Travel time saving assessment
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An important note for the reader

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Executive summary

Overview

This report on the assessment of travel time savings has been prepared by consultants (Jacobs NZ Ltd with Ian Wallis Associates Ltd) as part of the NZ Transport Agency's 2013/14 research programme.

The research addressed knowledge gaps (internationally and in New Zealand) relating to methods for the valuation of travel time savings (VTTS) for non-business travel, for use in the economic appraisal of transport investment projects, in the following four main areas:

- Significance and weighting of travel time savings. How significant are travel time savings relative to the total (monetarised and non-monetarised) benefits of typical transport investment projects?
- Valuation of time savings vs trip duration. Do people's unit VTTS (per minute) vary significantly with the overall duration (or distance) of their trip: and, if so, what is the pattern of variation?
- Valuation of time savings vs extent of time saved. Do people's unit VTTS vary substantially between small time savings and larger time savings; and, if so, what is the pattern of variation?
- Allowing for income effects. Should the unit VTTS applied in economic appraisals be based directly on travellers' willingness to pay (WTP) for time savings; or should these values be adjusted to offset the effects of income differences; or should a single 'equity' value of (non-business) time be adopted for all trips?

Significance of travel time savings in economic appraisals

New Zealand procedures for the economic appraisal of transport projects are set out in the NZ Transport Agency's Economic evaluation manual (EEM). Until 2013, the unit values of time savings in the EEM were based more-or-less directly on an extensive set of New Zealand-based market research surveys and analyses undertaken in 2001, with the survey results also being 'benchmarked' against wider international evidence. The values adopted were differentiated by mode and trip purpose, and by travel quality and comfort factors (eg congested conditions, standing vs seated public transport passengers). For the revised (2013) version of the EEM, the Transport Agency decided to move away from the modal differences in values and to adopt a single ('equity') base value across all modes.

In recent years a wider range of economic benefits than just time and vehicle operating costs (eg agglomeration benefits) have been included in the economic appraisal; and this appraisal has become only one part of a wider, multi-criteria analysis, framework (including strategic fit' and 'effectiveness') for prioritising projects.

Travel time savings account for the majority (typically around 80%) of 'conventional' economic benefits for most transport projects. Thus the unit value of time savings is one of the most important parameters in transport economics (for both demand forecasting and economic appraisal purposes). However, the moves over recent years to both expand the scope of economic appraisals and to incorporate these appraisals within a wider multi criteria analysis framework has reduced the importance of time savings in the overall decision-making process.

Value of travel time savings vs trip duration – international literature and practice review

The majority of the international evidence indicates there is a strong relationship between unit VTTS and some measure of trip duration (distance, time, costs). Typically, unit values (per minute) for longer distance trips (say 3+ hours) are in the order of 50% to 100% greater than values for shorter trips (say <20 minutes). Therefore, if unit appraisal values are to reflect behavioural valuations, there would be a good case for differentiating these values by trip duration. The most appropriate measure of trip duration (distance, time, some measure of costs) would need further exploration. We note that the implementation of a VTTS function varying with trip duration would add complexity and additional data requirements to the economic evaluation process in order to robustly forecast these trip length distributions.

However, some international researchers are sceptical of the prevailing conclusion from market research of higher VTTS for longer trips, and particularly note the following points: (i) any time savings on longer trips may be within the ‘buffer’ typically allowed for trip time uncertainty, and therefore are unlikely to be highly valued; and (ii) there are some suggestions, but currently very limited ‘hard’ evidence, that people’s response to time savings relates more to the proportionate rather than the absolute saving (eg analogous to a constant demand elasticity function), and therefore unit values would be lower for longer trips. Given the significance of this proportionality argument and the lack of international research on its validity, the project included an exploratory survey of car driver preferences between saving a given amount of time on longer duration trips vs shorter duration trips. The findings of this survey are summarised below.

Value of travel time savings vs extent of time savings – international literature and practice review

The project examined the international research evidence and the theoretical and practical arguments as to whether and in what manner behavioural VTTS (for non-business travel) varies with the size (extent) of the travel time savings in question. The key issue under this theme relates specifically to small time savings; given the market research evidence, should ‘small’ time savings (however ‘small’ is defined) be valued less per unit than larger savings?

Our examination of the international evidence focused on the more recent national VTTS research studies undertaken, using stated preference methods, in several NW European countries (including the UK). The survey evidence from these studies was consistent in finding that: (i) unit VTTS increases up to a threshold level of time savings, which is generally in the range of 15–45 minutes and dependent on the mode of travel; and (ii) values for time savings of 3–5 minutes are typically in the order of half the threshold values.

A number of reasons are advanced by researchers as to why the apparently lower unit VTTS for small time savings derived from stated preference research is not a ‘true feature’ of the value of travel time, but is the result of the artificial nature of the experimental design.

The research also examined the treatment of small time savings in economic procedures adopted in leading countries. This found that the great majority of countries adopt a constant unit value (CUV) approach, ie with no discounting of values for small time savings, although there are exceptions to this (including Germany and Canada). Also, several countries that previously used discounted values for small time savings have now changed to the CUV approach, including the USA and France. While the UK (England) uses the CUV approach, it also requires travel time benefits to be classified (into six time bands) according to the size of the time savings.

In the light of the international research evidence and prevailing practices, we concluded that the case for retaining the current CUV approach is strong: this conclusion is strengthened by the potential shortcomings of stated preference research relating to small time savings and the additional complexity involved in any appraisal methodology that applied different unit VTTS for time savings of different sizes.

Exploratory market research – extent of time savings and trip duration effects

In the light of the findings from the international literature and practice reviews relating to (i) the valuation of smaller (vs larger) time savings, and (ii) variations in valuations with trip duration (refer above), an exploratory New Zealand-based survey was undertaken to shed further light on these two aspects. The survey was web-based and covered a non-random sample of some 560 respondents.

The survey used stated preference methods, asking respondents to choose between two time-saving options in every case, with the responses being analysed to derive preferences between different levels of time savings in different situations, rather than estimating specific monetary values on these savings, as is the focus of most stated preference-based market research on this topic. By adoption of a methodology different from that generally used in such VTTS research, it was hoped to make a significant contribution to international research evidence on the topics.

The survey involved two parts, with the findings of each summarised as follows:

Part (1) – extent of time savings. It was found that, for a given total time saving (per week), respondents had a clear preference for this to accrue from a single trip rather than being a small amount on each of multiple trips. On average, respondents were indifferent between saving 15 minutes on a single trip versus two minutes on each of 10 trips (ie 20 minutes total). The implication of this is that their revealed unit (per minute) VTTS for a two minute time saving was c.75% of that for larger (15 minutes) savings.

These results for small time savings are not dissimilar to those from other stated preference research internationally, but our survey indicated a lower level of discounting of values for small time savings than is generally found (probably because it encourages respondents to think in terms of making multiple trips, rather than the single trip focus of conventional stated preference surveys). This indicates a good case for considering this methodology further for wider application.

Part (2) – effects of trip duration. The results indicated that, for a given time saving, respondents would place a substantially lower value on the saving on a longer trip than on a shorter trip (ie valuations may be more consistent with proportionate valuations rather than absolute valuations). This finding differs from the dominant finding from international studies that unit values are higher for longer trips.

While the reasons for these differing findings have not yet been fully explored, it seems likely that a major contributing factor is that our survey design, which involves trading-off time savings on two different trips, differs from that conventionally adopted, where time savings are traded-off against money for a single trip. There would seem a strong case for further investigations internationally (including in New Zealand) of the reasons for the different findings.

Treatment of income effects (‘equity’ issues)

The project addressed whether VTTS for use in economic appraisals should be based more-or-less directly on travellers’ WTP for time savings; or whether and how these values should be adjusted to offset the effects of income differences.

Our understanding is that the Transport Agency’s 2013 move to adopt equal modal values was primarily intended to ensure that income differences were ‘neutralised’ in economic appraisals (ie to avoid bias in investments to favour people with higher incomes and hence higher willingness to pay for time savings). While this intention has been achieved in terms of the ‘base’ values of time to be used for appraisal purposes for travel in ‘standard’ conditions, this equality of unit values no longer applies once the various adjustments specified in the EEM are made to the ‘base’ values.

However, income is only one of many factors that influence an individual's behavioural VTTS for any trip. An individual's choice of mode for a given trip may heavily depend on the circumstances of that particular trip: when they are very time constrained for a trip (ie have a high value of time), they are likely to travel by car or taxi (fast but expensive); whereas when they are less time constrained for a trip (with a lower value of time), they are more likely to travel by bus (cheaper but slower). This self-selection process will tend to result in the average VTTS on slower modes being significantly lower than on faster modes, even though the average incomes of people on both modes may be similar. Any adjustment of behavioural values of time to impose equal values across modes will ignore this self-selection factor – it will be trying to adjust for income differences that may not exist, but instead it will over-ride genuine willingness-to-pay differences that do exist and hence will significantly reduce the usefulness of any estimates of economic benefits in decision making.

One potential approach to this dilemma is to adopt a set of 'income-adjusted' unit values of time. Essentially this would start from behavioural values (as established through stated preference or similar methods) and adjust these for any differences in average incomes (eg by mode) from the average incomes for the overall travel market (with the adjustment allowing for estimated VTTS elasticities with respect to income). The result would be a set of 'equity' values that have been adjusted only for underlying income differences (between households, areas, etc) but still differentiate for other effects unrelated to income differences (eg self-selection effects). Such an approach is adopted in the national values of time used for economic appraisal purposes in Sweden.

Our research included an initial exploration of the merits of such an 'income-adjusted' approach and of how it could be applied in practice. We regard this as one of the most important issues in the enhancement of the current VTTS structure used in New Zealand, and recommend that more detailed research/ development be undertaken into its merits and practical application.

Abstract

This research report covers the following aspects (from New Zealand and international perspectives) relating to the valuation of travel time savings for use in the economic appraisal of transport initiatives:

- The relative importance of travel time savings in the appraisal of the overall benefits of transport initiatives.
- Primary market research on how the behavioural valuation of travel time savings varies with the size of the time saving and the duration of the trip; and comparisons of these results with international market research findings and appraisal practices.
- The case for adjustment of behavioural values of time savings (for application in economic appraisals) to compensate for any income differences (eg by mode); the effectiveness of 'equity' (equal values) approaches as a means of adjustment; and the merits of alternative adjustment approaches.

The report makes recommendations that have implications for economic appraisal practices in the transport sector in New Zealand and, potentially, internationally.

1 Introduction

This report on the assessment of travel time savings has been prepared by consultants (Jacobs NZ Ltd with Ian Wallis Associates Ltd) as part of the NZ Transport Agency's 2013/14 research programme.

New Zealand economic evaluation procedures rely heavily on the estimation of (generally small) time savings by many individuals, taking no account of possible variations in valuations (eg by extent of time savings, trip duration, level of income). It is unclear whether this is consistent with behavioural evidence or with international best practice on valuations of travel time savings (VTTS).

The objective of the research was to assist decision makers by providing guidance on the strengths and weaknesses of the existing New Zealand economic evaluation methods and on alternative methods for valuing, aggregating and weighting travel time savings (including small travel time savings) to individual users.

This report is structured around the following main topic areas:

- The significance of travel time savings in economic appraisals. This is addressed in chapter 2.
- International literature evidence and practice on how VTTS varies with trip duration (or trip length) and with the extent of time savings. This topic is summarised in chapter 3, with a detailed review of the literature and practice set out in appendices B and C.
- Review and summary of earlier New Zealand research evidence on the variation of VTTS with trip length and income. This topic is summarised in chapter 4, with additional commentary in appendix D.
- Findings from exploratory New Zealand-based market research undertaken in the project - which focused on respondent preferences between smaller and larger time savings per trip, and between time savings on longer compared with shorter trips. This is summarised in chapter 5, with the detailed survey specification and results given in appendix E.[1]
- Discussion of 'equity' issues and alternative approaches to treatment of income effects in the application of VTTS in project evaluation. This is the subject of chapter 6.
- Selected additional issues relating to economic appraisal methods and their application. These are covered in chapter 7.[2]
- The report concludes with chapters summarising our conclusions and recommendations (chapter 8) and providing a full list of references (chapter 9).

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[1] It should be noted that the topic areas covered in chapter 5/appendix E and in chapter 7 were not included in the original scope specified for the project, but were added subsequently as a result of discussions between the steering group and the consultants.

[2] Ibid.

2 Significance of travel time savings in economic appraisals

Travel time savings typically account for a major component of the total economic benefits of transport investments. Nationally as well as internationally, travel times often account for around 80% of scheme benefits (Gwilliam 1997). This chapter presents evidence on the proportion of travel time savings in comparison with other traditional benefit streams such as crash cost savings and vehicle operating cost savings. In addition, the travel time savings will be considered against wider economic benefits (WEBs) such as agglomeration benefits.

To understand the importance of travel time savings and how these are calculated, it is first useful to look at the historical development of the current appraisal requirements.

The central government in New Zealand fully funds state highways and funds local roads together with local authorities (with, on average, the funding split approximately equally between central and local government authorities). Given that central government plays a key role in the funding, it is not surprising the government takes charge of the evaluation review and decision-making processes to determine which projects receive funding. In addition to the decision-making and review process, the central government is also responsible for the upkeep and development of the funding appraisals to ensure that the appraisal procedures stay current by considering national and international advances and, if applicable, focusing on investigations into the applicability of new procedures in the New Zealand context (Ministry of Transport 2011).

The evaluation of travel time savings and other benefits in New Zealand is largely based on the adoption of findings from international research and practice, principally from the UK. In the 1990s, a number of reviews of international research and practice were undertaken but few changes were made to the then *Project evaluation manual* (PEM).

A major review in 2002 to update the PEM benefit parameters was initiated by Transfund NZ (now the NZ Transport Agency) (BCHF et al 2002). This review was mainly based on willingness-to-pay (WTP) surveys and the results were compared and benchmarked against international standards. After a consultation phase with the stakeholders, Transfund NZ adopted new unit values of travel time savings. These values have remained generally unchanged, except for annual unit value cost adjustments since 2003. The update factors are based on a combination of price indices provided by Statistics NZ (Parker 2012). The PEM was changed in 2006 and became the *Economic evaluation manual* (EEM) containing two volumes: volume 1 for roading projects and volume 2 for evaluating other modes. With this change the efficiency ratio used for evaluating ‘other modes’ since 1997 was changed into a benefit-cost ratio (BCR) calculation. In 2013 the EEM (NZ Transport Agency 2013a) was revised to include an element of modal equality. This is discussed further in chapter 6.

Over the last decade the sole use of cost-benefit analysis (CBA) by determining a BCR in evaluating schemes has been supplemented by a multi-criteria analysis (MCA) with the aim of widening the assessment criteria to include wider strategy-based metrics.

2.1 Current New Zealand analysis guidance

Currently the Transport Agency uses MCA as a decision-making tool. This includes the following three criteria, each assessed as low, medium or high scores:

- Strategic fit: assesses how an identified issue, problem or opportunity aligns with the investment direction set by the Transport Agency. This is a qualitative assessment.

- Effectiveness: considers the contribution the proposed scheme solution makes towards solving the identified issue(s). This is a qualitative assessment.
- Efficiency: evaluates the scheme benefits compared with resources needed to implement the solution, using CBA as set out in the EEM. This is a quantitative assessment and incorporates the evaluation of travel time savings as a key component.

The MCA concludes with an assessment profile consisting of three letters, with the first letter ranking the strategic fit, the second letter the effectiveness and the third letter the efficiency. The profile ranks the potential scheme into a priority order ranging from 1 to 11 for the allocation of funds as set out in table 2.1. This table illustrates that the outcome of the efficiency criterion is less important than the outcomes of the other two criteria: this effectively means the CBA has been downgraded in importance over the last decade.

Table 2.1 Prioritisation of activities

Profile	Priority order
HHH	**1**
HHM, HMH, MHH	**2**
HHL, HMM	**3**
HLH, MHM, MMH	**4**
LHH, HML	**5**
HLM, MHL, MMM	**6**
MLH, LHM, LMH	**7**
HLL, MML, MLM, LHL	**8**
LMM, LLH	**9**
MLL, LML, LLM	**10**
LLL	**11**

(Source: NZ Transport Agency, Planning and Investment Knowledge Base 2014)

The 'Better Business Case', business planning approach, as introduced by the New Zealand Treasury, has been modified to make it suitable for use by the Transport Agency. This is called the assessment framework for programme business cases and indicative business cases. Table 2.2 provides the Transport Agency assessment framework.

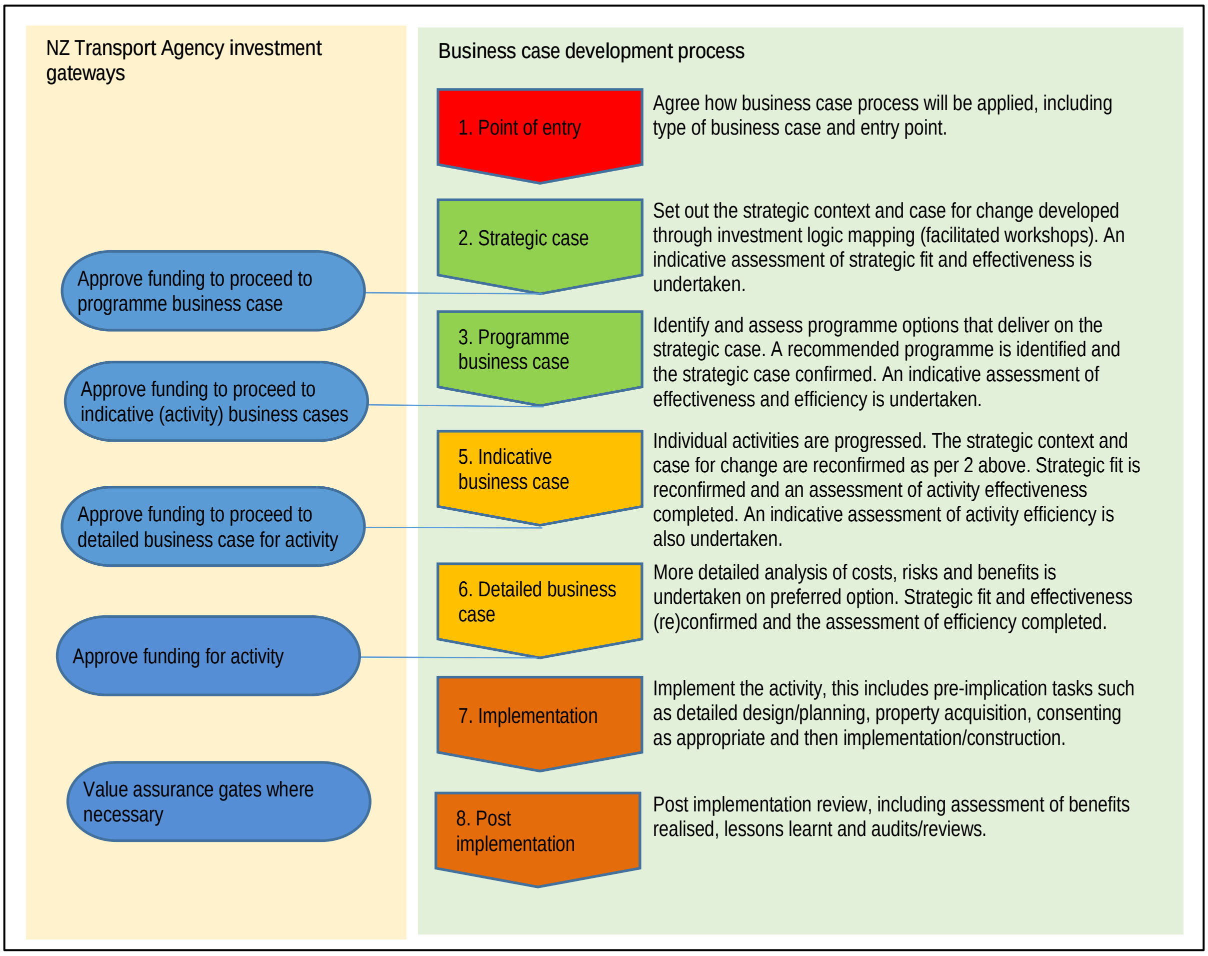
Table 2.2 NZ Transport Agency assessment framework

Business case stages	Strategic fit assessment	Effectiveness assessment	Efficiency assessment
1 Strategic case	Indicative	Indicative (conditional where appropriate)	Not applicable
2 Programme business case	Confirmed	Indicative (conditional where appropriate)	Indicative (conditional where appropriate)
3 Indicative business case	Re-confirmed (continued alignment)	Confirmed	Indicative (conditional where appropriate)
4 Detailed business case	Re-confirmed (continued alignment)	Re-confirmed (continued alignment)	Confirmed

(Source: NZ Transport Agency, Planning and Investment Knowledge Base 2014)

The main change from the previous appraisal procedures is to provide a clear order of actions to prevent, for example, a detailed analysis being undertaken before the problem and strategic alignment of the proposed scheme have been assessed. Table 2.3 provides an overview of the overall high-level business case approach as provided by the Transport Agency's Planning and Investment Knowledge Base 2014). Tables 2.2 and 2.3 clearly define that the efficiency assessment (using CBA) is not addressed as part of the strategic case, including travel time saving estimates, but is only undertaken from the programme business case phase onwards, first, as an indicative figure, followed by a confirmed analysis in the detailed business case phase.

Table 2.3 High-level overview of the business case approach



(Source: NZ Transport Agency, Planning and Investment Knowledge Base 2014)

2.2 Analysis

As stated at the beginning of this chapter approximately 80% of scheme benefits are typically attributed to travel time savings. This chapter takes a closer look at New Zealand schemes to validate this broad statement.

