro non-fare payers, although these results are recommended to be treated with caution due to the small sample size (40 respondents). Existing Metro users have higher constants than paying Bus users and Car users

An aggregate model is also estimated using a random parameter model (mixed logit). Based on these results, the study reports a mode constant (relative to bus) for

- Existing Metro: mode constant of 9.8 minutes
- New Metro: mode constant of 12.8 minutes
- Bus Rapid Transit: mode constant of 5.0 minutes

4.5 Studies from Overseas.

Whilst we do not have access to consultancy reports from overseas, there are a number of academic papers which we have accessed. Litman (2008) argues that conventional planning practices overlook and undervalue service quality impacts, and that often public transit is provided at a basic level with no option to pay extra for higher quality transport – such improvements are only made if planners can make a case for them. Highlighting comfort of vehicles, reduced crowding, nicer stations, improved walkability, better user information, improved security and marketing and promotion.

As highlighted by Litman (2008), service quality improvements will benefit existing passengers, new passengers, reduce traffic problems, provide scale economies from a cycle of improved service and increased patronage and increased fare revenue.

Caulfield and Mohoney (2007) examined factors influencing preferences for real time public transport information using SP methods on a sample of 495 individuals who work in Dublin city centre and as such covered a number of modes, with a total 0f 52% using public transport modes including Light Rail, Bus and Rail. They look at information provision at three stages: firstly at the pre-trip planning stage from home where the choice was between call centre, website or SMS, secondly at their transit stop/station via stop PID, call centre or SMS, and thirdly at their place of work via call centre, website or SMS. Although willingness-to-pay estimates were not derived they found that SMS was the most useful source of information at the first and third stage, with PID being the most useful at the second stage.

Dziekan and Vermeulen (2006) look at the psychological effects of design preferences for real-time information displays located at stops and stations, using a case study of the newly implemented traveller information on tramline 15 in the Hague, Netherlands. Systems displaying the next departure time can reduce anxiety and 'cognitive effort', reducing perceived or actual wait time in situations where travellers can complete another task once furnished with the information. One month before and 3 and 16 months after implementation the same sample of travellers completed a questionnaire. They found that perceived wait time decreased by some 20%, around 1 minute, while no effects on security or ease of use were found. Displays perpendicular to the tracks separate from the shelter were ranked highest.

4.6 Revealed Preference (RP) Models

Study 1 cites the example of SP studies sometimes overestimating the willingness of car users to switch to public transport. The RP-based scaling parameters for the high-level choice between car and public transport are therefore meant to ensure that the propensity of mode switching is realistic. However, the derivation of parameters from RP data is not included in included in their report.

Study 2 talks about Model validation tests being undertaken to examine the performance of the model at some future date.

We only found 2 actual examples of the application of RP in Studies 3 and 11.

Study 3 collected RP data from conventional bus, articulated bus and tram passengers and estimate a revealed preference model to ‘examine and calibrate the relationship between
choice of existing mode and the travel costs of both the existing mode and alternative mode’

A simplified generalised cost formulation was developed comprising of the stated access times, wait times, in vehicle times and egress times for the travellers’ existing mode and the alternative mode available for the journey. The approach taken appears rather unsatisfactory and arbitrary. For the alternative mode ‘the expected wait time was inferred from the alternative mode expected service headway and both stated headway and stated wait time for the existing mode. Access and egress times were allocated suitable values within the ranges obtained from the survey questionnaire.’ This suggests the RP data was not exactly Revealed, but partially inferred.

The calibrated models presented are based on a regression method (least squares) to generate the model scaling parameter and modal constant to best fit the revealed data. This is based on an unweighted calibration of total demand allocated to generalized cost differences bands.

In the model formulation the modal constant is effectively added to the bus cost. The calibration identifies a positive modal constant for the model of between 2-3.2 minutes, suggesting that tram is favoured over conventional bus when generalised costs are equal and tram modal share from the model is around 56-60%.

This work is not used to develop forecasts, and is based on observed market shares within the choice sample, so its transferability would be limited. However, the results offer some support to the SP estimates of a positive boarding penalty for tram of around 6 minutes. They do qualify their RP findings as to be ‘regarded as indicative only, since there is limited data available from the small sample, by RP standards.’

Study 11 also included an RP element, given data was collected on alternative modes available. This data was used to estimate a hybrid model to get over the problems associated with using SP models for forecasting, due to the scale factor problem. The RP modal constants are very high. For that reason the authors recommend dropping the quality measures, despite the fact they are significant. Again access/egress was insignificant. They recommend instead using the wait time parameter for access/egress. They also present models for car and non-car availability. The usability of all these models for forecasting is conditional on having real market share information on which the MSCs can be recalibrated- data for estimation of these models are collected from a choice based rather than a random sample. For this reason, a comparison of the forecasting ability of the SP vs RP models is not feasible.

4.7 Bus Rapid Transit Schemes Quality Attributes

Table 4.21 shows the results from the Stated Preference and transfer price exercises carried out amongst car drivers and bus passengers travelling along urban radial corridors in Birmingham and Leeds. This was undertaken as part of the UK Bus Priorities Study and referred to here as Study 13. Only bus and car travel are considered in the survey. The SP exercise aimed to produce individual valuations for specific quality improvements as well as a separate valuation for the package as a whole. Results for the individual and package valuations are relatively consistent although bus users surprisingly seemed to value the package more highly than the sum of the attributes.

Bus users put the highest value on a polite, helpful and cheerful driver (9.5p per trip), followed by route and timetable information at stops (8.1p per trip). CCTV at stops and on buses had the lowest value of all attributes tested (5.7p per trip). However, the absolute differences are relatively small. Car drivers valued reliability the most (100.6p per trip) followed by CCTV and polite, helpful and cheerful drivers (93.6p and 92p, respectively).

The transfer price exercise aimed to determine explicitly (as opposed to via SP choices) what the maximum willingness to pay would be for a package of improvements. The package of improvements used in the transfer price exercise was not strictly the same as that used in the SP exercise so the results are not entirely comparable. Still, assuming that the transfer price package subsumed all of the improvements in the SP exercise, bus users valuations seem to be inflated by at least 30%. Strikingly, car user SP valuations are about 9 times higher than the results suggested by the transfer price exercise.

In presenting the figures show individual valuations scaled down by the ratio between the transfer price cap and the package valuation.

Table 4.22 shows the results of the combined analysis of SP and ranking responses obtained from the CityMobil BRT study undertaken in 2008, referred to as Study 14. This used an online survey and a questionnaire handed out in Leeds amongst car drivers and public transport users. The right-most column gives a scaled WTP assuming that the maximum WTP for the whole set of improvements included in the exercise is similar to that obtained through transfer pricing in Study 13. The driverless vehicle feature is excluded from this calculation as it seems to have a negative value to respondents (possibly associated to the fact that this is perceived as absence of driver (which was shown to have a positive value in other studies) rather than a smoother ride.

Results show that the highest value is placed on the existence of a bus lane along whole length of route (taken as a proxy for reliability) closely followed by real time information at stops (7.6p and 7.4p per trip respectively). These results are not entirely consistent with those of study 13 (4.6 – 12p for reliability; 5.5p for real time information) but are of the same order of magnitude. One does need to bear in mind, however, that results from study 14 are scaled using the maximum WTP obtained in Study 13.

The remaining attributes are given a much lower value (CCTV – 3.6p; off-vehicle fare collection – partly a proxy for reliability – 4.3p; real time on-board information – 3.4p; hybrid engines – proxy for smoother ride – 3.8p). The results for CCTV are lower than for study 13 and much lower than for the other studies previously analysed. The results for driving quality (hybrid engines) are similar to those of study 10 but the other variables cannot really be compared.