The Transport Agency provided a project database comprising a collection of recent project funding applications that were drawn upon to look at the significance of travel time savings in New Zealand funding applications.

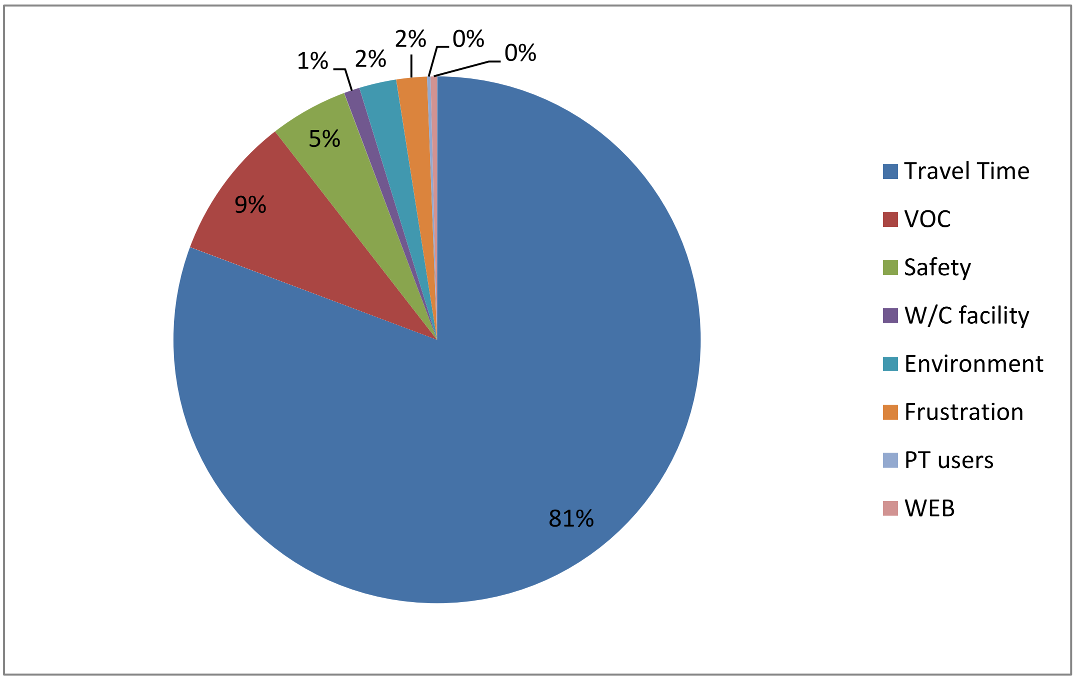
The database considers funding applications with an approved construction phase by the end of February 2014 in the 2012/15 National Land Transport Programme (NLTP). The information provided only includes schemes with a breakdown of calculated benefits recorded in the Transport Investment Online (TIO) tool. The information comprises 40 state highway activities and 36 local authority activities.

Figures A.1 and A.2 in appendix A provide an overview of the benefit streams split up between state highway activities and local road activities. These figures show the benefits predicted for local road schemes are about $2.5M which is nearly one-third of state highway benefits of approximately $8.7M. It also shows clearly that the travel time savings are the greatest contributors to the overall scheme benefits. In addition, figures A.1 and A.2 present the predicted total savings per benefit steam on a project-by-project basis for both state highway activities and local road activities respectively.

These figures also illustrate the dominance of travel time savings over all other benefit streams. This is regardless of the spending authority, though, as described above, the Transport Agency is responsible for the evaluation procedures and decisions regarding the funding allocation. It is therefore little surprise that the patterns between local road and state highway spending are similar.

The relativity of travel time savings compared with other 'traditional' benefit streams is presented in figure 2.1 in a combined overview of both state highway and local authority activities (the split of these overviews is provided for state highways in figure A.3 and local roads in figure A.4).

Figure 2.1 Percentage of project benefits per benefit stream (weighted over all projects)



Commonly, both state highway and local road schemes have high proportions of their total assessed benefits from predicted travel time (including reliability) savings. Vehicle operating cost savings and crash cost (safety) savings are typically 10% and 5% respectively. Some differences are found regarding the other five benefit streams, but these have little impact on the overall benefits.

This section has illustrated that travel time (including reliability) benefits typically account for around 80% of total scheme economic benefits, and therefore have a substantial impact on which schemes are selected for funding.[3]

2.3 Relativity between benefit components

This section examines the relativity crash costs and travel times and vehicle operating costs. As presented above, these three benefit streams are common to both local authority and state highway schemes. The aim of this section is to establish relativities between the different benefit streams by expressing the crash cost for fatal, serious, minor and non-injury crashes in terms of travel times and vehicle operating costs.

The information provided in table 2.4 is based on the EEM (2013) values. The following assumptions for the analysis were made:

1 Crashes
   a 50km/h speed environment
   b all vehicles
   c all movements
   d adjusted to $ July 2013 (update factor: 1.22)
2 Travel times
   a urban arterial
   b all periods
   c adjusted to $ July 2013 (update factor: 1.40)
3 Vehicle operating costs
   a 50km/h speed environment
   b zero ('0') gradient
   c urban arterial
   d adjusted to $ July 2013 (update factor: 1.06)
4 Overall
   a 365 days a year
   b discount rate of 6%
   c 40-year evaluation period
   d zero ('0') traffic growth

Table 2.4 has been created as follows:

[3] Safety benefits may be under-reflected in the overview. Safety can be regarded as a 'by-product' of roading schemes. If a new road is build or improvements are made to an existing roading infrastructure then these changes are made to the latest industry standards and guidelines. Over time safety consciousness has improved and new or improved infrastructure tends to be safer than the initial infrastructure or built to a safer environment than in the past.

The cost per crash column is based on the cost for a fatal, serious, minor or non-injury crash as provided in the EEM (2013) [column 2] and updated to $ July 2013 values [column 3]. This equates to annual savings of approximately $255,000 when considering a 40-year evaluation period and a discount rate of 6% for single payment present worth factor. Breaking this figure down into vehicle hours per day using 365 days a year and a base value of time of $22.78/hour (in $ July 2013) leads to approximately 31 vehicle hours/day over the 40 year period as the equivalent cost saving to preventing a single fatal crash [column 4]. Similarly applying vehicle operating costs of $0.315/km (in $ July 213) results in approximately 2,200 vehicle km/day [column 5] and so forth.

Table 2.4 Crash costs (in $m July 2013) in relation to travel time and vehicle operation costs savings

Crash severity	Cost per crash ($ July 2006) [2]	Cost per crash ($ July 2013) [3]	Travel time savings (vehicle hours/day) [4]	Vehicle operating costs savings (vehicle km/day) [5]
Fatal injury	3,350,000	4,087,000	~31	~2,220
Serious injury	360,000	439,200	~3.3	~240
Minor injury	21,000	25,620	~0.2	~14
Non-injury	2,100	2,562	~0.02	~1.4

Note that these numbers are indicative only; they would vary if the values of time were used per travel purpose such as non-work travel instead of all periods on urban arterial roads.

The Waitemata (Auckland) Harbour crossing carries approximately 100,000 vehicles per day. If each vehicle saves 1.1 seconds on their journey for the next 40 years that would be equivalent in benefit to saving one fatal crash.

The analysis is based on the statistical value of a human life. In New Zealand's transport sector the methodology followed to determine the value of statistical life was a WTP survey in 1991, asking New Zealanders what they were willing to pay to reduce the risk of premature death due to road crashes (Guria 2010). Since then the value of a statistical life has been updated using an income elasticity of 1.0 (Parker 2012). Guria indicated that using only the income elasticity as the update basis might not be the most suitable approach and suggested the value of a statistical life should be considerably greater. A study carried out in 1997/98 suggested the value of a statistical life should be over $5M instead of $3.5M in $ June 2009 values (Guria 2010).

The implications of having a higher statistical life value would mean that the safety aspect in schemes could potentially increase and lead to more funding for safety improvements due to the higher possible crash cost savings when considering the BCR analysis only. Strategic fit and effectiveness under the current framework are supportive of 'safer journeys' and the schemes would rank highly in these two evaluation criteria. The higher statistical life value would only change the funding outcomes when the efficiency of a scheme was evaluated, not as a result of the prior assessment which considered strategic fit and effectiveness.

2.4 Discussion

2.4.1 Other quantifiable benefits

Travel time benefits account for approximately 80% of 'conventional' quantified scheme benefits on average in New Zealand (see section 2.2). Compared with other quantifiable benefits the travel time benefit component is high. As discussed above, there could be potential for crash benefits to increase in value should an alternative cost of human life be used. It is also of note that, given, the Transport Agency's use of the MCA framework with lower emphasis on the CBA, changes in the values of crash savings are unlikely to impact substantially on funding outcomes.

2.4.2 Wider qualitative (resource) benefits

In addition to quantitative information, qualitative information (such as social and environmental aspects) is used in economic appraisals. Emissions can be captured in monetary terms and procedures are in place to consider these in the evaluation; however, it is difficult to quantify community acceptance or environmental sustainability. The ability of traditional benefit streams to be monetised means these often get a greater emphasis than qualitative attributes. Prior to MCAs, only the CBA was used to determine the schemes for funding, but with increased emphasis on the environment the MCA approach is more widely used. Results from the CBA are used in the ranking as well as qualitative outcomes. Therefore qualitative benefits have an increased importance in the evaluation of schemes under the current Transport Agency assessment framework.

2.4.3 Wider economic benefits (WEBs)

WEBs are in addition to conventional benefits. Traditional benefits evaluate changes in travel conditions but do not capture wider economic impacts and this may lead to sub-optimal investment decisions. Wider economic impacts are generally considered as a sensitivity test, demonstrating the BCR with and without the WEBs. Care must be taken not to double count benefits, as the traditional benefits and WEBs are not necessarily completely separate from each other. However, international research has shown that the issue of double counting is not as prevalent as initially anticipated (Saha International Ltd 2010).

The EEM provides procedures outlining how to quantify WEBs; these are indirect benefits and the following three benefit streams are classified as WEBs and procedures are in place for the evaluation in accordance with the EEM (2013):

- agglomeration
- imperfect competition
- increased labour supply.

WEBs currently play a minor part only in the overall evaluation of most schemes, as can be seen in figure 2.1 in section 2.2. This is likely to be due to WEBs typically only applying to larger schemes which are likely to have an impact on land use, usually close to major urban or industrial centres. For most of the schemes submitted for funding, WEBs have not been applied (EEM 2013).

The database provided by the Transport Agency only included two schemes that considered the WEBs. These schemes are the Dominion Road Public Transport Upgrade and Auckland Manukau Eastern Transport Initiative (AMETI) Stage 1. The WEBs were estimated to contribute approximately 22% and 14% of the overall scheme benefits in these two cases. Figures A.5 and A.6 in appendix A provide the pie charts in relation to the overall benefits for these two projects. Due to the small sample size no overall conclusions can be drawn.

A scheme that did evaluate WEBs is the Auckland City Centre Future Access Study. This project evaluation resulted in a BCR of 0.4 when considering traditional transport benefits only. The three WEBs noted above were calculated in addition to 'Move to more productive jobs'. By applying all these additional benefits the BCR was increased to 0.9. These figures were calculated based on a 30-year evaluation period and a discount rate of 8%. This project was also appraised using a 60-year evaluation period and a discount rate of 5.7%, as per Auckland Council's cost of capital, and this resulted in a BCR of 1.7. This shows that WEBs can have a significant impact on the BCR due to the potential of sizable additional benefits and assumptions on discount rates and evaluation periods can also alter appraisal outcomes (Bell and Darlington 2012).

2.4.4 Land-use impacts

In the vast majority of scheme appraisals in New Zealand, it is assumed there are no induced traffic impacts as a result of land-use impacts created through the scheme. It is noted that induced traffic from the perspective of trip redistribution, trip retiming, modal shift and trip rerouting can be captured using the variable matrix approach which is set out in the EEM. There has been significant discussion in recent years regarding the likely impact of major transport schemes (such as the roads of national significance, RoNS) from a roading perspective, or the Auckland City Rail Link from a public transport (PT) perspective) and the impact these schemes would be likely to have on land-use patterns. There is currently no definitive guidance on how these potential land-use impacts should be addressed in a scheme appraisal apart from the WEBs guidance.

Care also needs to be taken as short-term changes in travel times may be considered a proxy for longer-term changes in land-use patterns, and so by including both there is a potential element of double counting. It is possible therefore that for large schemes it is more practical to focus on and quantify the WEBs rather than the travel time benefits which require greater assumptions to be made

2.5 International evaluation practices

Table 2.5 provides a comparison of the values of travel times per trip purpose adopted in selected countries internationally. Mackie and Worsley (2013) in their paper *International comparisons of transport appraisal practice* provide a substantial overview of the different evaluation practices ranging from the UK to New Zealand. For the purpose of this project an emphasis was placed on the value of travel times used in the international appraisals. For ease of comparing these figures, the purchasing power parity (PPP) exchange rate was applied to convert the foreign currencies to NZ$ equivalents as indicated in the 'Value of time' column. These figures were generated through the application of the 2013 data from the OECD.StatExtracts table '4 PPPs and exchange rates' (OECD nd).

In general, all countries show the same patterns with work travel being the most highly valued due to the loss of work time. Commuting is slightly higher valued than the non-work/other travel typically done during leisure time. Evaluation periods and discount rates vary widely.

Table 2.5 Value of time and appraisal overview

Country	Value of time	Discount rate	Appraisal period	Comments
New Zealand (*Economic evaluation manual* 2013) ($ 2013)	Work travel: NZ$33.39 Commuting: NZ$10.92 Non-work travel: NZ$9.66	6%	40 years	Value of time provided as resource cost. Sensitivity tests required for 4% and 8% discount rates. 8% discount rate used by Treasury. Values of time also available on an aggregate level (by road hierarchy and periods etc).
United Kingdom (WebTAG Databook autumn 2014a) (£ 2010)	Employers' business: £22.75 [NZ$47.62] Commuting: £5.72 [NZ$11.97] Other: £5.08 [NZ$10.63]	3.5% (first 30 years) 3% (beyond 30 years)	60 years	Value of time provided as resource cost. Fewer appraisal years can be used.
Netherlands (Bates 2012) (Eijgenraam et al 2000) (€ 2010)	Business: €24.00 [NZ$42.26] Commute: €9.75 [NZ$17.17] Other: €7.00 [NZ$12.33]	4%	'life span'	Risk premium added to risk-free discount rate of 4%. Risk premium is determined by the covariance between the project return and the return on the average market portfolio. Appraisal period to be set at appropriate time horizon, typically the life span of the scheme.
Germany (Birn et al 2003) (€ 2003)	Business: €19.94 [NZ$37.02] Commute/other: €3.83 [NZ$7.11]	3%	'project specific'	Appraisal period determined project specific based on the weighted average of all project components. No differentiation made between other travel and commuting.
United States (Belenky 2011) (Federal Highway Administration 2013) ($ 2009)	Business: US$22.90 local[(a)] [NZ$33.32] US$22.90 intercity[(a)] [NZ$33.32] US$57.20 intercity[(b)] [NZ$83.23] Personal: US$12.00 local[(a)] [NZ$17.46] US$16.70 intercity[(a)] [NZ$24.30] US$31.90 intercity[(b)] [NZ$46.42]	7%	'project specific'	Project life cycle used for appraisal period.
Australia (Tan et al 2013) (Australian Bureau of Statistics 2013) ($ 2013)	Business: AU$42.15 [NZ$44.85] Commute: AU$13.17 [NZ$14.02] Personal: AU$13.17 [NZ$14.02]	7%	30 years	Appraisal requirements differ for federal, state and local funding. Sensitivity testing using discount rates of 4% and 10% required.

[(a)] surface modes (car, tram, bus, etc)

[(b)] using high-speed rail travel or air travel

2.6 Overall conclusions and implications for New Zealand

Economic appraisals in New Zealand have recently changed from a pure BCR analysis, with applied figures determined via WTP surveys, to a MCA taking into consideration the strategic fit and effectiveness of a scheme. Only if these two criteria are well aligned is a CBA carried out to assess the economic efficiency of the proposed scheme.

When entering the efficiency stage of the evaluation, the importance of travel time savings comes into consideration. Several assumptions make the evaluation sway towards schemes which have a high portion of travel time savings projected.

First, there has been significant debate regarding the valuation of a statistical human life. Increasing the value has the potential to increase the crash saving benefits and could alter the projects chosen for funding depending on the amount of crash versus travel time savings if only considering the BCRs (noting that under the current MCA framework, the strategic fit and effectiveness criteria are considered first). However, another issue raised is that post-implementation evaluations have highlighted a significant tendency for actual crash savings to be less than the prior forecasts (Wallis et al 2012). This study recommended a review of the crash forecasting procedures and changes may be introduced to rectify these.

Second, if a scheme has an impact on industrial and urban centres then WEBs should be incorporated into the evaluation. Care must be taken not to double count benefits. Depending on the evaluator, there can be major differences in the amount claimed for WEBs. This poses a risk as it reduces the confidence in the calculated figures. Thorough documentation of assumptions, reasoning and explanations should be provided to back up the claimed figures. If a scheme has an impact on industrial and urban centres then these benefits should be incorporated into the evaluation. Given the major impact some of the evaluated schemes could have on the economy and creation of large additional scheme benefits, the inclusion of WEBs has the potential to change the evaluation outcomes as illustrated in the Auckland City Rail Link example. Currently, only a minority of schemes have been identified as impacting on the wider economy to merit the use of WEBs and as such WEBs are only taking a minor role in the decision of funding.

Third, currently there is no guidance given on how to deal with any impacts of schemes on land use. This is an important topic and discussions are still ongoing on if and how the land-use impacts should be considered quantitatively.

Other benefits, which are not captured in monetary terms, are still difficult to incorporate. The industry moved towards a MCA, mostly in the scheme assessment report stage or detailed business case of a project, using qualitative and quantitative benefits leading to BCR values being incorporated in the overall MCA. The impact of qualitative benefits in comparison to quantitative benefits could not be established as the database received had no qualitative information included.

In general, the move from CBA to a MCA has lessened the importance of travel time benefits in the overall evaluation. Within the BCR calculation, the travel time savings are still contributing a major proportion, typically about 80%, of the overall scheme benefits.

2.7 Recommendation and implementation

The Ministry of Transport (MoT) is already undertaking investigations into the ‘under-valuation of a statistical life’. It was therefore recommended this should not be investigated any further in the current project.

It was originally anticipated that further analysis would be undertaken into the projects including WEBs. Unfortunately, at this stage, the information available on WEBs is very limited and therefore does not warrant any further analysis. However, this may be appropriate once more information becomes available.

3 International literature and practice review (summary) –value of travel time savings vs trip duration and extent of time savings

3.1 Value of travel time savings versus trip duration

3.1.1 Introduction

A number of research studies internationally (and in New Zealand) over the last 20 years have found that the unit value of travel time savings (VTTS) for longer trips is higher than for shorter trips, with values for longer trips in the order of double those for shorter trips, However, these findings have not been supported by all studies.

A number of factors are commonly put forward as to why unit VTTS for longer trips may be higher, eg:

- Longer journeys tend to be made by higher income people.
- Tedium and fatigue set in on longer distance trips.
- The length of time taken to make a long distance trip can cut into the time available at the destination.

Section 3.1.2 summarises the international and New Zealand market research evidence on whether, and to what extent, people's VTTS (per minute) vary significantly with the overall length or duration of their trip[4]; and, if so, what is the pattern of variation? The evidence examined relates almost solely to car drivers; there is an almost complete dearth of evidence in the international literature on car passenger VTTS variation with trip duration, and very limited similar information for PT passengers.

Section 3.1.3 summarises practices incorporated in project evaluation manuals/guidelines internationally as to how unit VTTS for appraisal purposes varies with a measure of trip length. Finally section 3.1.4 sets out our conclusions and implications on this topic.

More detailed information on the market research evidence and on international evaluation practices, to support the summaries in sections 3.1.2 and 3.1.3, is provided in appendix B.

3.1.2 Overview of empirical (market research) evidence

Here we provide a summary of the more important empirical evidence derived from market research studies internationally relating to how unit VTTS varies with some measure of trip duration, distance or cost. All the more recent studies, including those referred to here, have used stated preference (SP) methods, generally comparing hypothetical trip options with a 'reference' trip made by the respondent, with the two trips differing in terms of their time and monetary costs. This summary focuses on the more recent national VTTS studies undertaken in selected European countries, as these studies have used more sophisticated market research methods and enhanced modelling/analysis techniques compared with earlier studies.

Most of the research studies on this topic internationally have fitted a power function to the pattern of variation in unit VTTS with trip distance etc (ie that VTTS is proportional to distance to a power (elasticity)).

[4] The literature adopts various measures of relative trip 'duration', including travel time, travel distance and travel cost.

Such a functional form is intuitively appealing[5] and has some computational advantages, although it has not been adopted in all research studies (including the New Zealand study covered below).

Table 3.1 provides a summary of research evidence on unit VTTS variations with trip duration/distance from the more recent studies on the topic in New Zealand, UK, Denmark, Sweden and Norway. Key findings are as follows:

- The Danish national study found that the unit car driver VTTS (free-flow conditions) was lower (by c.20%) for 'long' trips than for 'shorter' trips.
- All the other studies (including New Zealand) found higher unit VTTS for longer trips than for shorter trips, with elasticities (with respect to distance) all in the range 0.05 to 0.41, but with the prevailing figures in the range 0.13 to 0.21.
- The New Zealand study elasticity estimates are at the lower end of the range (in the order of 0.1), but have not been derived directly from the base data and should be regarded as particularly uncertain.
- The UK literature in particular refers to the 'proportionality' argument, which would result in unit values decreasing with distance or duration; it notes the lack of explicit evidence on the empirical validity of this argument.