Table 4.21a: WTP Estimates from Study 13: (The UK Bus Priorities study) (2008 prices): Car

Attribute	**Attribute level**	**WTP per trip**	**WTP capped**
	Study 13 (2001) – L E K – car drivers large urban radials		
CCTV	From no CCTV to CCTV on all buses	87.9	10.5
	CCTV at all stops and on all buses	93.6	11.2
Reliability	From current reliability to buses always arrive to schedule	100.6	12.0
Information:	From no information to timetable and route maps at stops	47.3	5.7
	From no information to real time information at stops	46.0	5.5
Behaviour of driver:	From driver is not very helpful to driver is quite polite and helpful	64.8	7.8
	From driver is not very helpful to driver is very polite, helpful and cheerful	92.0	11.0
Package at maximum level			327.2
Transfer price cap			39.0

Table 4.21b: WTP Estimates from Study 13: (The UK Bus Priorities study) (2008 prices): Bus

	Study 13 (2001) – L E K – bus passengers large urban radials		
CCTV	CCTV at all stops and on all buses	5.7	4.3
Reliability	From current reliability to buses always arrive to schedule	6.1	4.6
Information:	From no information to timetable and route maps at stops	8.1	6.2
	From no information to real time information at stops	7.3	5.5
Behaviour of driver:	From driver is not very helpful to driver is quite polite and helpful	7.4	5.6
	From driver is not very helpful to driver is very polite, helpful and cheerful	9.5	7.2
Package at maximum level			39.0
Transfer price cap			29.7

Table 4.22: WTP Estimates from the CityMobil BRT study (2008 prices)

Attribute	**Attribute level**	**WTP per trip**	**WTP capped**
	Study 14 (2008) – CityMobil		
CCTV	CCTV on all buses	14.9	3.6
Reliability	off-vehicle fare collection	18.2	4.3
	Bus lane over the entire length of journey	31.7	7.6
Information:	Real time information at stops	30.7	7.4
	Real time information on board vehicles	14.0	3.4
Ride quality:	Hybrid engines	15.7	3.8
Driver presence:	Driverless vehicles (smoother ride)	-6.7	-
Transfer price cap (taken from study 13)			29.7

4.8: Synthesis of Results and Summary

Table 4.23: Synthesis of Studies providing WTP values

Mode	Tram	Tram	Tram/BRT	Tram	PT	Bus	Bus	BRT
Study no.	2	11	9	12	1	13	13	14
Study name	Croydon	MMMS	Sheff/ Rotherham BRT	VSF	NGT	LEK Car users	LEK Bus users	CityMobil
V1.Ride Quality	6	9	3					
V2.Comfort (seating)	7							
V3.Seating Availability/ Crowding	5	6	1					
V4.In vehicle Safety eg CCTV	3	3				2	4	5
V5.In-Vehicle Noise	9	5	5					
V6.Ease of alighting	2							
V7.Information						4	2	6
V8.Luggage/buggy space			7		7			
V9.Cleaner								
V10.Ventilation			6					
V11. Internal appearance								
S1.Reliability	4				4	1	3	
S2.Waiting Environment	8	4		3	1			
S3.Comfort								
S4.Information				4	4			2
S5.Ticket machine					6			3
S6.Lighting					3			
S7.Traffic priority/own lane			3					1
S8.Overhead electric wiring								
S9.Security/CCTV at stop	1	1		1	2	2	4	
S10.Image								
S11.Convenience								
S12.Ease of Understanding network/getting information		10						
S13.Environmentally Friendly								4
S14.Conductor								
S15.Able to board tram			2					
S16. Car Parking				2				
S17. Staff Attitude		2				3	1	

Table 4.23 presents a ranking of the WTP values within each study where they were estimated. We have split the factors into service (S) and Vehicle (V) related factors. This requires a health warning, as of course there is no particular consistency of the attributes, and indeed the levels, offered between studies, except for Studies 2 and 11. Studies 2, 10,11 and 12 report WTPs for Tram based surveys, 1 for an unspecified public transport option, 13 for bus and 14 for BRT. Given the inconsistency in dealing with the package nature of these attributes across studies, it is more sensible to consider the importance given to particular attributes as indicated by their ranking rather than absolute comparisons of values.

Table 4.23 highlights the disparate nature of the coverage of soft factors across studies. We have highlighted those factors which come above halfway in the rankings to get some visual indication of any consistency in the reported relativities. Factors such as Ride quality, Noise and Reliability, Comfort and Seating availability would have seemed to be integral to the benefits a Tram system could confer, at least over existing PT options, but they are not always presented to respondents.

Individuals are willing to pay relatively high amounts to ensure security at the waiting environment and in the tram. Quality of waiting environment, staff attitude and traffic priority/own lane attract a relatively high WTP when featured.