3.1.3 Treatment of duration (distance) effects in evaluation procedures internationally

We reviewed procedures adopted in economic evaluation (appraisal) manuals/guidelines in 10 countries as to how unit VTTS should vary with some measure of trip length for appraisal purposes.

Key findings were (refer table B.3 for details):

- In most countries, the unit VTTS used does not vary with any measure of trip length (distance, duration, etc).
- In Norway and Sweden, the car user VTTS figures differ between 'shorter' and 'longer' trips, with a dividing line at 100km distance. For the longer trips, the Norwegian values are c.90% higher than those for shorter trips and the Swedish values are 24% higher.
- In the USA, the differentiation is between inter-city and local travel: inter-city values are 40% higher for commuting, 90% higher for other (non-work) purposes.

3.1.4 Conclusions and implications

The majority (but not all) of the international evidence indicates there is a clear relationship between unit VTTS and some measure of trip duration (distance, time, costs). Typically, unit values for longer distance trips (say 3+ hours) are in the order of 50% to 100% greater than values for shorter trips (say <20 minutes). Therefore, if unit appraisal values are to provide a good reflection of behavioural trade-offs, there would appear to be a good case for segmenting these values by trip duration – through either a continuous function of trip duration (eg a power/elasticity function) or through a function varying by trip duration band. The most appropriate measure of trip duration (distance, time, some measure of costs) would need to be further explored.

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[5] It entails the unit VTTS increasing by a constant proportion for each doubling of the trip distance.

Table 3.1 Summary of market research findings on VTTS variation with trip duration (distance) from key studies

Country/study	Scope of work	Key findings
New Zealand – BCHF et al (2002)	Extensive SP survey of car drivers (2001)	Derived a 'best fit' function to data, expressing unit VTTS as varying in inverse proportion to a linear function of trip distance. No data collected for short (<5km) trips and function not reliable for longer (>100km) trips. Between these two limits, functional form suggested elasticity of VTTS with respect to trip distance in range 0.05 to 0.13 (relatively low compared with most evidence).
UK – various studies (1999–2010)	Several highly relevant studies: • ITS re-appraisal of AHCG (1999) data • M6T study (Wardman et al 2008) • ITS meta-analyses (including Europe-wide study)	All studies indicated that unit VTTS increases with respect to trip distance or duration. Elasticities varied in range 0.06 to 0.41, with prevailing values in range 0.14 to 0.21. Several studies included an income variable, and found that elasticity values were little affected by income differences. Analyses indicated that time sensitivity stays approximately constant with distance, while cost sensitivity decreases. Most recent review of evidence (for DfT) discusses the 'proportionality' argument, which would imply that a given time saving is of lesser value on longer trips: it notes the lack of explicit evidence on this argument.
Denmark – Danish value of time study (Fosgerau et al 2007)	Study estimated a model with separate time values for 'short' and 'long' trips, with the median trip length (c.25km) as the dividing line.	Found that mean VTTS for car drivers in free-flow conditions was c.20% lower for the long trips category than for the short trips.
Sweden – Swedish value of time study (Borjesson and Eliasson 2012)	SP survey of car, bus and train trips of all lengths and trip purposes. Analysis methods based on those developed in the Danish national study.	Found that unit VTTS increased with distance, with an elasticity of 0.13. Divided market into trips shorter/longer than 100km: unit values for 'longer' trips were in the order of 50% greater than for 'shorter' trips.
Norway – Norwegian value of time study (Samstad et al 2010)	SP survey, generally similar to Danish and Swedish studies.	Unit values for trips >100km were around double those for trips <100km.

The only New Zealand evidence on this topic appears to be that collected in the 2001 SP surveys of car drivers (BCHF et al 2002). This found that unit values did increase in a systematic manner with trip distance, although the relationship established was limited in its application (being unreliable for trips of >100km, and not including any data for short trips). Our re-analysis of this relationship indicated a trip distance elasticity at the low end of the international evidence, but this should be treated with caution: a more reliable estimate would require re-analysis of the original car driver survey data (which should be possible if required).

In regard to these conclusions, we provide two notes of caution: First, having values of time that vary with trip duration would increase the complexity in application of economic appraisal methods. For any given scheme appraisal, the analyst would require information on the trip duration (eg trip time or distance) distribution of users of that road section. To get accurate information of this nature would require some form of origin-destination survey, or could make use of appropriate transport/traffic model data where available. However, it should be possible to develop and apply simplified methods, perhaps dividing road sections into (say) three categories reflecting the prevailing trip lengths of their users (eg urban, peri-urban, inter-urban/long distance).

Second, a number of researchers have suggested that unit values of time savings would be dependent, to an extent, on the proportionate level of saving rather than just the absolute level of saving. For example, a 10-minute saving on a five-hour trip (3.3%) would be valued less (rather than more) highly than a 10-minute saving on a 30-minute trip (33%). This would be contrary to the prevailing evidence that unit values are higher for longer trips. It seems likely that the view that the proportionate level of time savings is important in determining their valuation is confounded (in SP surveys) with the issue of travel time reliability, and maybe also trip frequency: a 10-minute saving on a five-hour trip may be seen as of little value, as (i) the 10-minute saving is likely to be well within the level of uncertainty of actual trip times for a five-hour trip, and therefore has to be allowed for as ‘buffer’ time in any event; and (ii) most people do not make such long trips often, whereas 30-minute trips are typically made much more frequently .

The most recent UK research (for DfT) noted that detailed empirical analysis of ‘proportionality’ arguments has not been undertaken, and concluded that (Batley et al 2010):

> *There would seem to be some uncertainty as to the cause of the variation in the value of the time, and confounding effects from income, the size of time savings offered and purpose need to be isolated, whilst proportionality arguments also need to be tested.*

In part in response to these UK findings, it was decided that this project would undertake an exploratory survey of market preferences between saving a given amount of time on longer vs shorter duration trips, thus examining the proportionality argument in particular. The findings from this survey are presented in chapter 5, with further details in appendix E.

3.2 Valuation of time savings vs extent of time saved

3.2.1 Introduction

This section summarises the research evidence and the theoretical and practical arguments as to whether and in what manner behavioural VTTS (for non-business travel) varies with the size (extent) of the travel time savings in question. The key issue under this theme, which this section focuses on, relates specifically to small time savings: given the market research evidence, should ‘small’ time savings (however ‘small’ is defined) be valued less per unit than larger savings? In relation to this question, this section first summarises the key pieces of empirical (market research) evidence; and then, in the light of this evidence, considers the case for/against adopting lower values for ‘small’ time savings than for ‘larger’ savings in the context of project appraisal.

This section draws on a detailed review of the international evidence on how unit VTTS varies with the extent of time savings, and in particular for ‘small’ time savings relative to ‘standard’ (eg 10–20 minutes) time savings. The full review is set out in appendix C.

3.2.2 Empirical (market research) evidence

Here we provide a summary of the more important empirical evidence derived from market research studies internationally relating to the valuation of small time savings (relative to larger time savings). All the more recent studies, including those referred to here, have used SP methods, generally comparing hypothetical trip options with a ‘reference’ trip made by the respondent, with the two trips differing in terms of their time and monetary costs. This summary focuses on the more recent national VTTS studies undertaken in selected European countries, as these studies have used sophisticated market research methods and enhance modelling/analysis techniques compared with earlier studies.

Table 3.2 provides a summary of the conclusions relating to small time savings for the more recent studies in the UK, Denmark and Sweden, focusing primarily on the results from the study analyses on how unit VTTS compare with values for larger time savings.

The evidence from these three national studies (in each case based on SP surveys, pivoted around a reference trip) is consistent in finding that:

- unit VTTS increases up to a threshold level of time savings, which is generally in the range 15–45 minutes and dependent on the mode of travel
- VTTS of three to five minutes are typically in the order of half the threshold values.

These findings are after controlling SP survey results for 'reference dependence', which typically causes a higher estimated VTTS the larger the time difference between alternative choices.

Table 3.2 Summary of market research findings for small time savings valuations from key studies

Country/study	Scope of work	Key findings
UK—ITS/Bates reappraisal of AHCG findings (Mackie et al 2003)	The second UK national study (AHCG 1999) found that time savings of five minutes or less have negligible value. ITS/Bates (Mackie et al 2003) was subsequently commissioned to review the AHCG analyses, findings and recommendations on implementation.	Mackie et al (2003) concluded that: • The AHCG conclusion on significant differences in unit values according to the size and sign of time savings is invalid, due to a model specification error. • The data strongly indicates a low unit value for small time changes. There were no apparent issues with data or design which could have contributed spuriously to such an outcome, nor was it an artefact of the model specification.
Denmark – Danish value of time study (Fosgerau et al 2007)	Used a mixed logit model formulation and analysis methodology (based on the Fosgerau 2007 methodology).	Found that the mean VTTS for each mode increases as the level of time savings increases, up to a threshold, after which it is approximately constant. For most modes this threshold was around 15 minutes. For time savings of 3–5 minutes, unit values were in the order of half those at the threshold level.
Sweden – Swedish value of time study (Borjesson and Eliasson 2012)	Used a generally similar approach to the Danish study (based on the Fosgerau 2007 methodology).	Found the mean VTTS increases with the level of time savings, up to a threshold of c.45 minutes for car drivers, c.25 minutes for longer distance PT trips. For time savings of five minutes, unit values were about 70% of the threshold value for car trips, about 50% of the threshold for PT trips.

3.2.3 Possible reasons for lower VTTS for small time savings, based on market research

A number of reasons are advanced by researchers as to why the apparently lower VTTS for small time savings derived from SP research is not a 'true feature' of the value of travel time, but is the result of the artificial nature of the experimental design. These include the following propositions:

- **Short-term focus of SP methods**. SP survey methods typically encourage a short-term focus by the respondents; unless specific instructions to the contrary are given, respondents are likely to assess the options presented as of a one-off, short-term nature, so they perceive little or no opportunity to adjust their behaviour to make good use of any time savings. In the longer term, it might be expected that a regular time saving would become incorporated into people's schedules, so that they could secure significant benefits from it. (An alternative explanation is that a proportion of people are never likely to be able to make effective use of small time savings, and hence the lower values for small time savings are a 'true' feature.)
- **Task simplification**. When making choices in an experiment, people will tend to ignore time savings that are 'too small to matter' (eg very small compared with the overall journey time). This will be an issue particularly when survey respondents are presented with a mix of larger and smaller time savings.
- **Treatment of variabilit*y***. One reason for low valuations of small time savings may be that respondents assume the time savings will be imperceptible relative to the day-to-day variability in the time taken for typical trips. (This might be addressed through specific statements about trip time variability, or including variability as a specific SP variable – which has been done in some recent studies.)

3.2.4 Treatment of small time savings in evaluation procedures internationally

Our detailed literature and practice review (appendix C) includes a review of the treatment of small time savings in the economic appraisal procedures adopted in leading countries internationally. It finds that:

- The great majority of countries adopt the constant unit value (CUV) approach, ie with no discounting of values for small time savings.
- The main exceptions to this are: (i) Germany, which discounts travel time savings (for road traffic) of <5 minutes by 30% from the standard unit values; and (ii) Canada, which uses a CUV approach in valuing savings of <5 minutes (per one-way trip), but states that these savings should not be included in the overall economic performance results (BCR etc).
- Several countries that previously used discounted values for small time savings have now changed to the CUV approach – these include the USA and France.
- UK (England) requires travel time benefits to be classified according to the size of the time savings (with six time bands being specified). The EU (HEATCO) recommends that the proportion of economic benefits derived from time savings of less than three minutes should be identified.

3.2.5 Considerations in the case for/against discounting small travel time savings in economic appraisals

Under this heading we make the following comments:

- There is clear evidence that SP-based market research methods result in apparently lower VTTS for small time savings, up to time savings thresholds of 20+ minutes.

- However, SP methods tend to focus respondents on a short-term perspective of the benefits of time savings, in which there are many constraints on how people might benefit from these savings. In establishing VTTS for economic appraisal purposes, a longer-term perspective is required (given the typical 30+ years economic life of major transport investments).
- Taking a longer-term perspective, there is a lack of compelling evidence that transport user valuations of time savings would be significantly lower for small time savings than for larger savings.
- In the medium to longer term, the concept of travel time savings as a result of specific transport improvement schemes in the past becomes irrelevant. A large proportion of users of the transport system in say 20 years' time will be making different trips by different means than they are currently (some of them will not yet be born), and their behaviour will not be influenced by how much better the transport system is compared with what it might have been under a hypothetical (unimproved) situation that never materialised. People's behaviour in the future will be influenced by the overall quality of the transport system for the trips they wish to make, not by how much better/faster or worse/slower it is than a hypothetical alternative system.
- In practice, it is not difficult to estimate the distribution of time savings and corresponding economic benefits from an individual road project according to the extent of the time savings (more information on the distribution is required in the UK procedures).
- However, substantial practical difficulties would arise in applying any appraisal methodology that involved different unit VTTS for time savings of different sizes. These include:
  - Disaggregation issues. The benefit estimates for a scheme would differ according to whether it was divided into two (or more) sub-schemes or evaluated as a whole.
  - Appraisal complexity. The economic appraisal results would depend to an important degree on the distribution of time savings by their size, which would impose a severe requirement for difficult and expensive data.

If the view is taken that the apparently lower VTTS for small time savings is the result of the artificial nature of the SP design, then further efforts would appear warranted to develop improved designs. We suggest that these efforts should be focused on (at least) two aspects of the design:

- Emphasise the need for respondents to look at the time savings from a longer-term perspective (eg noting that, if they make a similar trip say 250 times per year, then the annual savings will be about X hours per year).
- Emphasise that the travel time variability for all options being traded off would be similar (eg zero). This might be helped by including travel time variability as an additional factor in the experimental design.

Both these aspects were considered, and addressed to some extent in the exploratory market research undertaken as part of this project (refer chapter 5 and appendix E).

4 New Zealand evidence on variation in VTTS with income and trip length

4.1 Introduction

This chapter addresses one of the project tasks which was specified as follows[6]:

> *To investigate and specify the work required to re-analyse the 2001 BCHF/SDG market research database, in order to assess New Zealand evidence on the variation in car driver VTTS with: (i) trip duration (distance); and (ii) household income (HHI).*

This task was addressed in two parts:

- The first part (section 4.2) presents the findings of an initial investigation of the relationships established by BCHF et al (2002) based on the 2001 car driver survey.
- The second part (section 4.3 following) sets out a specification of the work involved in a re-analysis of the original survey records, should a more detailed look at the variations in car driver VTTS with trip distance and (HHI) be thought worthwhile.

Our conclusions and recommendations then follow in section 4.4.

A summary and commentary on salient features of the 2001 car driver survey is provided in appendix D.

4.2 Analysis methodology overview

The BCHF analyses of the 2001 car driver survey were carried out separately for commuting trips and for other trip purposes. The 'base' model calibrations established the relationships between the time and cost variables, with the unit VTTS being derived as a ratio of the time variable to the cost variable. A fuller specification then allowed for the time and cost responses to vary with income and distance travelled. The results with this specification were consistent with the hypothesis that VTTS increases with HHI and with trip length.

After deletion of non-significant parameters, the following equation resulted for commuter travel[7]:

$$VoT = (0.0448 + 0.00068 * HHI)/(0.7235 - 0.0022 * TL) \qquad \text{(Equation 4.1)}$$

where: HHI = household income ($000pa, 2001)

TL = trip length (km)

VoT = unit value of time ($/min).

A similarly structured equation resulted for other purpose travel and had values not very different from those for commuter travel. For simplicity, the following analysis focuses on the commuter travel equation.

[6] The specification of the phase 3 tasks was agreed at a workshop held on 12 June 2014 between the consultants (Ian Wallis/Kerstin Rupp) and the Transport Agency (Iain McAuley).

[7] Given in BCHF et al (2002), para 5.2.30. Table 5.2.4 of that report gives t-statistics for the significance of the parameter estimates, showing that all four of the parameter estimates in the equation are highly significant (t>6.2 in all cases).

Table 4.1 applies the commuter VTTS equation to examine how VTTS varies with (i) HHI; and (ii) trip distance. We note that:

- The average HHI (2001) of the survey respondents was approximately $44,000pa.
- The average commuter trip length was stated to be about 19km, but noting that very short trips (less than 10 minutes duration) were excluded from the survey (NZ Household Travel Survey mean distance estimates were 10.7km for commuter trips, 9.1km for other trips)[8].

The following comments on these results.

4.2.1 Effects of household income

The lower section of table 4.1 examines, for a typical (surveyed) commuter trip of 20km, how the VTTS varies with HHI when applying the above BCHF formula:

- For a given trip length, the VTTS is a linear function of HHI.
- At the typical trip length of 20km and the average HHI of $44,000pa, the VTTS is 11 cents/ minute ($6.60/hour).
- This value varies by 1 cent/minute for a variation in HHI of $10,000pa.
- For an HHI of half the average value, the VTTS reduces by 20%. For an HHI of double the average value, the VTTS increases by 40%.
- In each case, the linear (arc) elasticity of VTTS with respect to HHI is 0.40; the logarithmic (point) elasticity values lie (as expected) either side of this arc value, at 0.32 and 0.49.

Section 6.1.3 of this report summarises the international evidence on this relationship. It finds that the evidence tends to indicate lower income elasticities from cross-sectional studies than from time-series studies, with typical values from cross-sectional studies around 0.4 to 0.5. Thus these New Zealand results are very consistent with the international evidence.

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[8] There is some lack of clarity in the BCHF report in regard to trip length statistics. Section 5.1.18 notes that, based on the survey data, 'The average trip length for commute trips is 19km, for other trips the average is 62km.' It also notes that all trips of less than 10 minutes duration were excluded from the surveys. The report sections 5.2.18/ 5.2.26 quote NZ Household Travel Survey data that the average distance travelled to work was 10.7km, and for non-commuting trips was 9.1km. No attempt appears to have been made to reconcile these large differences between the two sources, although it would appear likely that this is mainly the result of the omission of shorter trips from the BCHF surveys.

Table 4.1 Car driver value of time vs trip length vs household income (equation 4.1)

Ex Beca/SDG 2001 survey formula					
VoT = (-0.0448 - 0.00068 HHI)/(-0.7235 + 0.0022* TL)*					
where: HHI = household income ($000pa)					
TL = trip length (km)					
VoT = unit value of time ($/min)					
HHI	**TL**	**VoT**	**VoT**	**Elast VoT wrt TL**	
		c/min	**$/hr**	**Log**	**Linear**
44	5	10.5	6.29		
44	10	10.7	6.39	0.046	0.063
44	**20**	**11.0**	**6.60**		
44	40	11.8	7.05	0.097	0.130
44	100	14.8	8.90		
44	200	26.4	15.81		
44	300	117.7	70.60		
44	400	-47.7	-28.65		
HHI	**TL**	**VoT**	**VoT**	**Elast VoT wrt HHI**	
		c/min	**$/hr**	**Log**	**Linear**
10	20	7.6	4.56		
20	20	8.6	5.16		
22	20	8.8	5.28	0.322	0.400
30	20	9.6	5.76		
40	20	10.6	6.36		
44	**20**	**11.0**	**6.60**		
50	20	11.6	6.96		
60	20	12.6	7.56		
70	20	13.6	8.16		
80	20	14.6	8.76		
88	20	15.4	9.24	0.486	0.400
90	20	15.6	9.36		
100	20	16.6	9.96		

Abbreviations: VoT = value of time; HHI = household income; TL = trip length; wrt = with respect to; elast = elasticity; c = cent; hr = hour; min = minute.

Note: BCHF (2002, para 5.2.31) notes that, in regard to the relationship between value of time and trip length: 'Moreover, the relationship fails as the trip length increases towards 300km because the denominator approaches zero. It would be unwise therefore to use it to estimate value of time for trips longer than around 100km.'

4.2.2 Effects of trip length (duration)

The BCHF survey/analyses used trip distance (km) as a measure of trip 'duration'. The upper section of table 4.1 examines, for an average HHI (2001) of $44,000pa, how the VTTS varies with the trip distance (trip length) when applying the above BCHF formula.

We first note the comment in the BCHF report (refer footnote to table 4.1) that the formula relationships should not be applied to trips longer than about 100km (results for these are shaded in the table). Further, we note that as trips taking less than 10 minutes were not surveyed, most trips shorter than 5km (corresponding to a 10-minute trip at a typical urban commuter speed of 30km/h) would not be covered. Subject to these caveats:

- At the average HHI of $44,000pa, the VTTS is 11 cents/km ($6.60/hour) at the (surveyed) typical trip length of 20km.
- For a trip length of half this distance (10km), the VTTS reduces by 3.2%. For a trip length of double this distance (40km), the VTTS increases by 6.8%.
- The linear (arc) elasticity of VTTS with respect to distance is around 0.06 for a halving of trip length and 0.13 for a doubling; while the logarithmic (point) elasticity values are 0.05 for a halving and 0.10 for a doubling.

Section 3.1 of this report includes a review of the international evidence on this relationship. This indicates that, while a quite wide range of elasticity values were found in the international literature, typical values are around 0.15 to 0.20 (eg refer section 3.1.2/table 3.1).