Table 4.24 presents rankings from attitudes to the important quality attributes featured in public transport, as featured in Studies 2,9 and 11. This shows that personal safety and security are of paramount concern when considering transport options. These also emerge as the largest components of the ‘unpacked’ constant in Study 11. Reliability, ease of access and quality of waiting environment also emerge as important attributes.

In terms of the performance of tram against other modes, Study 11 throws some light on this. It found tram performs better than bus on most of the quality attributes featured, but particularly so for ride quality and reliability. Study 3 asked respondents the reasons for choosing their preferred mode. Reliability again emerged as by far the most common reason for preferring tram over bus, with convenience, comfort, ride quality and access emerging as important too.

Table 4.24: Public Quality Ranking of Factors

Table 4.24: Attitudes to Public Transport Quality Attributes: Ranking of important factors

Mode	Tram	Tram	Tram / BRT
Study no.	2	11	9
Study Name	Croydon	MMMS	Sheff / Rotherham BRT
V1. Ride Quality	11	9	
V2. Comfort (seating	7	3	3
V3. Seating Availability / Crowding	11	4	
V4. In Vehicle Safety e.g. CCTV	1	1	
V5. In-Vehicle Noise	13	9	
V6. Ease of alighting	3	5	
V.11 Internal appearance			2
S1. Reliability	9	2	1
S2. Waiting Environment	2		
S9. Security / CC	2		
S10. Image / appearance	15	10	5
S12. Ease of Understanding network / getting information	5	5	
S13. Environmentally Friendly	10	4	4
S17. Staff Attitude	5		
S18. Visibility of Staff	7		

5. Quantitative Analysis of SP Based Studies

5.1 Introduction

The analysis presented is based on the 10 post 2000 tram focussed studies shown in Table 5.1. All values are expressed in minutes, as this allows us to compare easily across years, use values from concessionary studies and utilise the results from Study 3 (West London Tram) which did not include fare as a variable.

All these studies capture the attractiveness of one mode over another in terms of the mode or specific constant (MSC).

5.2 Tram vs Bus MSC valuations

In referring to a Tram MSC we are referring to a constant used in the discrete choice analysis of Stated Preference surveys which captures the preference of a Tram/Light Rail scheme over a 'normal' (ie not BRT) Bus scheme. Values are in pence per journey unless otherwise specified.

Given the large variation in the studies in terms of existing modal choices, region, differing journey purpose, population composition etc, where possible we have included the most disaggregated versions of the models to provide the most number of valuations.

We might also expect the value of time to be influenced by mode. Thus the value of time might be expected to be lower on Tram than conventional bus and unless controlled for, these differentials would impact on the constant. Where possible we have focussed on specifications of the models which used generic values of time. Whilst this is a simplification, only 3 studies actually included models with mode specific journey time related parameters. In Study 4, this left the MSC for Tram insignificant. In Study 2, whilst mode specific and generic parameters were estimated, for some of the segmented models the mode specific values were insignificant and counter intuitive. Model 9 did not estimate an MSC and mode specific parameters simultaneously. It would seem difficult to identify models which can successfully elicit valuations for mode specific MSCs and journey time parameters – clearly there will be significant correlations between the estimates. Also, for the purpose of comparability, we focus on models which do not seek to identify the quality related attributes separately from the MSCs.

In Table 5.1 below we present measures of average MSCs over all our studies, and by different segmentations and also by the different studies themselves. We have an overall meta-sample of 4733 individuals, taken over 10 studies, from which we identified 33 sub studies, selected so that the models/segmentations are mutually exclusive. We present three measures of average valuations, firstly the mean weighted by the number of individuals sampled, the second the mean unweighted by size of sample and the third an unweighted median value.

The overall average Tram MSC, ie modal preference over bus, was 10.6 minutes of journey time, with a median of 8.6, indicating some skew from higher upper values. The valuations vary wildly between 2.4 minutes for Edinburgh (Study 4) and 23.4 minutes for Leeds Supertram (Study 5). We present segmentations by:

- Car Availability (CA);
- time of day,
- whether the sub-study focussed exclusively on concessionary passengers
- whether there was an existing tram scheme in place (so that valuations may be interpreted as more realistic, being based on some experience of existing systems),
- whether the scheme included a park and ride facility and
- whether the scheme was based in London.

Table 5.1 Tram preference over Bus by Study and Segmentation

	Weighted Mean Tram MSC over Bus (mins)	Unweighted Mean	Unweighted Median	n	Studies	Sub studies
All	10.6	9.9	8.6	4733	33	33
1.NGT	5.4					2
2.Croydon Tram	11.6					4
3.West London Tram	8.5					2
4. Edinburgh	2.4					1
5. Supertram	23.4					8
6. S.Hants	6.4					3
7. Mersey Tram	11.7					6
8 Centro/Metro	14.6					4
9. Shef/Roth BRT	6.4					1
11. Midland MMS	8.8					2
Car Available (CA)	12.9	14.6	14.2	2387	8	17
Non-Car Available (NCA)	8.8	11.0	10.6	1790	8	15
Peak	15.4	16.8	16.9	485	3	6
Off-Peak	16.3	15.8	12.4	458	3	6
Existing LRT	9.7	12.2	11.2	2641	5	13
No LRT	11.7	13.1	10.3	2092	5	20
London	10.6	9.8	10.3	813	2	6
Non-London	10.6	13.4	10.9	3920	8	27
Park and Ride	25.1	26.7	32.6	330	2	3
Concessionary	15.9	22.6	22.6	112	2	2

There was a clearly larger value for the Tram MSC over bus for those with Car availability – in most cases car drivers/passengers. This is probably due to the innate dislike amongst these people of the existing bus option. There was surprisingly little evidence of differences by peak/off-peak and by existing LRT/no LRT. The valuations for London, (although based on only two studies) suggested little difference here either. Values for Park and Ride facilities were considerably higher, probably due to the longer distances of these trips and the dislike amongst existing car drivers of bus.

Table 5.2 shows more detail for the CA vs NCA models. Studies 2, 4, 6 and 7 and 11 show consistently higher values for the CA segmentations.

Table 5.2 Studies considering Car Availability

	Other segmentation	NCA	n	CA	n
Study 1	All			5.4	*262*
Study 3	All	6.5	*190*	14.3	*64*
Study 2	Shopping	4.0	*120*	15.6	*242*
	Other	4.2	*61*	14.2	*136*
Study 4	Other/Bus	2.4	*188*		
Study 5	PeakBus	19.2	*34*	18.8	*54*
	Off-Peak/Bus	13.8	*38*	7.8	*63*
	PeakCar Local			15.1	*92*
	Off-Peak/Car Local			15.0	*15*
	PeakCar Non-Local			32.7	*94*
	Off-Peak/Car Non-Local			40.0	*106*
Study 6	Peak/Bus Travellers	4.0	*137*		
	Off-Peak/Bus Travellers	7.0	*149*		
	Car Travellers			7.8	*171*
Study 7	Peak	10.9	*74*		
	Off-Peak	10.9	*87*		
	Car Travellers			19.6	*157*
	Car Travellers Free parking			9.7	*159*
	Car Travellers PR			7.5	*130*
Study 8	Tram passengers	4.0	*127*		
	Bus Passengers	2.5	*96*		
	Car Travellers			4.7	*126*
Study 11	All	14.1	*516*	8.1	*377*

Clearly Studies 2 and 3 show higher CA values than NCA, but the opposite is found in Study 11. Studies 6 and 8 have similar values and Study 1 only has CA values.

Table 5.3 shows more detail for the Peak vs Off-peak models. Here it is hard to establish any consistent pattern of valuations over the studies.