The estimates inherent in the BCHF formulation in the range 0.05 to 0.13 are at the low end of international evidence – being around half or less of the typical values identified in this evidence. Without re-analysis of the original dataset, it is not clear whether this elasticity estimate is significantly different from zero.[9]

We are not aware of any valid explanation for these relatively low values. While the BCHF formulation is such that the elasticity is higher for longer trips than those on which we have estimated these values, we note the BCHF comment that its formulation becomes increasingly unreliable (and eventually 'fails') for longer trips; and we also note that there would have been relatively few longer trips in the data set used to calibrate the BCHF model. Further, we note the omission of shorter duration (less than 10 minutes) trips from the survey: this could well have affected the relationship established by BCHF, although it is far from clear that it is a causal factor in the low elasticity value we have derived.

By going back to the original dataset, a new model formulation based on (say) a constant VTTS elasticity with respect to distance could be calibrated – although it may well not provide as good a fit to the data as the current formulation. Such a model may result in a somewhat higher elasticity value than the 0.05 to 0.10 range estimated above, although we would not anticipate a major increase from these estimates. Such a re-analysis would also allow for establishing the significance (confidence interval) of any new elasticity estimate.

[9] Prima facie, it is puzzling that the VTTS elasticity with respect to trip distance that we have estimated (around 0.06), for trip lengths in the range 10km – 40km) is so low, given that the coefficient of the trip length variable in the commuter equation (0.0022) is very significant ($t = 8.5$). This may be the result of the coefficients being estimated over the full distribution of journey lengths, although the BCHF report advises that the relationship should not be used for trips longer than c.100km.

4.3 Specification of potential task to re-analyse the BCHF 2001 car driver survey data

The objective of this (potential future) task would be to re-analyse the BCHF car driver survey database, in order to establish revised relationships for the variations in VTTS with HHI and trip distance.

Our examination in section 4.2 of the relationships established in the BCHF report of unit VTTS to HHI and trip distance have taken us further than originally anticipated towards meeting the specified objective (for subsequent work) of 'assessing New Zealand evidence on the variation in car driver VTTS with trip duration (distance) and household income'. It has established in particular how VTTS varies with (i) HHI, and (ii) trip distance, based on the relationships BCHF derived from the original survey data set. While the BCHF formulation was not couched in terms of VTTS elasticities, we have been able to derive approximate elasticities from this formulation (which may then be compared with international elasticity evidence).

However, we note that the BCHF formulation does not approximate to constant elasticity relationships for VTTS with respect to either HHI or trip length. We also note that, for trip length, the BCHF relationship breaks down completely for longer trips (>100km); and cannot be tested for short (<10 minutes) trips as these were not surveyed: for intermediate distance trips, the implied elasticity values are very low relative to all international evidence.

A next step in analysis, if warranted, would be to go back to the original BCHF survey records and re-analyse the relationships of VTTS to HHI and trip length. Such re-analysis could test a number of alternative formulations, including elasticity-based formulations. In particular, it could examine alternative formulations for the relationship of VTTS to trip length, with the aim of developing a formulation that better fits the data for longer trips, and may shed further light on implied elasticities.

We have ascertained that the original survey records are still available and that re-analysis of these should be feasible. Any further analyses would involve the following:

- Obtain, inspect, understand and transform the database of survey records.
- Undertake further analyses of the data, including testing of elasticity-based and alternative formulations for VTTS with respect to HHI and trip distances.
- Review results, undertake supplementary analyses if required and report findings.

Total consultancy costs for this task are expected to be in the range $10,000 – $15,000.

4.4 Conclusions and recommendations

From our work to date on this topic, we have drawn the following conclusions:

- The BCHF analysis of the 2001 car driver survey data established a relationship of VTTS with respect to HHI and trip lengths.
- The relationship with HHI is linear, with a unit value for a household at double the average income being some 40% higher than that for an average-income household. If an elasticity-based formulation were to be fitted to the data (in place of the current linear relationship), the implied elasticity with respect to HHI would be around 0.4 (at around average income levels). This is well within the range found from international evidence on cross-sectional relationships between VTTS and incomes.
- The BCHF relationship with trip length is more complex, with only small changes in VTTS for trips of up to c.50km, but with the relationship becoming implausible ('failed') for trips of 100+km. To the extent that the BCHF relationship for the shorter trip lengths could be replaced by an elasticity- based

formulation, the implied elasticity values with respect to trip length would be relatively low, at around 0.05 for trips of half the typical length (c.20km) and around 0.10 for trips of double this length. This range is at the low end of the range of values found from international evidence (typical values are in the order of 0.20).

- We have ascertained that it should be possible to obtain and re-analyse the original records from the 2001 car driver survey. This would enable testing of a range of relationships for VTTS with respect to HHI and trip lengths and could be expected to shed more light on the apparently anomalous result we have identified for trip length elasticities.
- While such re-analysis of the original survey records could be done for a relatively modest cost (in the range \$10,000 – \$15,000), we consider it unlikely that it would add much useful knowledge to the findings presented in this chapter. We would therefore recommend against proceeding further with this.

5 Exploratory market research (trip duration and extent of time savings)

5.1 Survey outline

This task involved an exploratory survey (with a non-random sample) to examine people's preferences on two controversial VTTS topics:

1. For a given time saving (eg per week), preferences between the saving comprising small time savings on a number of trips or a larger saving on a single trip.
2. Preferences between savings of given amounts of time on longer trips relative to shorter (c.20-minute) trips.

The survey used SP methods. However, rather than the more usual SP approach of asking people to choose between (two) options with differing travel times and costs, it involved questions asking people to express their preferences between two options that:

- in part (1), involved total (the same or similar) time savings over one single trip compared with very small (one to two minutes) time savings over each of multiple trips.
- in part (2), involved (the same or similar) time savings on trips of differing durations.

By varying the survey method from that most commonly used in SP surveys on the valuation of time savings, it was hoped that the survey results might shed new light on these two valuation topics.

The survey questionnaire is attached (appendix E). It was web-based, administered through SurveyMonkey.

Respondents were invited by emails sent out by the project team members to their contacts (and also via Facebook), and then passed on by the initial contacts to their own contacts. In total, 562 completed responses were received. (Most of these were from New Zealand-based respondents, with lesser numbers from Australia, the UK and Germany.)

This is a very satisfactory response for a survey of this 'exploratory' nature. However, it was not a random survey and therefore cannot necessarily be considered representative of the New Zealand (or wider) population.

For all the main survey questions (13 in total), people were asked to express their preference between two options (A and B). Preferences were requested on a five-point scale: definitely prefer A, probably prefer A, no preference/can't decide, probably prefer B, definitely prefer B.

A final question asked respondents for any comments they had on the survey, including any difficulties in understanding the questions and options offered.

5.2 Survey analysis and findings

5.2.1 Overview

Most of the feedback received (either from the survey 'comments' question or from informal discussions with respondents) indicated that people had few difficulties in understanding the questions. A significant proportion of respondents remarked that the survey questions were interesting and had made them think carefully before answering. All the main survey questions were answered by between 95% and 100% of the total respondents.

The survey results are attached in appendix E. For analysis purposes, we derived from these an average preference score. The points on the preference scale were each scored, between ‘definitely prefer A’ (score +2) through ‘no preference’ (score 0) to ‘definitely prefer B’ (score -2). In practice, it was found that:

- For part (1), larger versus smaller time savings per trip, mean preference scores varied from about +0.4 (fairly weak overall preference for A) to about -0.4 (fairly weak overall preference for B).
- For part (2), long versus short trips, mean preference scores varied from about +1.8 (ie strong overall preference for option A, which involved time savings on shorter trips) to about +0.4 (ie fairly weak overall preference for A).

5.2.2 Smaller vs larger time savings per trip

Table 5.1 provides a summary of the results for the five questions on preferences between saving a small amount of time on each of 10 trips per week (option A) and a larger amount of time on a single trip (option B). The total time saved (per week) in the two options being compared was not the same in all cases (see questions 2, 4, 5).

Key points of note from the results presented in table 5.1 are:

- Q1 and Q3 have the same total time savings (per week) in their two options. The responses show a clear preference for option B, ie the option where the total time saving comes from one trip rather than small savings (one or two minutes) on multiple trips. This result is consistent with respondents perceiving lower unit values for small time savings than for larger savings.
- In Q2 and Q5 the total time savings with option B are only half those for option A. The responses show a clear preference for option A. This result is consistent with respondents’ unit valuations (per minute) of the small time savings in option A (one or two minutes) being more than half those of the larger time savings (5 or 10 minutes) in option B.
- In Q4 the total time savings in option B are 75% of those for option A. Respondents (on average) were almost indifferent between the two options (average preference for B was 0.03, which is very close to zero). This result is consistent with respondents’ unit valuations of the small time savings in option A (two minutes) being approximately 75% of those of the larger time savings (15 minutes) in option B.

In summary:

- The survey preferences indicated that for a given total time saving (per week), respondents had a clear preference for this to relate to a single trip rather than being a small amount on each of multiple trips.
- On average, respondents were indifferent between saving 15 minutes on a single trip versus two minutes on each of 10 trips (ie 20 minutes total). The implication of this is that their revealed unit (per minute) VTTS for a two-minute time saving was c.75% of that for larger (15 minutes) savings.

Table 5.1 Survey analysis (part 1): time saving preferences-smaller vs larger time savings

Quest #	Option	Time saving min/trip	Trips/ week	Tot saving min/week	Response #	Preferences A def	A prob	No pref	B prob	B def	Average Pref A (1)	Comments on results
1	A	**1**	**10**	**10**	**562**	109	69	47	175	162	**-0.38**	
	B	**10**	**1**	**10**		*19.4%*	*12.3%*	*8.4%*	*31.1%*	*28.8%*		
2	A	**1**	**10**	**10**	**558**	166	107	62	156	67	**0.27**	
	B	**5**	**1**	**5**		*29.7%*	*19.2%*	*11.1%*	*28.0%*	*12.0%*		
3	A	**2**	**10**	**20**	**559**	105	86	34	139	195	**-0.42**	
	B	**20**	**1**	**20**		*18.8%*	*15.4%*	*6.1%*	*24.9%*	*34.9%*		
4	A	**2**	**10**	**20**	**555**	145	96	32	161	121	**-0.03**	
	B	**15**	**1**	**15**		*26.1%*	*17.3%*	*5.8%*	*29.0%*	*21.8%*		
5	A	**2**	**10**	**20**	**560**	193	115	51	127	74	**0.40**	
	B	**10**	**1**	**10**		*34.5%*	*20.5%*	*9.1%*	*22.7%*	*13.2%*		

Notes:

(1). This average is calculated by averaging the % preferences in each of the preference categories, assuming these are on a linear scale, and on the basis that 'A def' = 2.0, 'No pref' = 0.0 and 'B def' = -2.0.

5.2.3 Time savings on shorter vs longer trips

Table 5.2 provides a summary of the results for the eight questions on preferences for saving a given amount of time on a shorter trip vs a longer trip. For some questions, the specified time saving is the sane in each option; for other questions the time saving differs between the options.

Key points of note from the results presented in table 5.2 are:

- Q8–Q13 all involve the same base trip times (A 20 minutes, B 120 minutes), with absolute time savings for A of 5 or 10 minutes, for B of 5–20 minutes, and differences in time savings (in favour of A) of +5, 0, -5, -10 minutes.
- For the questions with equal time savings in both options (Q8, Q11), the average preferences for A are 1.62 (five minutes savings), 1.60 (10 minutes savings). For equal time savings, these indicate very strong preferences in favour of savings on the shorter trips, ie the unit VTTS benefits are perceived as considerably lower on the longer trips.
- For the question with A having a greater time saving, by five minutes (Q10), the average preference for A increases to 1.80, ie by about 0.2 relative to the equal time savings case above.
- For the questions with A having a lesser time saving, by five minutes (Q9, 12), the average preference for A reduces to 1.02 (Q9) and 0.98 (Q12), ie by about 0.6 relative to the equal time savings case above.
- For the question with A having a lesser time saving, by 10 minutes (Q13), the average preference for A reduces further to 0.44, ie by about a further 0.6 relative to the five minutes time savings case above.
- While no question was included with A having a lesser time saving by 15 minutes, extrapolation of the above results suggest that, in such a case, there would be a modest preference in favour of B.
- The implication is that, for this scenario with base trip times of 20 minutes (A) and 120 minutes (B), the time savings for the longer trip would need to be 10–15 minutes greater than those for the shorter trip for respondents (on average) to be indifferent between the two trip options. The implication of this is that respondents' unit VTTS were substantially lower (in the order of one half) for the longer trip relative to the shorter trip in this scenario.
- Comparing these results with those for Q7, it appears that in that scenario (base trip times 20 minutes, 60 minutes), the time savings for the longer trip would need to be 5–10 minutes greater than those for the shorter trip for respondents (on average) to be indifferent between the two trip options.

Table 5.2 SP survey analysis (part 2): time saving preferences – long vs short trips

Quest #	Option	Base trip	Time saving		Response	Preferences					Average	Comments on results
		time	Mins	%	#	A def	A prob	No pref	B prob	B def	Pref A (1)	
6	A	20	5	25%	541	366	109	32	25	9	1.48	Equal time savings: results show strong preferences (i.e. savings valued more
	B	60	5	8%		*67.7%*	*20.1%*	*5.9%*	*4.6%*	*1.7%*		highly) for shorter trips.
7	A	20	5	25%	537	155	111	48	156	67	0.24	Although B has 5 minute (double) time saving over A, A is still preferred
	B	60	10	17%		*28.9%*	*20.7%*	*8.9%*	*29.1%*	*12.5%*		(although not by a wide margin). Compare results with Q9.
8	A	20	5	25%	536	392	103	26	9	6	1.62	Equal time savings: results show strong preferences (i.e. savings valued more
	B	120	5	4%		*73.1%*	*19.2%*	*4.9%*	*1.7%*	*1.1%*		highly) for shorter trips. Very similar results to Q11; but compare with Q7.
9	A	20	5	25%	538	261	147	37	67	26	1.02	Although B has 5 minute (double) time saving over A, A is still quite strongly
	B	120	10	8%		*48.5%*	*27.3%*	*6.9%*	*12.5%*	*4.8%*		preferred. Very similar results to Q12.
10	A	20	10	50%	531	458	53	10	5	5	1.80	Very strong preference for A, with 5 minute time saving relative to B.
	B	120	5	4%		*86.3%*	*10.0%*	*1.9%*	*0.9%*	*0.9%*		
11	A	20	10	50%	538	408	81	19	23	7	1.60	Equal time savings: results show strong preferences (i.e. savings valued more
	B	120	10	8%		*75.8%*	*15.1%*	*3.5%*	*4.3%*	*1.3%*		highly) for shorter trips. Very similar results to Q8.
12	A	20	10	50%	538	268	130	30	83	27	0.98	Although B has 5 minute time saving over A, A is still quite strongly preferred.
	B	120	15	13%		*49.8%*	*24.2%*	*5.6%*	*15.4%*	*5.0%*		Very similar results to Q9.
13	A	20	10	50%	538	179	122	56	117	64	0.44	Although B now has 10 minute time saving over A, A is still significantly
	B	120	20	17%		*33.3%*	*22.7%*	*10.4%*	*21.7%*	*11.9%*		preferred.

Notes:

(1). This average is calculated by averaging the % preferences in each of the preference categories, assuming these are on a linear scale, and on the basis that 'A def' = 2.0, 'No pref' = 0.0 and 'B def' = -2.0.

In summary:

- The survey preferences indicated that respondents had a strong preference (ie implying a higher valuation) for a given time saving on a shorter (c.20 minutes) trip than a longer (60–120-minute) trip.
- For the scenario comparing savings on a 20-minute trip against a 120-minute trip, the time savings on the longer trip would need to be about 10–15 minutes greater than on the shorter trip, for respondents (on average) to be indifferent between these two options. This indicates that respondents' unit VTTS were substantially lower (in the order of a half) for the longer trip relative to the shorter trip.
- Similarly, in comparing savings on a two-minute trip with those on a 60-minute trip, the time savings on the longer trip would need to be 5–10 minutes greater than on the shorter trip for respondents (on average) to be indifferent between these two options.

5.3 Discussion of findings and international comparisons

5.3.1 Discussion of findings

This section reviews and comments on our survey results in the light of the international and New Zealand evidence on(1) how unit VTTS varies with: (i) the extent of time savings (per trip); and (2) the duration of the trip involved.

In attempting to compare the findings of our survey with the international evidence, it is important to note the differences between our survey approach and that commonly used in the main national (and some other) VTTS research studies in other countries:

- The prevailing approach used in international research studies into VTTS is an SP methodology based on actual (recent or frequent) trips made by the respondent, requiring the respondent to choose between their actual trip and a similar (or the same) trip with marginal changes in both travel time and some measure of costs. The unit VTTS is then derived (in principle) as the ratio of the cost change to the time change to which respondents (on average) are indifferent. A key point is that the methodology involves the respondent in marginal time vs cost trade-offs for a single trip (with which they are familiar).
- When developing a relationship between unit VTTS and (for example) trip duration or distance, the international studies examine the SP findings on marginal time vs cost trade-offs for trips of (typically) different distances. It is unclear whether it is appropriate to apply the resulting unit values to the valuations of any time savings (eg resulting from road improvements) on a trip of a given distance.
- The methodology adopted in our exploratory survey is distinctly different from that commonly used in VTTS studies (we are not aware of a similar methodology being used in any previous studies on this topic). It does not attempt to estimate absolute **valuations**, but rather to establish respondent **preferences** between different options that save the same (or a similar) amount of time. Essentially, it involves respondents in time vs time (in different situations) trade-offs, rather than the conventional time vs money trade-offs.
- For example, the second section of the survey asked respondents to give their preferences between saving a specified amount of time on a shorter (time) trip vs a longer (time) trip. One output was the point of indifference (no preference) between a saving of X minutes on a 20-minute trip or Y minutes on a 120-minute trip. In our view, it is then valid to infer from such preferences that, if X >Y, the respondent places a higher value (per minute) on a given time saving (minutes) for the shorter trip

than for the longer trip. This was one of our survey findings. Any variations in the (perceived) disutility of marginal costs with distance are not relevant to this finding, as our survey methodology is concerned with travel times only.

- Our survey method has a number of **strengths** relative to the VTTS research methods generally adopted, in particular:
  - In the case of smaller vs larger time savings, its emphasis on the repetitive/frequent nature of trips helps to overcome one of the weaknesses of the conventional SP methodology, that it encourages a very short-term/one-off focus (with low unit values resulting for small time savings).
  - Arguably, the trade-offs adopted between the same (or similar) time savings in different situations are more readily interpreted than the results of conventional SP exercises, where income and other characteristics of individuals may complicate interpretation of the underlying results.
  - Arguably also, the preferences expressed in regard to saving time in different circumstances (eg longer vs shorter trips) are more relevant to typical VTTS applications (eg reducing the travel time for a given trip) than is a function for how people trade off marginal time vs cost changes for trips of different distances.
- Our survey method also has a number of potential **weaknesses**, relative to the SP methods generally used, including:
  - It is possible that the differing specified trip distances and trip frequencies in the various options results in respondents regarding the specified options as differing in other respects (eg comparing a trip made 10 times per week, most likely commuting, with a trip made once per week, more likely shopping, social, etc and similarly when comparing a 20-minute trip with a 120-minute trip); this may bias the results.
  - Our method allows only **relative** valuations to be estimated (eg respondents' unit VTTS for a two-minute time saving was c.75% of that for a 15-minute saving), not absolute VTTS. Where required, it would need to be 'anchored' against absolute values obtained by other methods.
  - Our survey did not involve a random sample. However, the sample size was relatively large (very large for an 'exploratory' survey), and the results were very clear-cut: it seems highly unlikely that random sampling would have made major differences to the results.

To date, given the time and budget constraints on this research project, we have not been able to reach a definitive view on the merits of our exploratory survey methodology relative to the SP methods generally used in VTTS research internationally. In the following, we make brief comments on how our survey findings compare with those from research studies internationally.

5.3.2 Comparisons with international evidence – smaller vs larger time savings per trip

Comparing our survey findings with the international evidence summarised elsewhere in this report (chapter 3.2 and appendix C), for small time savings in particular, our comments and conclusions are as follows:

- Our international review found that, based on 'conventional' SP surveys, expressed unit values of time for 'small' savings were substantially lower than for larger (15–20 minutes or greater) savings, in almost all studies. It found that unit VTTS for savings of three to five minutes are typically in the order of half the values for larger savings.

- Our survey results were broadly consistent with this pattern from the international evidence, but appear to indicate a lesser discount on small time saving values: our finding is that the unit valuation for a two-minute saving is c.75% of that for a 15+ minute saving.
- This result seems likely to be a reflection of our different survey methodology (and possibly other factors). While the 'conventional' SP methodology tends to put the emphasis on a single trip, in the near past or near future, our survey attempted to emphasise repeated small time savings over a period, or indefinitely. In that respect, it may be regarded as providing more realistic (relative) values.
- Based on our survey approach and this evidence, we suggest there is a case for further consideration of this approach (or something similar) as an alternative to the 'conventional' SP approach adopted, particularly in research on valuing small time savings.