Table 5.3 Studies Considering Peak and Off-Peak segmentations

	Other segmentation	Peak	n	Off Peak	n
Study 5	Car Drivers	15.1	*92*	15.0	*15*
	CA/Bus Users	18.8	*54*	7.8	*63*
	NCA/Bus Users	19.2	34	13.8	*38*
	Rail Users	33.0	*94*	40.0	*106*
Study 6	Bus Users	4.0	*137*	7.0	*149*
Study 7	Bus Users	3.6	*74*	2.9	*87*

Using the meta-data set we compiled for these tables, we also ran two simple regressions, of the MSC (in minutes) on a number of explanatory dummy variables for peak, existing tram scheme, London, concessionary fare holders and park and ride schemes. We included a dummy for Study 5 which had markedly higher values than the other studies, for reasons we could not establish or control for. Using this method we can examine the impact of the various factors on the MSC, whilst controlling for the impact of others. The first regression was weighted by the numbers of respondents in each of the 32 sub-studies and the second unweighted. The results are shown in Table 5.4 below:

Table 5.4: Regression of Tram over Bus MSC in mins over the studies

	Weighted by sample size		Unweighted	
	Coeff	T-stat	Coeff	T-stat
(Constant)	6.796	3.69	5.650	2.80
Peak Flag	-0.550	-0.14	2.045	0.61
Existing Tram	2.340	0.97	6.593	2.11
London Flag	1.455	0.52	-2.432	-0.67
Concessionary	8.511	1.31	13.603	2.82
Study5	12.527	3.03	10.230	3.17
Park and Ride	10.869	2.49	13.561	3.29

The results are interesting. They suggest that, from the data we have on these studies, that values are higher for surveys where existing tram schemes are in place. It also highlight the MSC is higher for tram the Park and Ride sub-studies, ie all else equal Car drivers in these studies have a higher preference for tram over bus than elsewhere. It also provides weaker evidence that concessionary users have a higher preference for tram (although they will typically have lower values of time) and that studies in existing tram corridors yielded higher values. We found no significant impact of London or based studies or studies which broke down results by Peak and Off-peak, Tram vs Car MSC valuations

In the table below we present values of MSC of Tram vs Car where such options were presented. What we find here is that in all cases the value is negative, ie all else being equal Cars are still preferred to Tram, even though Trams are consistently preferred to bus. On average the results suggest drivers would be willing to sacrifice a 19 minute journey penalty before changing to tram.

Table 5.5 Tram preference over Car by Study and Segmentation

	Other segmentation	MSC (min)	N
Study 1	All	-21.3	*262*
Study 2	Shopping	-18.6	*242*
	Other	-9.6	*136*
Study 5	Peak	-38.0	*92*
	Off-peak	-17.0	*15*
Study 6		-12.4	*171*
Weighted Average		-18.8	*918*
Unweighted Average		-19.5	
Unweighted Median		-17.8	

5.3 Tram vs Quality Bus MSC valuations

Four of our studies (1,2,8,9) offered respondents modal choices which included both tram and a Quality Bus option (as well as a normal bus). Table 5.6 shows a comparison of the difference in MSCs between the Tram and Quality Bus options. Study 2 is omitted as valuations of the Quality Bus option were insignificant. On average there is around a 3.8 minute premium attached to Tram over Quality Bus.

Table 5.6 Tram Preference over Quality Bus by Study and Segmentation

Study	Segmentation	MSC	*n*
Study 1	Car/Business	-0.5	*210*
Study 8	Metro user	3.8	*127*
	Bus user	8.5	*96*
	Car user	8.5	*126*
Study 9	All	3.5	*556*
Weighted Average		3.8	*1167*
Unweighted Average		4.8	
Unweighted Median		3.8	

6. Conclusions and Recommendations for Further Work

This study has considered findings of some 12 recent tram based studies measuring the preference of Tram over Bus and other modes via SP analysis. In some cases, more detail was provided on WTP values for certain attributes, attitudes to the importance of these attributes, and performance by modes on these attributes. We have drawn also comparisons with studies from other PT modes where appropriate.

It is clear from the different approaches taken that there is no straightforward way to adequately model quality attributes on tram, or other modes.

We have a number of points to draw the readers' attention to. Firstly with regard to MSCs:

- Mode choices are driven by personal and journey characteristics. Different markets respond differently to the same travel opportunities, so insufficiently segmented models are likely to have MSCs that work to scale the model to fit the unmodelled variability of the data rather than capturing the actual preference of the mode.

- We find the modal constant varies by model form and the degree of segmentation undertaken. It cannot be viewed as an accurate proxy for modal preference unless the model has been properly specified with relevant attributes included.