5.3.3 Comparisons with international evidence – shorter vs longer trips

Comparing our survey findings with the international evidence on variations in unit VTTS with trip duration or distance (refer section 3.1 and appendix B), our comments and conclusions are as follows:

- Our literature review of the international evidence on the variation of unit VTTS with trip duration concluded that the strong weight of evidence is that values increase significantly with trip duration (or distance), with typical values for longer trips (3+ hours) being 50%–100% greater than those for shorter trips (in the order of 20 minutes).
- Our analysis of the 2001 New Zealand car driver survey data (BCHF 2002) indicated a weak relationship between unit VTTS and trip distance; the relationship appears to be positive (VTTS increasing with distance), but was not valid for short trips (under 10 minutes duration, which were not surveyed) or for long trips (over about 100km).
- Our survey results indicated respondents had a strong preference for saving a specified amount of time on a shorter trip than a longer trip – which we translated into lower valuations of a given time saving on longer trips: our results indicated that unit values for a two-hour trip are in the order of half those for a 20-minute trip. This result is the opposite of that found in most (but not all) the international evidence (refer section 3.1.2).
- We would speculate that a major reason for the apparent differences from the international evidence is how the questions are posed. In particular, our survey questions make reference to both the absolute (minutes) and proportionate (%) time savings on the trips in question, whereas the 'conventional' SP survey refers only to the absolute time savings.
- Our methodology was designed, in part, to test the 'proportionality' argument, ie that people tend to value time savings more as a proportion of their total trip time than in terms of absolute minutes saved. Our results tend to give support to this argument. We note (section 3.1.4) that detailed empirical analysis of this argument has not been undertaken hitherto.
- We also question whether the value function vs trip distance established in the international research studies is the most appropriate for valuing the time saving benefits of road/transport improvements on a given trip.
- We make no attempt at this stage to conclude which survey methodology is likely to provide answers that more closely reflect actual traveller behaviour.

5.4 Recommendations on further market research methods and applications

Resulting from the exploratory survey on VTTS aspects undertaken in this project and the 'unfinished business' associated with the interpretation of the survey results, we recommend that any further New Zealand-based work on VTTS market research methodologies should incorporate the following tasks:

1. Distribute this chapter (5) of the report to a selection of international 'experts' in the field of VTTS market research, to seek feedback specifically on our (exploratory) survey methodology – including its validity, its strengths and weaknesses relative to conventional VTTS (SP) methods, and how it might be enhanced.
2. Depending on the outcome of task (1), undertake some qualitative research (focus groups and/or in-depth interviews). This research would investigate issues concerning attitudes to and valuations of small time savings and similarly attitudes to and valuations of time savings on trips of different durations/distances.
3. Following tasks (1) and (2), it may then be appropriate to undertake further quantitative market research in New Zealand, covering random samples of the travelling population. This research could be separate from, or part of, any future comprehensive update of the last (2001) major New Zealand surveys of VTTS issues.

6 'Equity' issues and the treatment of income effects

6.1 Equity values of time – rationale and issues

6.1.1 Introduction

There is significant contention in the literature regarding whether 'non-work' values of time applied in transport project appraisals should be based directly on WTP evidence relating to particular circumstances (and therefore linked to income or ability to pay) or whether an (averaged) 'equity' valuation approach should be adopted. A separate question relates to how 'non-work' values of time should vary over time, as incomes change. This chapter explores the literature on the theoretical and practical considerations involved and considers the empirical evidence on the relationship between values of time and incomes. It also summarises international practices with respect to 'equity' valuation approaches, as a prelude to considering potential policy options in the New Zealand context, which is the subject of section 6.2.

6.1.2 Key theoretical and practical considerations

In principle, the objective of an 'equity' value is to adjust for income differences, although it is widely recognised that behavioural values of time differ by numerous factors other than income. We define the 'equity' approach as involving the adoption of a single (generally weighted average) value of time savings for non-work time independent of the incomes of the users of the facility/service being appraised: such a single value typically covers all areas/regions of a country, urban and rural situations, and all modes, and it may also cover all (non-work) trip purposes. It may or may not extend to cover different travel conditions (eg congested vs uncongested, seated vs standing PT passengers).

There is no universally accepted or agreed approach to the use of 'equity' values for 'non work' values of time and their wide use appears to be driven by a combination of political and practical considerations. From a pure economic efficiency perspective, (income-varying) WTP-based values should be used in economic appraisals as they are more likely to relate to market values which will incentivise the efficient usage of resources. This is particularly important in the appraisal of commercial projects through an approximation to market responses (and price signals). From an income-distributional perspective however, a WTP-based approach would likely weight appraisals in favour of projects associated with higher income travellers and this is widely considered as inequitable for publicly funded projects.

Aside from distributional concerns with WTP-based values of time, there is a range of widely acknowledged practical considerations associated with the use of equity values. These include decisions relating to the measurement of the 'equity' value (an important example being the question of trip- or distance- weighting[10]), and how and at what level they should apply (with implications for the range of detailed information required for their application).

In practice, many countries adopt 'equity' values in economic appraisals supplemented by a range of separate adjustments to allow for other personal and trip characteristics (eg comfort, reliability) that affect 'non work' values of time.

[10] Given the apparent relationship between VTTS and distance (refer section 3.1), the latter form will incline towards higher values.

A summary of the key theoretical and practical considerations discussed in the literature relating to the use of equity values for economic appraisal purposes is provided in table 6.1.

On the basis of the research presented in this table we can deduce four key areas with respect to ‘equity’ values: income distribution, definition of ‘equity’ value, changes over time and types of inconsistency (ie predicting the wrong choices and getting the wrong outcomes).

Table 6.1 Key theoretical and practical issues concerning the use of 'equity' values in transport appraisals

Topic	Key issues	Perspectives
Equity	Given the well-established positive relationship between income and WTP, the use of WTP-based values of time in transport appraisals will assign higher value to projects associated with high-income travellers. There is significant contention in the literature as to whether distributional concerns with transport investments should be addressed through the use of 'equity' values or more widely through other social welfare mechanisms.	*One view which supports WTP-based values is that it is the role of income tax and the social welfare system to redistribute incomes, and to provide transport subsidies. This process should be transparent and manipulation of the methods of project assessment should not be used as a disguised form of cross-subsidy.* (BCHF 2002). *From an equity perspective, the choice of whether or not to incorporate an adjustment in the VTTS for income levels requires a public policy decision. There is evidence that time values do differ with income levels, and benefit cost principles focus on net benefits to society (regardless of who gains and loses). The overall wealth in the economy is potentially reduced through a deviation from projects with the highest net benefits, and it is traditionally argued that separate policies should be used to deal with income re-distribution.* *The opposing concern is the possibility that government projects (based on highest net benefits) could aggravate income distributions over time and the report acknowledges that this is likely to be influenced by how projects are financed and the mix of projects carried out over time.* (Waters 1992) Appraisal values based on WTP (differentiated between trips/individual as possible) implicitly give more weight to high-income groups (Mackie et al 2001); Pearce and Nash 1981).
Economic efficiency	WTP-based values should be used in transport appraisals as these maximise social welfare and optimise resource allocation (on the basis that the underlying income distribution is considered 'optimal'). Applying an 'equity' value is inconsistent with the underlying principle of CBA that measures project benefits according to what individuals are willing to pay. If applied to project appraisal, this has potential implications for the ranking of transport projects. Furthermore, given that values of travel time savings depend on a range of socio-economic and trip-related characteristics (eg personal characteristics, trip circumstances, quality of travel mode), applying an 'equity' value can go beyond the primary objective of controlling for income (to the extent that allowances are not	*Any departure from WTP VTTS for use in the evaluation of public projects, other than to correct for misperceptions, must be regarded as a departure from consumer surplus principles on which social cost benefit analysis of road projects is ostensibly based. Pure economic efficiency requires that values of time are differentiated according to income in transport appraisals.* (Waters 1993) *The argument that income effects should be removed from the VTTS has lead several countries to adopt appraisal practices where all or almost all differences in the VTTS are removed, sometimes called 'equity values' of time. This practice reduces the information contained in the appraisal, and eventually leads to the misallocation of resources across the transport sector. Differentiating the value of time in appraisal shows which kinds of travel time reductions will create most value to society.* (Borjesson and Eliasson 2012) *In line with the requirements of the Pareto ranking, the fact that the value of a time saving is a function of the level of income implies that in cost-benefit studies we should differentiate between groups with different incomes and apply higher values of time for those with higher incomes.* (Bruzelius 1979)

Topic	Key issues	Perspectives
	made for other effects).	
Funding	'Who pays' and 'who benefits' are important considerations. An equity approach might be appropriate for publicly funded projects, where the benefits are largely expected to remain within the community. However, for privately funded projects, investors are seeking the best estimates of costs and benefits and a departure from market (WTP-based) values could lead to inefficient resource allocation. The ultimate consideration in whether equity valuations should be used rests on how the policy is funded and who are the final beneficiaries of the transport investment. Where a project is paid for with public funds, and a substantial part of the benefits are expected to stay with travellers, income effects should be removed. The VTTS should be based on the marginal utility of money of the relevant funding source (eg state, region, city) and is likely to vary for regionally funded projects compared to nationally funded projects. (Borjesson and Eliasson 2012).	*When projects are publicly funded (directly or indirectly), we need to use an Equity Value of Time, otherwise there will be a tendency to build new roads in richer parts of the country for example.* (Fowkes 2010) *If greater involvement of the private sector were envisaged in NZ, for example in tolled roads, then a departure from market values would be inefficient (in that private sector providers would base their analyses on unadjusted WTP values).* (BCHF et al 2002) *In application to the M2, the paper states that an equity value is not suitable as potential investors need the best estimate of potential traffic (unless there is agreement with the State Government that the equity issue must be considered).* (Hensher 1994) *The British approach….may have been reasonable when appraisals were primarily applied to government funded projects, but appraisals now are often applied to schemes which explicitly trade off time savings against money costs. In these cases, it could conclude that the scheme was highly desirable on the basis of a standard value of time, when according to actual values of the user it was not (or vice versa).* (Nash 2010)
Consistency	There are two key issues relating to 'consistency': one is the importance of consistent treatment of time and non-time benefits in appraisal. Another is the mismatch between values used in forecasts and appraisals. If income effects are removed from values of non-work time savings (via the use of 'equity' values of time) in appraisal, many argue in the literature that this should also apply to other appraisal costs and benefits. It is also important to note the distinction between values of time used for demand forecasting/	*Although theoretical and empirical evidence generally conclude that there is some link between VTTS and income levels, many government agencies are reluctant to recognise this and some explicitly reject such an adjustment on equity grounds. This results in an inconsistent treatment of time and non-time benefits (and/or costs) in public projects, hence could distort choices among government investments.* (Waters 1993) *The reasoning behind the use of equity values and their relationship to the question of income distribution is anything but clear, particularly since the problem of income distributional consequences of cost-benefit analysis in general is only raised with respect to time savings and not to other cost or benefit items. It is not clear why time savings have been singled out for attention; nor has it ever been explained why an equity value should be a value which is equal for everyone.* (Bruzelius 1979) *The inconsistency arises because, whereas the money costs and benefits of schemes are valued at unadjusted market values, the non-working time benefits and safety benefits are adjusted by the use of a standard value. This*

Topic	Key issues	Perspectives
	modelling and values used for appraisal. In particular, it is generally acknowledged that transport demand modelling should utilise WTP data that most closely reflects real behaviour. Transport appraisal is ultimately more concerned with the socially optimal allocation of resources from a national perspective. Having said this, it is important that where various projects are being ranked on the basis of appraisals (where equity or averaged values are used), it is acknowledged that this might lead to a sub-optimal allocation of resources.	*inconsistency could lead to misallocation of resources; for instance a scheme which gives the poor time savings at an increased money cost of travel could be selected in circumstances in which they would rather forgo the time savings for the sake of cheaper travel.* (Pearce and Nash 1981; Mackie et al 2003) *Overall, as the previous 2003 study concluded for non-work values, we would see the equivalence of appraisal and forecasting values as a practical "second best" option, which will run into problems from time to time with quasi-commercial appraisals such as rail investment and toll roads. This remains, in our view, an unresolved issue, as the remarks about equity, above, imply.* (Wardman et al 2013a) *The standard value of non-working time is an incomplete approach to social weighting and introduces problems of inconsistency between time and costs. Specifically, it leads to the relativities between time and costs being different in modelling and evaluation, and this introduces problems involving users paying for benefits through fares or charges…* (Sugden 1999)
Practical consider-ations		*It is one thing to say what the evidence is for variation in the VTTS with respect to economic, social and trip characteristics. It is another to make recommendations for the application of this evidence in modelling and appraisal practice. There may be reasons of principle for overriding or moderating what the evidence says. Also there may be relevant practical issues – consideration of data collection, cost effectiveness, auditing and control of the appraisal process impinge on what can be recommended…* (Mackie et al 2003) *From a practical perspective, working with income-varying time values requires a range of detailed information from detailed traffic flow data to information on the income levels of travellers.* (Waters 1992) *A number of policy issues arise from the standard value approach:* *First, there is the issue of what sort of average it should be – ie average over travellers or the whole population…, weighted by use? To the extent that values are derived from Revealed or Stated Preference methods it seems reasonable to weight these by current usage.* *Second, there are issues of consistency of treatment within the appraisal. None of the monetary costs or benefits, such as changes in fares or vehicle operating costs, are weighted in any way.* *Third – difference between values for use on public sector appraisal and the values which a commercial operator would wish to use in a WTP analysis of the same project. This becomes more relevant as we move more into a regime of PPPs* (Mackie et al 2001).

6.1.3 Empirical evidence on the relationship between values of time and income

It is important to consider the relationship between 'non-work' values of time and income as this informs both the appropriateness of using 'equity' values at a general level together with the range of potential evaluation approaches. In theory, one would expect the value of 'non-work' time savings to increase with income via the 'marginal utility of income' relationship (see MVA Consultancy et al 1987, section 3.3). This section sets out the empirical evidence relating to the relationship between values of time and income – first summarising the literature in support of an empirical link between income and value of time, then considering the evidence on the magnitude of this relationship.

As noted above, distributional concerns are a key driver of the use of 'equity' values – largely based on an assumed positive relationship between income and values of 'non-work' time. While it is generally accepted that there is an empirical link between 'non-work' values of time and income, the extent of this link should ideally be used to inform the appropriate degree of (dis)aggregation in applied appraisals. As shown in table 6.2, the majority of empirical and anecdotal evidence surveyed in the literature confirms there is a positive relationship between values of time and income.

Table 6.2 Empirical relationship between income and (non-work) values of time

Study	Evidence
Pricing strategies for public transport. (Douglas 2015)	Analysis showed that respondents with higher incomes placed higher values on (a) saving travel time, and (b) the quality of their vehicle (although the strength of the relationship was weaker than for travel time).
UK Department of Transport sponsored national value of time study (MVA Consultancy et al 1987)	The evidence suggests that persons from higher income households tend to put greater value on personal time saving and that the value of time as a proportion of income is a decreasing (rather than constant) function of income. On the basis of research, recommendations were made on the adoption of a range of time values differentiated by income group, mode and employment status. However, while the MVA research led to increased values of (non-work) time savings (increase of 58%), the Department of Transport still recommended the use of a single average value for non-work time savings for all travellers.
Swedish value of time study (2008) (Borjesson and Eliasson 2012)	This involved a stated choice survey with values differentiated with respect to mode, travel purpose and trip length (shorter and longer than 100km). A large number of socio-economic variables were tested, with only four significant variables found: employment status, income, whether there are children in the household and whether the respondent lives in Stockholm. The study found that VTTS increased with income. However, income effects were removed from travel time valuations adopted for appraisal purposes (after significant debate)
Fosgerau et al (2007)	'Theory and estimated models suggest that the *VTTS* should depend on income. Further, different income levels tend to *drive* different modes of transport.'
Bruzelius (1979)	'A study of the empirical evidence indicates that, at *least for the journey to work,* there seems to exist a positive relationship between annual income/wage rates and empirical values of time.'
BCHF et al (1992)	'The VTTS has been found to vary with income in overseas studies, although the income effect does not appear to be as great as once thought.'
Gwilliam (1997)	'Recent studies show a wide distribution of individual time values for given income levels. Slower modes might thus be expected to attract those with lower values of time and faster modes to attract those with higher values. Empirical evidence confirms this hypothesis…'
Mackie et al (2003)	'We find that the valuation of travel time savings varies significantly with income and with journey length.'

In terms of the magnitude of the relationship between values of time and income, the tables below present a sample of the empirical results showing the income elasticity in relation to (non-work) values of time. We present results from cross-sectional studies and time series studies separately in tables 6.3 and 6.4 (respectively).

Table 6.3 shows there is a reasonable consistency on the empirical evidence from cross-sectional studies on VTTS elasticities with respect to income. The elasticity values obtained from evidence from four countries tend to cluster around 0.4 to 0.5. There is insufficient evidence to attempt to distinguish values by trip (non-work) purposes, or by income measure (personal or household, gross or net). The evidence covers both car (driver) mode and PT modes, and again there is no evidence of significant modal differences.

Table 6.3 Evidence on VTTS elasticities with respect to Income differences – cross-sectional analyses

Country	Mode	Source	Income elasticity	Notes
New Zealand	Car driver	BCHF (2002)	c.0.40	Refer analysis in section 4.2. Relates to car driver in-vehicle time (commuter purposes).
New Zealand	PT	Douglas (2015)	c.0.45	Relates to PT in-vehicle time.
UK	Car driver	Mackie et al (2003)	0.36 commute 0.16 other purposes	Values with respect to HHI. Report notes that original values estimated by AHCG (1999) (same data) were 0.65 commuter, 0.35 other purposes.
UK	Car driver	Wardman et al (2008)	c.0.2	M6T study (car drivers). Values with respect to gross HHI. Noted that typical cross-sectional income elasticities are around 0.5.
Sweden	Car driver	Borjesson and Eliasson (2012)	0.50	
Denmark	Various	Fosgerau et al (2005)	0.3 to 0.7	Values with respect to personal income. Stated that values vary by mode, within range 0.3 (bus) to 0.7 (train).
	Car driver	Fosgerau et al (2006)	0.6 to 0.8	Direct income elasticity estimates of 0.63 wrt before tax income, 0.79 wrt after tax income.

Table 6.4 Evidence on VTTS elasticities with respect to income differences – time series analyses

Country	Mode	Source	Income elasticity	Notes
France	--	Boiteux and Baumstark (2001)	0.7	No further details
UK	??	Mackie et al (2003)	0.72 to 0.82	Time series meta-analysis results were 0.72 for all data, 0.82 for IVT data only
USA	??	Zhang et al (2005)	0.75	Cited in US DoT (2012). No further details
EU	All	Wardman et al (2013b)	0.72	Based on Wardman meta-analysis. Income measure GDP/capita. Notes that income elasticitiesby segment in the range 0.68 to 0.85.

Table 6.4 reports on inter-temporal (time series) income elasticities from four separate studies. These studies produce consistent results in the range 0.7 to 0.8, which is substantially greater than the cross-sectional values. However it is acknowledged that income specification affects the results (with most studies based on gross income). In particular, Wardman (2001) concluded ‘There are also doubts about the cross-sectional income elasticities obtained, and whether the income elasticity over time is as low as the cross-sectional evidence implies. In part this relates to whether the use of HHI has distorted the results’.

The estimation of income elasticities is also dependent on other variables (which may themselves depend on income).

Given that income elasticities generally appear to be less than unity (by a considerable margin in some cases), adjustments to WTP-based data by applying income elasticities would still leave significant variability in VTTS both between modes and within modes. This might also suggest that the use of full ‘equity’ values in VTTS might not be appropriate as a means of allowing for income differences (although it might still be supported on practical grounds). In particular, the application of averaged ‘equity’ values would tend to mask the ‘non-income’ effects (ie trip purpose, modal and circumstantial effects) that may be significant determinants of travel behaviour and of non-work values of time.

This is reinforced by the Swedish value of time study (Borjesson and Eliasson 2012) which found that ‘controlling for income differences changes the VTTS only slightly in most cases… Most differences across modes, purposes and trip length remain’. Alternatives to the ‘equity’ approach to adjusting for income differences are examined further in section 6.2, including further discussion of the Swedish evidence and practices (section 6.2.4).

6.1.4 International appraisal practices

This section summarises international appraisal practices with respect to the valuation of non-work time, and in particular the extent of adoption of ‘equity’ values. In practice, due to the wide range of variation in ‘non-work’ values of time savings, appraisal values must by necessity apply simplifying assumptions. The use of ‘equity’ values in economic appraisals continues to be common international practice with all countries surveyed adopting some form of ‘equity’ or ‘averaged’ values.

Table 6.5 Differentiation of ‘non-work’ VTTS – international evaluation practices

Country	Work/non-work values	Comments
New Zealand	$7.80 (commuting) $6.90 (other non-work travel)	EEM 2013 A4.1 (b) Appraisal value (in $/hr 2002). NB 3.15 C, 2.75 other (max congestion increments). See table 6.6 for further details on adjustments in the EEM 2013.
NSW Australia	Private A$13.76/hr 2012 for roads (and recommended TfNSW equity value of time). Rail NSW $14/hr (work commuting.	$13.76 is based on 1997 Austroads 40% average wage rate value. Reliability: Value of travel time variability set equal to IVT. For rail, average lateness, valued at 3.7 * IVT used. Walk 1.15-1.5 * IVT, Wait 1.5 * IVT
England	£6.81/h (commuting) £6.04/h (other)	(2010 values and prices – see DfT (2014a) WebTAG table A1.3.1) Equity values (based on mileage-weighted average value of non-working time savings of travellers) are used in appraisal with no regional/income differentiation. Reliability: ratio: 0.8-1.4 Value of lateness incl. variance 3 * IVT

Country	Work/non-work values	Comments
		Walk 2 * IVT Wait 2.5 * IVT
Germany	€5.47/h (1998) (€6.3/h 2008) (other)	Reduced by a 30% threshold for small time savings to €3.83/h (1998). For 2008, values for time savings below 5 mins are reduced using a declining function.
Netherlands	9–10 (commuting) 6–7 (other)	Values being updated 25% surcharge on time benefits.
Denmark	67 DKK per hour (2004 prices)	Full equity approach applied to in-vehicle travel time (for non-business trips) across all transport modes.
Sweden	Car: €9.8/€11.7 (commuting), €6.1/€11.7 (other) Bus: €5.3/€3.8 (commuting), €2.8/€3.8 (other) Train: €7.2/€7.3 (commuting), €5.0/€7.3 (other)	Differentiated by mode and distance (trips shorter/longer than 100km) Income effects removed ('equity' values).
USA	$12 local (commute and other) $16.70 intercity (commute) $23 intercity (other)	VTTS increases with distance. For local personal travel – VTTS is estimated at 50% of hourly median HHI. Intercity personal travel is valued at 70% of hourly income (Belenky 2011) Reliability: RR 0.8 – 1.1 based on 80th – 50th percentile. $24 Walk and wait

Abbreviations: IVT = in-vehicle time; TfNSW = Transport for New South Wales; DKK = Danish kroner; RR = ??

Note: Adapted from Mackie and Worsley (2013, table B).

As noted by Wardman et al (2013):

> *The principal disaggregation options for appraisal are (i) no disaggregation (i.e. full equity value), (ii) disaggregation by mode as in the existing guidance with further disaggregation by journey length, time of day of trip; and (iii) disaggregation by income with similar level of further disaggregation, through modal specific factors (e.g. issues relating to comfort and productivity would need to be introduced).*

A summary of current international practices with respect to non-work VTTS and the adoption of 'equity' values is provided in table 6.5.[11] As can be seen, a number of countries (including New Zealand, England, Germany and Netherlands) adopt 'equity' values that apply on a national level across all modes (although trip purpose is differentiated). Sweden and the USA adopt 'partial equity' appraisal values, which are differentiated by distance and mode. In a number of cases, various other adjustments are made on the basis of eg congestion, reliability and size of time savings.

While 'equity' values are theoretically aimed at adjusting for income effects, as shown above they are often supplemented by a range of adjustments to account for other (modal and circumstantial) effects. It is worth noting that modal differentiation is commonly used as a form of income differentiation (by proxy).

[11] A more detailed discussion on the recent UK studies and the Swedish value of time studies (in particular) is provided in the section on trip duration.

An alternative approach would be to adjust for income differences (based on income elasticity evidence) but still reflect other behavioural characteristics. Such an approach is addressed further in section 6.2.

6.1.4.1 Relevance of type of application

As mentioned in table 6.1, 'equity' values (that bear no relationship to behavioural or market-based values) are potentially problematic in the application to commercial projects – where market-based values would be more effective in signalling true resource costs to private sector participants. In particular, Nash (2010) states that:

> *('equity' values) might have been reasonable at a time when appraisal was mainly applied to road schemes which were paid for by the government but gave time savings to users, but now that appraisal is often applied to schemes which trade off time savings against money costs (e.g. whether to replace buses with higher priced light rail services, whether to reduce road congestion by means of road pricing), it may be highly misleading. It would be quite possible for the appraisal to conclude that the scheme was desirable on the basis of a standard value of time, when according to the actual values of the users it was not (or vice versa).*

Furthermore, according to Borjesson et al (2012), the 'crux' of the 'equity' debate rests on:

> *what should be assumed about the final beneficiaries of a transport investment. In a situation where the improvement is paid for with public funds, and one has reason to believe that a substantial part of the benefits stay with travellers, differences in VTTS due to income differences should be removed; otherwise, the actual VTTS should be used.*

Some UK commentators have proposed the use of a two- or three-tier system for appraisal that differentiates between 'standard' projects, 'semi-commercial' projects and 'fully commercial' projects (eg M6T). Along these lines, Mackie et al (2003) proposed the following potential breakdown (which was never adopted by the Department for Transport):

'**Level 1 – routine appraisal work** – relatively simple standard values applied to both modelling and evaluation. Much appraisal work in practice should continue to rely on standard values. The benefits of a standard approach outweigh the costs of creating and auditing special values for every context.

Level 2 – major schemes and strategies – the value of non-work travel time savings varies with a number of factors such as income, journey length and retired status. For strategic modelling, including major schemes such as motorway widening, we recommend the use of a more differentiated set of behavioural values than for level one*. A*cknowledging issues of principle and practice, we suggest:

- *in* the first place, a level 1 approach should still be carried out as a benchmark
- *any* level 2 disaggregation by income should present the distribution of benefits separately for the three income levels distinguished
- *as* far as practical, the distributional implications of any increase in the overall benefits consequent on the move from level 1 values to level 2 values should be clearly indicated.

Level 3 – special applications – in some situations it may be necessary to segment the market into sub-components with different WTP characteristics. Examples might include those involving varying mixes of time and cost in the choice set – toll roads, cordon pricing, LRT vs buses – where such market segmentation is essential. In such cases, it is likely that bespoke SP exercises will be conducted in order to elicit context-specific values.'

The above highlights that 'who pays' and 'who benefits' are key considerations in the appropriateness of 'equity' values for transport appraisals. 'Equity' values may be justified for the appraisal of transport projects which are publicly funded and are expected to (primarily) benefit travellers. It may be more appropriate, however, for certain (commercial/privately funded) projects to use WTP-based values that are disaggregated by income. This is becoming increasingly relevant as alternative funding methods are considered for transport projects (ie PPP and user charges).

6.1.5 Current New Zealand practice (*Economic evaluation manual*)

6.1.5.1 NZ Transport Agency new policy

Prior to the new edition of the EEM in 2013, the unit VTTS (for non-working time) in the EEM had been based more-or-less directly on the findings from the 2001 market research and analysis programme (BCHF et al 2002); in that regard, all values were 'behavioural' and no attempt had been made to define values for economic evaluation (appraisal) purposes that differed from these behavioural values.[12]

The Transport Agency changed this policy (and practice) for the 2013 EEM. The NZTA Board, at its meeting on 5 July 2013, adopted a resolution that its economic evaluation policy and procedures be amended… to 'Use a multi-modal approach requiring … equal values of travel time across modes for calculating benefits'.

This policy change was subsequently described in a Transport Agency circular in the following terms (*General circular – funding: no. 13/06*, 17 July 2013): 'We have applied equal value of travel time across all modes in order to achieve equal modal treatment for monetising total travel time benefits with the same travel purposes.'

6.1.5.2 New EEM values

The new EEM unit values of travel time (and reliability) benefits are given in the following sections of the July 2013 manual:

- Section A4.2 – base values (and congestion adjustments, – behavioural values table A4.1a and evaluation values table A4.1b
- Section A4.5 – benefits for changes in trip time reliability (road traffic)
- Sections A18.2–A18.7 – benefits for changes in PT travel conditions, including reliability (A18.2), service frequency (A18.4), transfers (A18.5), PT infrastructure and vehicle features (A18.7).

Table 6.6 presents a summary of which of the EEM VTTS items are relevant to which travel mode (car driver, car passenger, PT, active) and provides additional notes/comments on each item. Further commentary is provided in the next section.

6.1.5.3 Some comments on new EEM relative modal values

As noted above (6.1.5.1), the intention of the Transport Agency's policy change relating to the valuation of travel time savings for application in economic appraisal appears to be that the unit VTTS is:

- independent of mode, but
- differentiated by trip purpose (ie work/business, commuting, other purposes).

This intention appears to be achieved in terms of a 'base' set of unit VTTS, in the new EEM table A4.1b. While it is not explicitly stated in the policy, or in table A4.1b, we assume these values are intended to relate to a set of 'standard' conditions (relatively uncongested and relatively reliable car trips, seated PT trips, 'normal' conditions for active travel trips).

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[12] The market values derived from the BCHF surveys were adjusted downwards to omit the indirect taxation component, and hence to represent resource values considered suitable for economic appraisal.

As shown in table 6.6, these 'base' values are then to be adjusted by a number of factors, particularly for car drivers, car passengers and PT users, creating a relatively complex set of adjustments:

- for car drivers (and car passengers) – adjustments for congestion and travel time reliability
- for PT users – adjustments for reliability, waiting time, interchange time and numerous infrastructure/ vehicle features.

For car drivers and passengers, the effects of these adjustments could be to increase the base VTTS by up to around 50% (in situations where highly congested conditions with unreliable travel times are encountered and/or relieved).

For PT users, it is unclear what the potential increase in the base VTTS might be. But for a short journey involving waiting for an unreliable service, and then making a transfer between routes/modes, the overall increase in the base VTTS could well be 100% or more.

For active travel, no factors are given that would result in adjustment of the 'base' unit values.

Table 6.6 EEM (2013) parameter values for travel time benefit estimation

Item	Car driver	Car passenger[(a)]	Public transport [(a)]	Active modes[(a)]	Notes
Base values (in-vehicle time)	\$7.80/\$6.90	As CD	As CD	As CD	Table A4.1(b)
Congestion (adjustment)	<\$3.15/\$2.75	As CD	–	n/a	Assumed the congestion adjustment applies to car passengers as well as car drivers (not clear from EEM).
Standing (factor)	n/a	n/a	–?	n/a	Appears to be no factor for PT standing passengers for economic appraisal (but factor 1.4 on behavioural values – table 4.1(a) as included in previous EEM). Also no 'standing' allowance for active mode values (was included in previous EEM).
Reliability (car users)	1.065 (factor)	As CD (?)	n/a	n/a	As section A4.5. Understand that factor 1.065 on base value is typical factor for major roading projects that are relieving previously highly congested roads. Assume same factor applies to car passenger as well as car driver (not clear from EEM).
Reliability (PT users)	n/a	n/a	As section A18.2	n/a	Table 18.1 (PT) gives stated IVT factors to be applied to change in average minutes lateness. Assume the table A18.1 values are to be treated as appraisal values as well as behavioural values. Text refers to use of vehicle travel time values (ex table A4.2): suggest this should be PT passenger time values (ex table A4.1b).
Access/egress time	n/a	n/a	?	n/a	Appears not to be explicitly addressed for PT – hence assume as base value ex table A4.1b (previous EEM applied a factor of 1.4).

Item	Car driver	Car passenger[(a)]	Public transport [(a)]	Active modes[(a)]	Notes
Waiting time (service frequency)	n/a	n/a	As section A18.4.	n/a	Method applies a wait time v headway relationship, then multiplies wait time by factor 2.0 (common factor for waiting time) and by standard IVT (ex table A4.1b). Application of the table A18.2 methodology could usefully be clarified.
Interchange time	n/a	n/a	As section A18.5.	n/a	Allows for interchange walk/wait time (with factor 2.0) plus interchange penalty (5 mins IVT). Assume this applies to both behavioural and appraisal values – but not clear (appears to include a walk/wait time factor of 2.0, as previous EEM).
Infrastructure and vehicle features	n/a	n/a	As section A18.7.	n/a	Provides set of perceived values for individual infrastructure and vehicle features for appraisal purposes (expressed in IVT minutes). These values are then multiplied by standard IVT (ex table A4.1b).

[(a)] CD = car driver

Note: Figures are given either in terms of $/person hour (July 2002 prices) or as multiplier factors on 'base' values. Where two sets of figures are shown (eg $7.80/$6.90), the first figure relates to commuting purposes, the second figure to other (non-work) purposes (work values not shown here). Source references relate to EEM (July 2013 update).

6.1.5.4 Specific issues relating to PT values

For PT trips, the earlier (2010) EEM gave a set of behavioural VTTS values, structured broadly into:

- A 'base' behavioural value, relating to in-vehicle time, for PT travel (2010 EEM1, table A4.1) – and giving separate values for seated and standing passengers.
- Various formulations for behavioural values for other journey time components (walk, weight, interchange etc) (2010 EEM2, section 7.2). These formulations were expressed in terms of factors or increments, to be applied to the base behavioural values to give total behavioural generalised costs for the PT trip.

In the new EEM, this structure has been generally retained (new section A18), but a number of apparent anomalies seem to have arisen, which have resulted in the appraisal 'generalised costs' for each journey component no longer being in consistent relationships with the previous behavioural generalised costs for that component (based on the 2001 surveys). Specific examples are:

- **In-vehicle standing time.** Previously valued at 1.4 times IVT (consistent with behavioural evidence), now appears to be valued equal to IVT (there is no specific mention of any differences).
- **Access/egress (walk time) to/from stop.** Previous EEM appeared to value this at 1.4 times IVT (consistent with behavioural evidence), now appears to be valued equal to IVT.
- **Waiting time (service frequency).** The same formulation is adopted in the previous and new EEM, incorporating an assumption that waiting time is valued at 2.0 times IVT.

- **Interchange (transfer) time.** The same formulation is adopted in the previous and new EEM. This incorporates Interchange walk and wait time still valued at 2.0 times IVT (but noting above that access/egress walk time to/from a stop is now valued equal to IVT).

Table 6.7 provides a summary for PT travel of the various factors on IVT required to be applied to the base VTTS value in the previous EEM and the new EEM (noting that the base value has itself been changed). Compared with the previous behaviourally based ratios, anomalies appear to have arisen in relation to journey components for access/egress time and standing (in vehicle) time.

Table 6.7 EEM (2010 and 2013) summary of adjustment factors for PT appraisal. Adjustment factors to 'base' VTTS for PT users: previous (2010) and current (2013) EEM

Item	EEM 2010	EEM 2013	Comments
Standing (in-vehicle)	1.4	1.0	The previous separate standing value has not been included in table A4.1b.
Reliability	Average minutes late formulation	No change	Reference in new EEM (A18.2) to table A4.2 should perhaps be table A4.1b
Access/egress	1.4	1.0	Previously applied pedestrian value – this no longer exists
Waiting time (service frequency)	2.0	2.0	No change (table A18.2 application needs to be clarified?)
Interchange time	2.0	2.0	Also includes a 5-minute interchange penalty. The 2.0 factor applies to walk and wait time – for walking time this is now inconsistent with walk access/egress factor (above)
Infrastructure and vehicle features	1.0	1.0	No change – all values expressed in terms of IVT minutes.

6.1.5.5 Summary

New Zealand practice changed with the new (2013) edition of EEM from an approach which applied different values of time for car drivers, car passengers and PT passengers, with appraisal values based more-or-less directly on behavioural evidence, to the current approach which applies 'equity' values across the various modes (but differing by trip purpose) for economic appraisal. While the Transport Agency's intention to adopt equal values of travel time across all modes has been achieved in terms of the 'base' values of time to be used for appraisal purposes for travel in 'standard' conditions (EEM 2013, table A4.1b), this equality of unit values no longer applies once the various adjustments specified in the EEM are made to the 'base' values. For car trips in congested conditions, these adjustments may be up to 50% on the base value. For PT trips, they may be greater than this and may be in the order of 100% (or more) in some circumstances. For active (walk/cycle) travel, there would appear to be no adjustments (upwards or downwards).

Our review of the structure of the unit VTTS in the updated EEM has also identified a number of anomalies that appear to have arisen in relation to PT values, inasmuch as the new appraisal values do not bear a consistent relationship with the previous values which were based directly on behavioural evidence. The two most significant anomalies appear to relate to access/egress (walking) time and standing (in- vehicle) time: these were previously both valued at 40% above the base time value, but appear now to be valued the same as the base value. It appears that these changes in relativities were not intended, but are the result of an oversight.

6.1.6 Overall conclusions

All countries use a degree of averaging (across regions, market segments etc) in setting unit VTTS for appraisal purposes. While 'equity' is a loosely used term, in the context of this report it generally refers to an approach that does not differentiate values according to the income of the traveller. A range of 'partial' equity approaches may be contemplated, eg:

1 Equalising base (behavioural) values across regions only

2 Also equalising base (behavioural) values across sub-modes (eg bus vs train)

3 Also equalising base values across all modes (eg car vs PT vs active), while still allowing value differences to reflect travel conditions

4 Equalising all values across modes and conditions (ie no adjustment of values for travel conditions such as congestion, reliability, standing etc)

5 Also equalising all values across trip purposes (but probably retaining separate values for business/in work travel and non-work travel).

With the changes in the EEM in 2013, New Zealand has moved broadly from approach 2 to approach 3, ie the main feature of the change is the adoption of the same 'base' values across all modes, while still allowing adjustment of these values according to the specific travel conditions.

Approach 3 is also adopted by a number of other leading countries in the transport appraisal field, including the UK and the Netherlands.

One of the main arguments against the behaviourally-based approach (and thus by implication, favouring the equity approach) is that it is likely to result in more investment tending to be allocated to those areas/modes where traveller incomes are relatively high, at the expense of areas/modes where they are lower: over time this is likely to exacerbate current income differences, which is generally regarded as undesirable. On the other hand, the adoption of an equity-based approach may result in very sub-optimal investment decisions in certain cases, where the behavioural WTP-based estimate of benefits may be very different from the equity-based estimate. This can be a particular problem in relation to commercial/semi-commercial investments, where the market (customers) may be very willing to pay for the benefits of a particular scheme, but it does not proceed because it appears unviable (or of low priority) from an equity-based appraisal. The controversial UK HS2 rail scheme, still under debate, is a case in point.

The empirical evidence internationally on the variation in (behavioural) unit VTTS with income shows quite high income elasticities, although generally less than unity. This indicates that equity adjustment of WTP values is likely to be a substantial issue.

However, it should be recognised that income (household or personal) is only one of many factors that influence an individual's behavioural VTTS for any trip. In addition to the obvious factors (such as car availability), the evidence indicates that while a given individual may have a preference (all other factors being equal) for one mode over another, their choice of mode for a given trip may heavily depend on the circumstances of that particular trip: when they are very time-constrained for a trip (ie have a high value of time) they are likely to travel by car or taxi (fast but expensive); whereas when they are less time-constrained for a trip (with a lower value of time), they are more likely to travel by bus (cheaper but slower). This self-selection process will tend to result in the average VTTS on slow modes being significantly lower than on faster modes, even though the average incomes of those on both modes may be similar. Any 'equity' adjustment of values of time across modes will ignore this self-selection factor – it will be trying to adjust for income differences that may not exist, but instead will over-ride genuine WTP differences that do exist.

One potential approach to this dilemma is to adopt a set of 'income-adjusted' unit values of time. Essentially this would start from behavioural values (as established through SP or similar methods) and adjust these for any differences in average incomes (eg by mode) from the average incomes for the overall travel market (with the adjustment allowing for estimated VTTS elasticities with respect to income). The result would be a set of 'equity' values that adjust only for underlying income differences (between households, areas etc) but still allow for other effects that are not related to income differences (eg self-selection effects). This approach is explored further in section 6.2.

6.2 The concept of and rationale for 'income-standardised' VTTS – exploratory investigations

6.2.1 Introduction

Section 6.2 addresses one of the specified project tasks.

> *To define and further develop the concept of 'income-standardised' VTTS, including commentary on the merits of such an approach and how it might be applied in practice.*

This section follows on from the work on 'equity' values of non-working time (see section 6.1) and is structured into the following sub-sections:

- Summary of policy/practice developments and their rationale relating to the valuation of non-working time for evaluation purposes in key countries – New Zealand (section 6.2.2), UK (section 6.2.3) and selected European countries (section 6.2.4).
- The case for a fresh look at current New Zealand practices (section 6.2.5).
- What the adoption of an 'income-adjusted' approach for New Zealand would look like and how it could be implemented in practice (section 6.2.6).

6.2.2 New Zealand developments and their rationale

Table 6.8 sets out the significant changes in policies and practices relating to non-work VTTS adopted in New Zealand (through EEM and its predecessors) over the last 20–25 years.