- We do find service quality and (mode specific parameters) are a significant contributor to the choice process. Once unpacked, true modal preference seems small and is likely to be related to wider issues such as the overall transport system performance.

- It is clear that tram is preferred to bus schemes. Car is preferred over tram where the choice is considered. In most cases, tram is preferred to quality bus schemes where offered as an option.

- There is considerable variation in values across and within the studies, due to differences in journey purposes, regional/local transport provision, socio-economic and demographic factors, and attitudes to public transport, only some of which are controlled for. Values are higher for those individuals with car availability and for park and ride schemes reflecting to some extent car users' distaste for bus. Values do not appear to consistently vary by other segmentations.

- A balance between segmentation and sample size must be found as, segmentation can often lead to small sample sizes which can lead to insignificant or counterintuitive estimates of key parameters.

Secondly, with regard to the Quality Attributes considered:

- The coverage of the Quality Attributes of a Tram scheme is patchy and inconsistent across studies, suggesting that there is clearly a need to understand what the potentially important factors are, even before survey work is undertaken. For example factors such as Ride quality, Noise and Reliability, Comfort and Seating availability would have seemed to be integral to the benefits a Tram system could confer, at least over existing PT options, but they are not always presented to respondents.

- Willingness to pay valuations do not facilitate easy comparisons across studies as they use different questions, attributes, attribute level ranges.

- When focusing on the rankings of the WTP valuations, they indicate a high willingness to pay for improvements in security and safety in the vehicle and the waiting environment. Quality of waiting environment, staff attitude and traffic priority/own lane attract a relatively high WTP when featured.

- The use of a transfer price exercise or a secondary SP package exercise is essential to complement SP surveys to ensure the valuation of quality attributes is realistic and consistent.

- Only one study unpacked the constant in a meaningful way. This gave the highest share of the constant to personal safety and security.

- When considering attitudes to the important quality attributes featured in public transport, personal safety and security are of paramount concern when considering transport options. Reliability, ease of access and quality of waiting environment also emerge as important attributes.

- In terms of the performance of tram against other modes, tram performs better than bus on most of the quality attributes featured, but particularly so for ride quality and reliability.

- In the context of choosing their preferred mode, reliability again emerged as by far the most common reason for preferring tram over bus, with convenience, comfort, ride quality and access important too.

Given the small number of studies we had at our disposal, all our findings have to be treated with a degree of caution. However, the relative paucity of the evidence does itself indicate that there is more work to be done in this area to establish the benefit that tram schemes can offer.

7. References

Bates, J. and Terzis, G. (2000) Stated preference and the ecological fallacy, in: J. de D. Ortuzar (Ed.) Stated Preference Modelling Techniques, pp. 173-190. London: PTRC.

Copley, G. and Vaughn, B (2001), The Impact of Light Rapid Transit in Three UK Cities, European Transport Conference 2001.

Defra (2007), Guidelines to Defra's GHG conversion factors for company reporting, http://www.defra.gov.uk/environment/business/envrp/pdf/conversion-factors.pdf

Oscar Faber (2000), London Transport, Stated Preference Working Paper

Oscar Faber (2001), Midland Metro Monitoring Study, Working Paper on After Household Survey, prepared for Centro

MVA (2005), West London Tram Project, SP Surveys Final Report, Prepared for TfL, London.

MVA (2007), Midland Metro Extension, Report on Stated Preference Research

MVA (2008), Making Better Decisions, Sheffield and Rotherham Bus Rapid Transit: Stated Preference Research, report for Arup and South Yorkshire Passenger Transport Executive

SDG (2001), Leeds Supertram Stated Preference Surveys

SDG (2004), South Hampshire Rapid Transit Stated Preference Survey, prepared for SHRT.

SDG (2004), Valuation of Station Facilities, Draft Final Report, prepared for GMPTE.

SDG (2006), Edinburgh Tram, Stated Preference Report, prepared for tie Ltd.

SDG (2007), Multi-Modal SP Study, Phase 1 Final Report, prepared for Transport for London .

SDG (2008), New Generation Transport in Leeds, Stated Preference Study, Final Report, prepared for Metro and Leeds City Council

SDG (2008), New Generation Transport in Leeds: Stated Preference Study, Report for METRO and Leeds City Council