Table 6.8 New Zealand policy and practice developments – valuation of non-working time

Year	Review scope	Policies and practices adopted	Comments	Reference
1991	Review by Transit NZ of equity issue and related practices	**Policy** adopted that 'income differences should not be acknowledged in PT evaluation values (ie values should be averaged over all incomes), but that differences between transport modes should be recognised where these existed'. **Practices** adopted: • Car passenger values < car driver values. • Bus passenger (seated) values < car passenger values. • Standing bus passengers > seated bus passengers. • No differences in values between regions (no data available to justify any differences).	The practices adopted were largely based on evidence and practices internationally. However, the differences adopted between car driver, car passenger and bus passenger appear likely to partly reflect income differences as well as intrinsic modal differences (ie may be inconsistent with the claimed policy). No differences between behavioural and evaluation values.	BCHF et al (2002)
1993	Review for NZ Treasury of CBA procedures. Noted that it would be consistent with the Transit NZ Act 1989 principal objective (to maximise national economic and social benefit) for evaluation values to use 'the actual utilities perceived by the users, rather than imposing national or socially-engineered values', and that the use of such imposed values can results in perverse project rankings 'whereby users appear to select options with lower benefits'.	No policy or practice changes relating to 'equity' etc values were made as a result of this review.		Travers Morgan/ McInnes Group (1993), cited in BCHF et al (2002)
1996	Following the formation of Transfund NZ (1996), previous practices were largely continued, with one significant exception.	Values for seated bus passengers were adjusted (increased) to the same level as those for car passengers.	Understood to be a political/policy decision, without any justification in terms of WTP evidence. No differences between behavioural and evaluation values.	BCHF et al (2002)

Year	Review scope	Policies and practices adopted	Comments	Reference
2001-02	Major review of all parameter values based on a programme of new (WTP) surveys of car drivers and PT users.	Findings from the WTP surveys provided the basis for a new set of VTTS. Values were segmented by mode (car driver, car passenger, PT, active) and by purpose (work, commuting, other non-work). Adjustments to base values were made for standing PT passengers, for car user travel time reliability and congestion. No adjustments were made for trip length, despite the evidence on higher values for longer trips (in part due to income effects).	It was noted, in regard to PT, that the Transfund Board 'decided not to adopt equity values, and instead adopted the mode-specific values produced by the NZ research'. No differences between behavioural and evaluation values.	Melsom (2003)
2008	Review of application of practices for people switching to active and shared modes.	In the case of people switching to active and shared modes, adopted practice that they would retain the values from their previous mode.	This was a move towards modal equity in these situations. Unclear whether modal equity values were to be used in more general applications.	NZ Transport Agency (2010)
2013	Review of VTTS policy and practices as part of a wider review/restructure of EEM	New policy stated that: 'We have applied equal value of travel time across all modes in order to achieve equal modal treatment for monetising total travel time benefits with the same travel purposes.' 'Base' VTTS were restructured, to provide separate behavioural (modelling) and evaluation values. Previous behavioural values were retained unchanged. New 'base' evaluation values adopted retained purpose differentiation (work, commute, other non-work), bur adopted the same values across all modes, equal to the highest (car driver) behavioural values.	This was first time that New Zealand procedures differentiated between behavioural and evaluation values. Previous adjustment factors to 'base' values for congestion, reliability vehicle/station quality factors were retained, essentially unchanged (but now applied to different 'base' values). Result likely to be that, typically, factored PT values would be higher than factored car values, which would in turn be higher than active travel values (refer section 6.1.5.3).	NZ Transport Agency (2013)

Key features of these developments have been as follows:

- Until recently (2013), only a single set of non-work values existed, covering both behavioural (modelling) and appraisal (evaluation) applications.
- Prior to 2002, values were largely based on international behavioural evidence (adjusted for New Zealand wage rates etc). Values were differentiated by trip purpose and mode, but not otherwise differentiated by incomes (eg between regions). While the modal differences adopted (and also the trip purpose differences) would have incorporated income differences, the effects of these income differences (relative to other factors affecting the differences in values) remain unclear.
- All values were revised in 2002 as a result of the major market research programme undertaken in 2001 (BCHF et al 2002). However, the overall structure of the set of values was not changed substantially from the prior period – despite the Transfund Board statement that it had 'decided not to adopt equity values', contrasting with the earlier (1991) Transit NZ policy that 'income differences should not be acknowledged in evaluation values'.
- Appraisal values were further revised in the 2013 EEM revision and differentiated (for the first time) from the behavioural values (which remained unchanged from the values established in 2001/02). Appraisal values continued to be differentiated by trip purpose but no longer by mode: the appraisal values adopted were equal to the highest (car driver) behavioural values. The various multiplier factors previously applied to the behavioural values continued to be applied to the new appraisal values (which were now higher than the previous values for all modes except car drivers).

In summary, throughout the 20+ year period up to 2013, appraisal values have been differentiated only by trip purpose.

6.2.3 UK developments and their rationale

6.2.3.1 Current policy and rationale

Current UK policy for economic appraisal purposes is to adopt a standard value of non-working time savings across all modes and all (non-working) trip purposes. This standard value is the mileage-weighted average value of non-working time savings for travellers.

The context for this policy is stated as (DfT 2014c, TAG Unit A1.3):

> *Non-work time savings typically make up a large proportion of the benefits of transport investment. If values of time for appraisal are based on individual's willingness-to-pay (behavioural values) which are related to income, then investment decisions will be biased towards those measures which benefit travellers with higher incomes. Investment would be concentrated into high-income areas or modes, and the interests of those on lower incomes, who may already suffer from relatively lower mobility and accessibility, will be given less weight. For this reason, the first source of variability is controlled for by the use of average values, which should normally be adopted in transport appraisal.*

This policy has remained unchanged since the 1960s.

There are two main arguments supporting this 'standard value' approach:

- **Argument of principle.** In principle, the same values for non-working time savings in all locations and modes should be applied irrespective of the WTP of the particular group of consumers who get the benefits.

- **Argument of practice.** Using a single standard value is a practical procedure to follow given the difficulty of acquiring relevant market information (incomes etc) on which case-specific values would be based.

6.2.3.2 Appraisal of current policy and alternatives

The Mackie et al (2003) report to DfT *Values of travel time savings in the UK* explored the evidence on differences in WTP by mode. It then addressed the question of 'is there a case, in the light of the theoretical and empirical evidence, for modally differentiated values of non-working time?'

In regard to the differences in WTP by mode, this is particularly an issue between PT modes. The Mackie et al (2003) conclusions on this were as follows:

- *There is some evidence that individuals value non-working time savings on the bus mode more highly than for car and these in turn more highly than travel time savings by rail, other things being equal. This appears to be true equally for commuting and leisure.*
- *We interpret these differences as reflecting differences in comfort, cleanliness, information and other characteristics of spending time on each mode. In principle, we think it is consistent with UK public sector appraisal conventions to move towards a differentiated 'value of time' by mode, inasmuch as they reflect users' valuations of these differences.*
- *Evidence also indicates that when aggregating across individuals to the level of 'user types', a reverse pattern is found. Bus users have the lowest value of time savings, followed by car and rail. his pattern is likely to be due to some combination of income differences between the 'user types', differences in journey lengths between modes, and self-selectivity – individuals migrating to modes whose characteristics suit their own.*
- *Although we see no theoretical objections to allowing modal values of time to vary **for the same individual** to reflect comfort etc, valuations in transport appraisal, we think that more work is needed to identify statistically robust values. We would prefer to see these values tied to specific attributes rather than to time.*
- *We also think that work is justified to **define, quantify** and **value** the modal characteristics involved.*

In regard to the case for modally differentiated values of non-working time, Box 6.1 reproduces the discussion and conclusions from the Mackie et al summary report (2003b).

Following from this discussion, the report then proposed, in the light of issues of both principle and practice, that 'DfT should consider moving to a more varied set of appraisal options', comprising three levels (further details given in section 6.1.4.1):

- Level 1 – routine appraisal work.
- Level 2 – major schemes and strategies.
- Level 3 – special applications (involving varying mixes of time and cost in the choice set, and thus requiring market segmentation – eg toll roads, cordon pricing, light rail vs bus modes).

BOX 6.1: COMMENTARY ON UK POLICY ON VALUATION OF NON-WORKING TIME AND ALTERNATIVE APPROACHES (Mackie et al 2003b)

Robert Sugden's paper for the Department called for an end to the use of the standard value of non-working time on the grounds that it is 'incompatible with the logic of CBA' (Sugden 1999). This is an important recommendation from a wide-ranging paper, most parts of which are accepted by both us and Department. We have to agree with Sugden that there is an inherent inconsistency in the traditional approach.

The inconsistency arises because, whereas the money costs and benefits of schemes (plus in principle, the working time benefit) are valued at unadjusted market values, the non-working time benefits and safety benefits are adjusted by the use of a standard value. So, a poor person who gains a money cost saving of 5 pence is allocated a benefit of 5 pence. However, if the same person gains a one minute time saving which they value at 2 pence, that is valued at the standard value of, say 5 pence. As Pearce and Nash (1981) point out:

'This inconsistency could lead to misallocation of resources; for instance a scheme which gives the poor time savings at an increased money cost of travel could be selected in circumstances in which they would rather forgo the time savings for the sake of cheaper travel'.

We conclude that:

- The standard value of non-working time is an incomplete approach to social weighting in cost-benefit analysis and introduces problems of inconsistency of treatment between time and costs.
- Specifically, the relativities between time and costs are different in modelling and evaluation, and this introduces problems where users are paying for benefits through fares or charges.
- The standard value relies on the strong assumption of equal marginal utility of time across groups.

In an ideal world, we believe that appraisal should:

- Discover the willingness-to-pay for all the costs and benefits accruing to all relevant income groups.
- Use those values consistently in modelling and evaluation.
- Re-weight the cost and benefits according to some social weighting scheme which is common across all impacts. There is no particular reason to expect that the outcome would be a single standard social value of time.

In such an ideal context, the argument of principle for the standard value of time falls.

However, we regard a full distributive weighting approach to appraisal as very ambitious for most transport applications, considering the following difficulties:

- Obtaining the relevant data on the pattern of usage by income and social group at the scheme level.
- Defining the final incidence of costs and benefits to income and social groups – especially difficult for working time, including freight and for revenue effects.
- Treating the non-monetised elements in the appraisal consistently with the monetised ones within the social weighting scheme.
- Agreeing the set of social weights.

Implementing a full social weighting scheme for transport sector appraisal is likely to be challenging. Therefore on pragmatic grounds, we would recommend falling back on the use of a set of standard values of non-working time for most scheme appraisal work. We regard this as a practical second best in an appraisal regime which contains many standard parameters.

However, because we are relying on pragmatism rather than principle, we accept that there are circumstances where the disadvantage of using the standard value outweighs the advantages. These are primarily quasi-commercial appraisals such as rail investment, toll roads, major policy initiatives such as road user charging. It is in these applications that the problems of inconsistency in modelling and evaluation are most serious.

A seminar was held by the Department in December 2001, attended by consultants, academics and practitioners. The purpose of the seminar was to discuss the practical feasibility of implementing the conclusions arrived at on the basis of theory and evidence. The seminar was moderated by Dr Denvil Coombe whose report the Department has. Dr Coombe's conclusions were that it would be practical to increase the number of user classes or segments used in modelling and appraisal so as to allow, for example, for income, distance and purpose classes.

6.2.4 Other European countries

6.2.4.1 Sweden

In the Swedish value of time study (Borjesson and Eliasson 2012), values of time were derived from SP market research, and were differentiated with respect to mode, trip purpose, trip length and region. Average values for each segment were derived from the individual values, weighted by travel distance. Table 6.9 shows on the left the VTTS estimates derived from the survey; and on the right these values adjusted for income differences, ie where the income effect is taken out by evaluating the mean VTTS at the mean income of the sample.

Table 6.9 Swedish values of time for use in applied appraisal (€/hour)

Region	Actual (survey) values of time			Values of time evaluated at mean income of the sample		
	Short distance, commute	Short distance, other purposes	Long distance, all purposes	Short distance, commute	Short distance, other purposes	Long distance, all purposes
Car – Stockholm	12.1	7.8	14.9	10.9	7.6	14.0
Car – other regions	9.2	5.9	11.4	8.3	5.7	10.6
Car – all regions	9.8	6.1	11.7	8.8	5.9	10.9
Bus	5.3	2.8	3.8	5.3	3.3	3.9
Train	7.2	5.0	7.3	7.0	5.3	7.4

(Source: Borjessen and Eliasson 2012 (table 3)

Two points are particularly noteworthy about the table 6.9 values:

- Standardisation of values for income differences did not make major differences to the relative unit values.
- The regional differences between the Stockholm region and the rest of the country are quite large, and again are little affected by the standardisation process.

In deciding how to translate the study results (from table 6.9) into its evaluation guidelines, the Swedish Transport Administration had to consider both these points:

- In regard to the first point, after lengthy discussions it decided to adopt the values on the right of the table (ie after standardisation for incomes).
- In regard to the second point, it eventually decided not to differentiate the car values between Stockholm and other regions, ie it adopted the ‘all regions’ values (and noted that no other countries adopted different values on a regional basis).

6.2.4.2 Denmark

The Danish value of time study (Fosgerau et al 2007) derived VTTS distributions and mean values by mode and trip purpose. It then re-estimated the mean values on the assumption that all segments would have the same average income, by applying the estimated income elasticities from the econometric model.

The result of this standardisation was that, for any mode, the differences in mean VTTS between the trip purposes reduced quite significantly, although with values for commuter and education trip purposes still higher than those for other (non-work) purposes. Given this convergence in values between trip purposes, the study team recommended that the adopted set of values should not distinguish between trip purposes: this recommendation was accepted by the steering group.

However, the differences in values by mode, even after adjusting for income effects, remained relatively large, with bus values less than half the average values and car driver values significantly greater than the average. The steering group was concerned that adoption of these modal values would tend to favour improvements to modes used mainly by people with higher incomes. It therefore decided to adopt a single (non-working) VTTS for appraisal purposes:

> *In line with the discussion concerning income differences, the steering group for the project has expressed the view that the cost-benefit analysis will be considered most relevant by policy makers if the analysis treats everybody equally…* (Fosgerau et al 2007, p19).

6.2.5 The case for a fresh look?

6.2.5.1 Overview of 'equity' and 'standardisation' policies (selected countries)

Table 6.10 summarises the policies and practices relating to VTTS 'equity' and income 'standardisation' in the four countries covered in the previous sections. The differences between the countries in terms of policy rationale (objective) and equity/standardisation practices are notable:

- Three of the four countries have adopted the specific policy rationale of avoiding/minimising any bias in investments towards people with higher incomes.
- The fourth country, New Zealand, only states the rationale for its policy in terms of 'equal modal treatment', but without a broader policy objective being explicit. (We surmise that its underlying policy objective is similar to that for the other three countries.)
- Among the three European countries, each has chosen different practices, in terms of its structure for non-work VTTS, to achieve the same policy objective. One (Denmark) has adopted a single value across all modes and trip purposes; a second (Sweden) has adopted different values by mode and purpose, but has standardised these for income; while the third (UK) has adopted equal values across all modes, but retains separate values (not standardised) by purpose.

New Zealand has essentially adopted the UK structure, with equal modal values and differing (not standardised) values by trip purpose. This summary illustrates that, on this topic, different countries have adopted markedly differing practices as means of achieving the same policy objective. It immediately leads to the question as to whether some of these practices are likely to be materially more effective and better targeted than others in achieving the objective. The following sub-sections address this question in two parts, related to the differing practices adopted in the four countries and starting from a 'base' position of directly using behavioural values for economic appraisal purposes (ie the New Zealand practice pre-2013):

- The case for and implications of VTTS **standardisation for income differences**.
- The case for 'going further' by **adoption of equal values** across modes (and potentially also purposes).

Table 6.10 Selected country policies re VTTS 'equity' and 'standardisation'

Country	Non-work VTTS structure		Policy objective/rationale
	Mode	Purpose	
New Zealand	Equal	Differ – not standardised (* 2)	Equal modal treatment (broader policy objective not stated).
UK	Equal	Differ – not standardised (* 2) [check?]	To avoid bias in investments towards people with higher incomes.
Sweden	Differ – standardised (car, bus, train)	Differ – standardised (*2)	To avoid/minimise bias in investments towards people with higher incomes.
Denmark	Equal	Equal	To avoid/minimise bias in investments towards people with higher incomes (by equal treatment across modes).

6.2.5.2 Income standardisation approach

This approach is epitomised by the Swedish model, which involves a 3*3 matrix of 'standardised' values:

* modes – car[13], bus, train
* purpose – commuter (short distance)
  – other non-work (short distance)
  – all (long distance).

The Swedish income standardisation process involved adjusting the behavioural VTTS mean estimates to the mean income of the total survey sample, by applying estimated elasticities for VTTS with respect to income.

The Swedish study (Borjessen and Eliasson 2012) was able to examine the effects of income standardisation on the unit VTTS for the above market segments:

> *The differences across modes and trip distances… are due partly to trip characteristics, such as trip purpose or the comfort of the mode, and partly to self-selection among travellers, ie travellers with high opportunity cost of time will tend to choose faster but more expensive modes. Fosgerau et al (2010) find that the mode differences in values of time are due to both self-selection and comfort effects in the Danish VTTS study. Some of the heterogeneity in the opportunity cost of time can be explained by socio-economic differences, such as differences in income or household composition, but a substantial part is due to idiosyncratic variation between trips. Socio-economic differences are far from the only source of VTTS differences between modes: even when controlling for all socio-economic differences, car drivers have higher VTTS than train passengers which in turn have higher VTTS than bus passengers. In particular, income differences are not the main source of VTTS variation across modes or distances…*

[13] As discussed in section 6.2.4.1, while the Swedish VTTS study found substantial differences in car VTTS between Stockholm and other regions, an 'average region' car value was adopted for appraisal purposes.

It also goes on to explain that the effects of income standardisation on the different modes and trip purposes are quite small because the differences in average incomes across modes and purposes (in the Swedish context) are not very large (not because the VTTS elasticity with respect to income is low).

The Swedish study report also examines, in some detail, the various arguments for and against income standardisation. Its key conclusion is: 'Whether income effects should be removed from the value of time in appraisal depends on which groups pay for the suggested policy and on the final incidence of benefits'. The report comments that:

- In a situation where the investment is paid for with public funds, and a substantial proportion of the benefits stay with the travellers, then it is appropriate to standardise for income differences.
- In situations where the benefits (measured by actual WTP) are likely to be dispersed across the economy, then it is more appropriate to use actual VTTS.

We are unable to reach any conclusion here as to which of these situations is likely to dominate in the case of New Zealand transport investments.

6.2.5.3 'Equal values' approach

This approach is adopted in the three other countries examined (New Zealand, UK, Denmark). Denmark applies one single value for all modes and trip purposes; while New Zealand and the UK have a single value across all modes, but differentiate by trip purposes (essentially between commuter trips and other non-work trips).

The Danish VTTS study report (Fosgerau et al 2007) does briefly address the arguments for and against adopting equal values by mode and trip purpose. In regard to trip purpose, it finds that after income standardisation the differences in values between trip purposes are quite small, and therefore on pragmatic grounds it is not worth making the distinction. In regard to mode, it finds that the differences between modes are relatively large, spanning a range between 74 DKK/hour for car drivers, and 33 DKK/hour for bus passengers. The study steering group decided that, for appraisal purposes, 'everyone should be treated equally', and hence an average VTTS across purposes and modes was adopted.

The Swedish study report addresses the arguments regarding the 'equal values' approach in more detail. It comments as follows:

> *The argument that income effects should be removed from the VTTS has lead several countries to adopt appraisal practices where all or almost all differences in the VTTS are removed, sometimes called 'equity values' of time. This is clearly a misunderstanding of the debate (which is also specifically pointed out by Galvez & Jara- Diaz (1998). This practice reduces the information contained in the appraisal, and eventually leads to the misallocation of resources across the transport sector. Differentiating the value of time in appraisal shows which kinds of travel time reductions will create most value to society. It can also lead to paradoxical results, where user-paid transport improvements can be judged to be socially unprofitable even if users would gladly pay for the improvement (Sugden 1999).*
>
> *Regarding general equity concerns – a wider issue than just income differences – it should be stressed that most people make many kinds of trips, with different modes, purposes and trip lengths. The difference in resource spending caused by differentiating the value of time in appraisal is hence not so much a difference across individuals than it is a difference across trips made by the same individual. Clearly, it can be perfectly logical that an individual values a travel time saving during his morning car commute higher than a travel time saving on his Saturday bus trip to a museum. Using only a single value of time for appraisal will*

destroy this distinction, and hence misallocate resources out of (in this case) misguided 'equity concerns' – in this case, 'equity concerns" would mean that the morning car commute "should' be valued exactly as the Saturday museum trip, despite that the individual would prioritize differently.

One of the paper's conclusions is as follows:

Even if one wishes to remove income effects from the value of time, removing all or most of the value of time differences in applied appraisal because of income equity concerns, is an over-reaction. This practice removes heterogeneities in the valuations that are highly relevant for appraisal, if the purpose is to find policy measures and investments that maximize aggregate utility.

We consider the comments of the Swedish study on this topic are highly pertinent and have no disagreement with them. We are not aware of any equivalent discussions in either UK or New Zealand papers as to why they have adopted equal modal values in order to achieve their (stated or unstated) objective of avoiding bias in investments towards people with higher incomes.

6.2.5.4 Would it make a difference?

The question addressed here is, if an 'income standardisation' approach were to be adopted in the New Zealand (EEM) context in place of the current 'equal values' (by mode) approach, would it make a material difference to the relative benefits of different schemes, some involving different modes?

In addressing this question, we assume that

- the current EEM trip purpose distinctions would remain essentially unchanged
- no distinction would be attempted between 'longer' and 'shorter' shorter' distance trips (like that included in the Swedish values (refer table 6.9). We see this as a largely independent issue.

Hence, the main change would be to replace the current equal values across modes by differentiated values by mode, based on behavioural values adjusted for income differences between modes.

Based on these assumptions, our expectation is that the change would make material differences to benefits, both within and between modes. Having regard to the relative Swedish income-adjusted values (table 6.9, three columns on the right) we comment as follows:

- 'Base' bus and train values seem likely to reduce somewhat relative to car driver values. However, it needs to be kept in mind that the 'final' PT values may not be very different from the car driver values, as typically the various factors currently applied to the New Zealand base PT values are greater than those applied to the car driver values (refer section 6.1.5.3).
- It is a matter for further consideration whether PT values are segmented between bus, train and ferry. Based on the recent Transport Agency PT pricing strategies research project (Douglas 2015), we do not anticipate large differences between bus and train adjusted values.
- The income-adjusted values for car passengers and for active modes would need to be further explored (but this is a largely separate issue from that of standardisation for incomes).

6.2.6 Approach to the process of income standardisation

if it is decided to pursue the concept of income standardisation (essentially across modes) further, then a detailed methodology needs to be defined and applied to derive a set of standardised values – prior to any commitment to implement the change. It is beyond the scope of this report to define such a methodology, but the following provides brief comments relevant to that task.

We assume the starting data would be the pre-2013 EEM unit values, inasmuch as these are essentially based on the New Zealand 2001 market research findings (and decisions on values that were made based on these findings). While there are clearly some weaknesses in that set of values (eg car passengers), addressing them is an independent issue.

The usual approach adopted to income standardisation is to adjust the market research mean values (by purpose by mode etc) by: (i) the ratio of the mean income of all survey respondents (assumed to be a random sample of all travellers, after weighting as appropriate) to the mean income of the modal users; factored by (ii) the (cross-sectional) elasticity of VTTS with respect to income derived from the survey data.

Table 6.3 provides information on cross-sectional elasticities (of VTTS with respect to some measure of income) that have been found in previous New Zealand and international studies. The evidence on cross-sectional elasticities shows reasonable consistency across the values from different countries, and no clear evidence of any differences between modes. As part of the methodology development, a view would need to be taken as to the most appropriate values to use in the New Zealand context (different values may be appropriate for different modes).

The income standardisation procedures may be more or less detailed. For car travel, the main parameter for which standardisation is required is the base value of in-vehicle time, and the relatively simple approach outlined above may be sufficient. For PT modes, to derive a full set of standardised values (covering walk time, wait time, in-vehicle time and quality features), standardisation would ideally be undertaken separately for each of these journey aspects, as the variation in people’s valuations with income is not likely to vary in the same manner for all journey aspects.

In this regard, Douglas and Jones (2013) undertook separate standardisation against in-vehicle time and fare levels for a 2012 SP survey undertaken in Sydney. They describe a six-step standardisation procedure:

1 ‘In-fill’ responses to the income question

2 Undertake choice regressions by income category

3 Regress the fare and IVT parameters on the mid-point income

4 Standardise the regression parameters for the average income of the sample

5 Multiply the fare and IVT income adjustments against the IVT and fare differences

6 Re-estimate the choice model.

Similarly, in Douglas (2015), the following parameter values were subject to separate standardisation: in-vehicle time, service interval (headway), fares, stop/station quality and vehicle quality.

It is evident that methodologies for income standardisation are well developed and tested in this context: we would be confident of success in the detailed development and application of such methods if the income standardisation approach were to be pursued following this project.

7 Economic appraisal application and information aspects

This chapter addresses two topics relating to the presentation and application of evaluation results:

- The manner in which information on travel time benefits of schemes is most usefully presented (section 7.1).
- The basis for evaluation of inter-related schemes ('packages') so as to provide the most useful information for decision-makers (section 7.2).

7.1 Travel time and benefit information

7.1.1 Band classification rationale

WebTAG Unit A1.3 (DfT 2014c) sets out a requirement for economic appraisals undertaken in the UK to classify travel time savings into time bands (further details are given in section C.9/Box C.3). It is recommended that similar information should also be provided during the programme business case stage (or when transport modelling is first undertaken) for economic appraisals in New Zealand. This is the stage at which an indicative assessment of the economic efficiency of the programme is undertaken. It is of note that the time saving bands (noting that a positive number implies a saving) provided in table 7.1 are suggestive only with more refined or coarser travel time classification bands possible as required to suit the specific project. There is no recommendation to exclude any of these impacts, or value them differently. The objective of providing the additional information regarding savings bands is to demonstrate to decision makers the impacts of the scheme compared to the objectives.

Table 7.1 Travel time saving bands

Travel time classification bands
Less than -5 minutes
-5 minutes < -2 minutes
-2 minutes < 0 minutes
0 minutes < 2 minutes
2 minutes < 5 minutes
Greater than 5 minutes

Source: WebTAG 2014c

7.1.2 Examples

In order to demonstrate the value of this categorisation, two sample assessments of traffic modelling results were undertaken and are presented below. These two different roading schemes are:

1 Introducing a bypass

2 Intersection improvements.

The rationale of introducing a whole new piece of infrastructure and providing a bypass for a section of road is to release current bottlenecks which ultimately should lead to travel time savings for those people who use the bypass (and particularly also for people who use routes from which traffic diverts to the bypass). It may also be expected that changing the routing of vehicles, potentially facilitating the movement of a large number of vehicles to an area they otherwise would not be able to reach (a downstream bottleneck for example) may result in disbenefits to a number of vehicles also. Table 7.2 shows that approximately 30% of the trips experience travel time savings with the highest proportion having savings in the order of zero to one minute. However 70% of the network trips will experience travel time increases of zero to one minute as well. Overall the scheme had a travel time benefit of approximately 300–350 vehicle-hours in the AM peak hour. In this example 1.5% of the total trips are contributing approximately 70% of the total travel time benefits. It was deemed to be too coarse to use the zero to two-minute bands and therefore an additional band was introduced.

Table 7.2 Travel time bands – bypass

Saving (minutes)	Trips	% of total trips	Benefits ($)	% of total benefits
>5	1,700	1.5%	$5,025	70.7%
5 to 2	1,600	1.4%	$1,800	25.3%
2 to 1	1,900	1.7%	$950	13.3%
1 to 0	30,000	26.0%	$1,250	17.5%
0 to -1	79,000	69.1%	-$1,650	-23.2%
-1 to -2	400	0.3%	-$175	-2.4%
-2 to -5	100	0.1%	-$75	-1.0%
<-5	0	0.0%	0	0.0%
Total	**115,000**	**100%**	**$7,125**	**100%**

This additional information provides the following insights:

- While the overall impact of the project is a net benefit with regards to travel time savings, the majority of people will be slightly worse off (note that reduced bandwidths demonstrate there is probably a significant number of people for whom the disbenefit is minor, hence the overall benefit of the project).
- Over 85% of the impacts (positive or negative) are less than one minute. Again, with reduced bandwidths, this analysis could be refined. This can provide information on the quantum of benefits relative to the sensitivity of the modelling tools used. For example, if the majority of the benefits were arising from a saving of a few seconds, this would provide a measure of required accuracy for the transport models.
- There are very few vehicles (less than 0.5%) adversely impacted by more than one minute, of which some 1.5% benefit by more than five minutes.
- There are a significant number of vehicles (approximately 5%) that benefit by more than one minute.
- A comparison could be made between direct users of the bypass and second and third order users to confirm whether the benefits of re-routing were experienced by the direct users, or by others from the relief of a bottleneck elsewhere (noting that this is not a judgement on whether this is right or wrong, merely that it is the likely impact of the scheme which can be assessed against the scheme objectives).

The second example provides results for a sample intersection improvement. Due to the increased traffic in the future the current intersection layout is not performing well, causing widespread rerouting onto alternative routes to avoid large delays. By introducing a new form of intersection design the delays are decreased significantly at the intersection and traffic is routing back onto the primary route. The overall savings are approximately 450–500 vehicle-hours in the AM peak hour. In this example, as shown in table 7.3, approximately 55% of the total benefits are for trips saving more than five minutes travel time. As with the previous results, the more refined bands splitting up into zero to one minute and one to two minutes have been used for illustration purposes.

Table 7.3 Travel time bands – intersection improvement

Saving (minutes)	Trips	% of total trips	Benefits ($)	% of total benefits
>5	2,400	2.2%	$5,525	55.0%
5 to 2	2,200	2.1%	$2,600	25.7%
2 to 1	2,900	2.6%	$1,500	14.9%
1 to 0	36,500	33.7%	$2,275	22.7%
0 to -1	61,800	57.0%	-$625	-6.3%
-1 to -2	2,400	2.3%	-$1,000	-10.0%
-2 to -5	100	0.1%	-$75	-0.7%
<-5	50	0.0%	-$125	-1.2%
Total	**108,000**	**100%**	**$10,050**	**100%**

As with the previous results approximately 34% of the trips experience savings in the order of zero to one minute with an additional approximately 7% of trips incurring travel time savings of more than one minute, and accounting for over 95% of total (net) benefits. Around 57% of trips experience slight travel time disbenefits between zero and one minute with less than 2.5% of trips experiencing between one and five minutes additional delays. As with the bypass, given suitable model outputs the number of direct users who benefit from the project could potentially be compared with second and third order users.

7.1.3 Recommendation and implementation

We recommend including the travel time saving band classification as additional information in an economic evaluation. Having time saving bands consistent with the project objectives would provide the benefit of knowing whether the travel time benefits and disbenefits of a project were in line with the project objectives (supporting the strategic fit and effectiveness objectives). It would also provide information on the likely sensitivity of the total benefits to small changes in travel time for a large number of users. This could be included in the next EEM revision.

Table 7.1 could be provided together with a sector table of where benefits and disbenefits are experienced. This would be helpful for large roading projects in determining primary and secondary impacts of schemes. This report deals predominantly with roading projects but our recommendation would also be applicable to PT scheme assessment.

7.2 Appraisal procedures for interrelated schemes (packages)

The interrelationship of schemes was initially considered when exploring whether multiple small time savings on a complete journey (through a package of works) should be treated differently from a large saving at one location.

The traffic benefits of an individual road scheme in a corridor are typically sensitive to other improvements that may, or may not, be implemented in that corridor. For example, an improvement scheme that is the first component in an overall ‘package’ of corridor improvements may, on its own, provide very limited benefits (if it just ‘shifts the bottleneck’ a short distance); but if it is built as the last component ('missing link') it may provide much greater benefits, as it may effectively remove the critical bottleneck in the overall corridor.

The adoption of appropriate procedures for transport improvement packages and their components is important, as the sequencing of component schemes can have substantial effects on the overall benefits achieved from a package, and (in some instances) the information may affect whether all components of a package should proceed at all. This importance was underlined by the recent (2014) board of inquiry hearing into Wellington's proposed Basin Reserve Flyover: 'The board of inquiry hearing may also have set a precedent that major transport projects linked to other big schemes will need to be presented as a package in order to get consent' (DominionPost, Wellington, 22 August 2014).

Current Transport Agency practice in assessing scheme packages has tended to focus on the overall package, with less attention being paid to the merits of its component schemes. This may result in some component schemes being implemented, where their incremental (and stand-alone) BCR performance may be relatively poor and they may not be essential to the overall package strategy.

While there are typically various practical constraints on the sequencing of component schemes in any overall package, it is generally desirable that economic appraisal methods be applied to assess the incremental economic performance (typically using a first-year rate of return assessment) of feasible scheme combinations: this will enable optimum sequencing on economic grounds to be determined, and will help to identify any scheme components that may not be justified in the form proposed.

A key input to any such incremental benefit analyses will be an appropriate traffic model, which realistically reflects the effects of scheme improvements on traffic performance over the wider corridor: micro-simulation modelling methods are often required for such situations although these may not be appropriate in all cases.

Currently, the Transport Agency provides guidance on the approach to the appraisal of packages and their components, through the EEM (NZ Transport Agency 2013a) and the knowledge base website (NZ Transport Agency 2014). We see merits in bringing this guidance together in one document, clarifying and strengthening its content, and also bringing it to the attention of transport modellers and evaluators through a series of workshops and/or other means of dissemination.

7.2.1 Recommendation and implementations

We understand the Transport Agency is considering undertaking workshops in the different regions dealing with the subject of 'packages'. The study team is in support of these workshops, which have the potential to clarify incorrect perceptions, Providing clear messages to the industry and presenting case studies to illustrate these will help achieve the outcomes intended by the EEM and knowledge database.

It would be desirable that during the current EEM review some of the knowledge base information is integrated into the EEM to provide more streamlined specification of requirements on this aspect.

8 Conclusions and recommendations

The following table summarises our conclusions and related recommendations on each of the main topic areas addressed in the report.

Table 8.1 Summary of conclusions and recommendations

Conclusions	Recommendations
Significance of travel time savings in economic appraisals (chapter 2) • Current New Zealand practice is to assess funding priorities between candidate transport schemes against three objectives – strategic fit, effectiveness and (economic) efficiency. • The economic efficiency assessment is undertaken using cost-benefit analysis (CBA). Travel time savings are generally the largest single component of benefits in this assessment, typically accounting for c.80% of total quantified benefits for major road schemes. Hence the (unit) value of time savings used in appraisal is a key determinant of economic benefits and scheme benefit:cost ratios (BCR). • Other significant economic benefit components that are commonly quantified in New Zealand practice are travel time reliability, vehicle operating costs, crash (accident) costs and GHG emissions. More recent practice has also estimated 'wider economic benefits' (WEBs) for some major urban schemes. Land use impacts of schemes are not assessed in any quantitative manner.	
Valuation of time savings vs trip duration – literature and practice review (chapter 3.1) • Most international evidence indicates that unit VTTS increases with trip duration (distance, time or costs), with values for longer trips (3+ hours) being around 50%–100% greater than for shorter trips (<20 minutes). • The only New Zealand evidence on this topic (from 2,001 car driver surveys) indicates a rather weak tendency for unit values to increase with trip length, although this finding is not conclusive. • Contrary to most international evidence, several international researchers have suggested that unit VTTS may be more a function of the proportionate time saving rather than the absolute level of saving, thus implying that unit values would reduce with trip duration. No detailed empirical analysis has to date been undertaken internationally on this hypothesis (refer chapter 5 section below). • The introduction of a VTTS function that varies with some measure of trip duration or distance would increase the complexity of appraisals, but simplified methods could be readily developed to minimise any additional complexity.	
Valuation of time savings vs extent of time saved - literature and practice review (chapter 3.2) • International research studies using SP methods have generally found that (i) unit VTTS estimates start from a low	• For New Zealand, there is a strong case for retaining the present constant unit VTTS

<table>
<tr><th>Conclusions</th><th>Recommendations</th></tr>
<tr><td>level for small time savings and increase up to a threshold level of time savings, which is generally in the range 15–30 minutes; and (ii) for time savings of 3–5 minutes, unit values are typically in the order of half the threshold values.
• The economic appraisal procedures adopted in the great majority of countries assume that unit VTTS is constant over all levels of time savings, although there are some notable exceptions. The UK adopts constant unit values, but requires travel time benefits to be grouped into time bands, according to the size of the time savings (or losses), so as to provide additional information for decision-makers (refer chapter 7 section below)
• Substantial practical difficulties would arise in applying any appraisal methodology that involved different unit values for time savings of different sizes.</td><td>approach for appraisal purposes; based on the empirical evidence, there is no convincing case for the adoption of lower values for smaller time savings, particularly from a medium/longer-run perspective; and any such change would add considerable complexity to appraisal applications and the interpretation of appraisal results.</td></tr>
<tr><td>Exploratory market research – trip duration and extent of time savings (chapter 5)
• A non-random survey (c.560 responses) was undertaken to investigate car driver preferences between saving a given amount of time: (A) on a single trip or through smaller savings on multiple trips; and (B) on a long trip versus a shorter trip.
• In part (A), respondents had a clear preference for a given amount of time savings to be made in a single trip rather than through smaller savings on each of multiple trips. On average, respondents were indifferent between saving 15 minutes on a single trip versus two minutes on each of 10 trips (ie 20 minutes in total). This implies that their revealed unit (per minute) VTTS for a two minute time saving was c75% of that for a larger (15 minute) saving.
• These results are quite similar to those from other SP research internationally, although the survey indicated a lower degree of discounting of values for small time savings than is generally found from SP research. This suggests a good case for considering our survey methodology further for wider application.
• In part (B), respondents had a strong preference (implying a higher valuation) for a given time saving on a shorter (say 20 minute) trip than on a longer (say 120 minute) trip. The time savings on the longer trip would need to be about 10–15 minute greater than on the shorter trip for respondents (on average) to be indifferent between these two options. This indicates that respondents' unit VTTS were substantially lower (in the order of half) for the longer trip relative to the shorter trip.
• These results indicate that respondents place a substantially lower value on the saving of a given amount of time on a longer trip than on a shorter trip, ie suggesting that preferences may be more consistent with proportionate valuations than absolute valuations of time savings. This conclusion differs from the dominant findings from international studies that unit values are higher for longer trips (refer ch 3.1 above). A major contributory factor to these</td><td>• In the light of the findings from our exploratory search, high priority should be given to the following further tasks:
- distribute the findings of the exploratory survey to a selection of international experts in the field of VTTS market research, to seek feedback on our survey methodology, interpretation and possible enhancement
- subject to positive feedback from the above task, undertake qualitative research (focus groups or in-depth interviews), to investigate perceptions on the valuation of small time savings and time savings on trips of different durations
- subject to outcomes from both the above tasks, undertake further quantitative (random sample) market research in New Zealand, particularly to further investigate relative valuations of time savings on trips of different durations.
• While these tasks are seen as New Zealand based, they should be undertaken in close consultation with leading international experts in this field, with the intention that the outputs would be widely accepted as a leading-edge contribution to VTTS research internationally.</td></tr>
</table>

Conclusions	**Recommendations**
differences in findings may be that our survey design differs from the SP designs conventionally adopted.	
'Equity' issues and the treatment of income effects (chapter 6) • New Zealand economic appraisal practice was changed recently (2013) to adopt equal ('equity') base values of non-working time across all modes (while retaining variations by trip purpose and for quality/comfort factors). • A generally similar 'equal values' approach is adopted in a number of other countries, primarily with the objective of adjusting for income differences and avoiding investment being focused on groups/areas with higher income levels. However, such an approach does not take into account that income differences are only one of many factors affecting traveller willingness-to-pay values for time savings. Adoption of this approach over-rides such factors and is likely to significantly distort appraisal results. • Sweden adopts an 'income-adjusted' approach, which adjusts behavioural values for income differences, while retaining modal differences resulting from other factors. We consider that this approach has some significant advantages over the current New Zealand approach, and so undertook initial exploration of its merits and possible methods for its application.	• An income-adjusted approach to adjust behavioural values of time to allow for income differences (broadly similar to that in Sweden) should be investigated in more detail. This should include the further assessment of the merits of such an approach and of methods for its practical application and its implications if adopted in New Zealand.
Presentation of information on travel time benefits (chapter 7.1) • Current New Zealand economic appraisal practices usually just report benefits of schemes at a net aggregate level. This provides minimal information for decision-makers on any distributional effects (eg 'gainers' vs 'losers'), or on the extent of benefits to various groups of users. The UK practice for reporting scheme performance provides a breakdown of time savings into time bands according to the level of savings (eg 0–2 minute, 2–4 minute etc).	• A practice of reporting travel time impacts at a disaggregated ('banded') level, based on that applying in the UK, should be adopted in New Zealand. This should provide information disaggregated by time band on the proportions of affected travellers by time saved (or lost) and by benefits obtained.
Appraisal procedures for inter-related schemes (' packages') (chapter 7.2) • A large proportion of total road improvement expenditures in New Zealand, particularly in the metropolitan areas, is on 'packages', each comprising several individual schemes - which typically would be constructed in phases over quite a number of years. Hitherto, there has been a tendency to focus economic appraisal work on the total 'package', with relatively little attention paid to the merits and phasing of the individual schemes on the overall package, so as to maximise the total package benefits over the full evaluation period (while recognising that typically there are various practical constraints on phasing).	• Workshops should be provided for transport modelling/ economic appraisal practitioners on the topic of evaluating 'package' schemes;, current advice to practitioners consolidated into one readily accessible document and enhanced where seen as desirable.

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Appendix A: Composition of total savings by benefit stream – New Zealand examples

Figure A.1 Total saving by benefit stream (state highway activity)

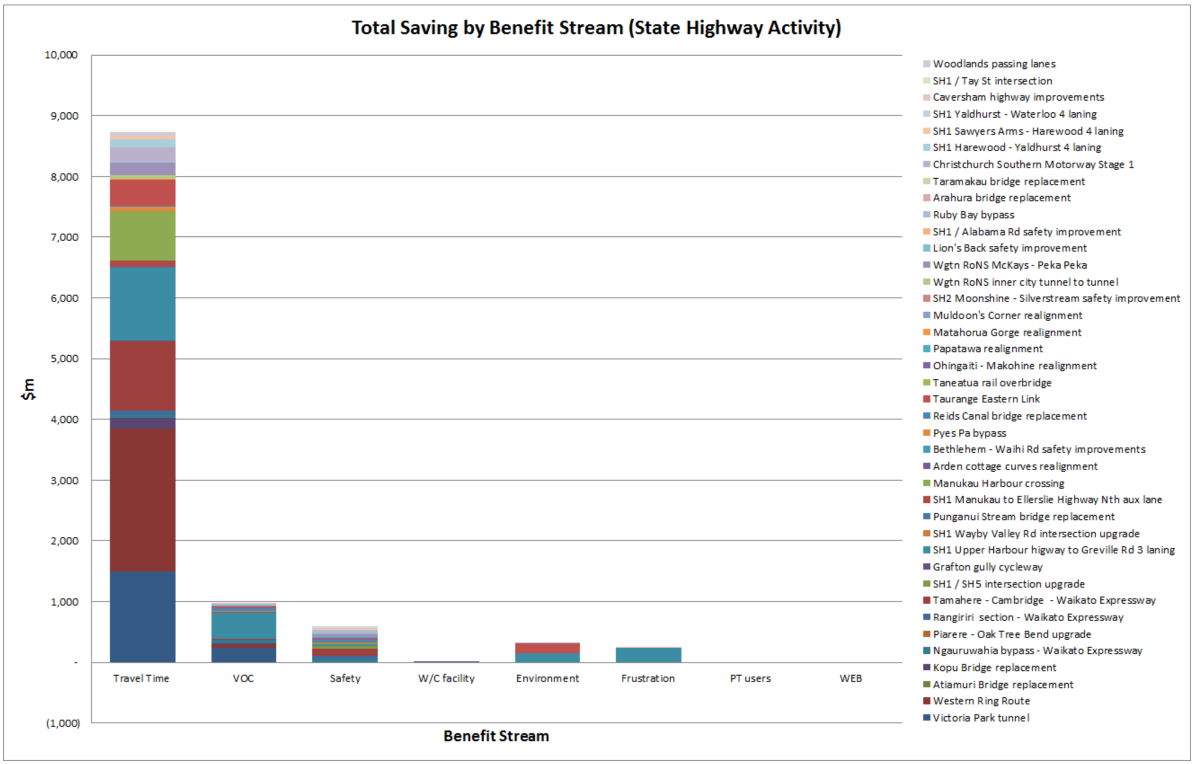


Figure A.1 shows the Western Ring Route scheme has the highest individual travel time component of all state highway projects considered (approximately one-third of the overall travel time benefits). More than 95%of the project benefits are attributed to the travel times with the remaining benefits being vehicle operating cost and crash cost savings.

Figure A.2 Total saving by benefit stream (local authority activity)

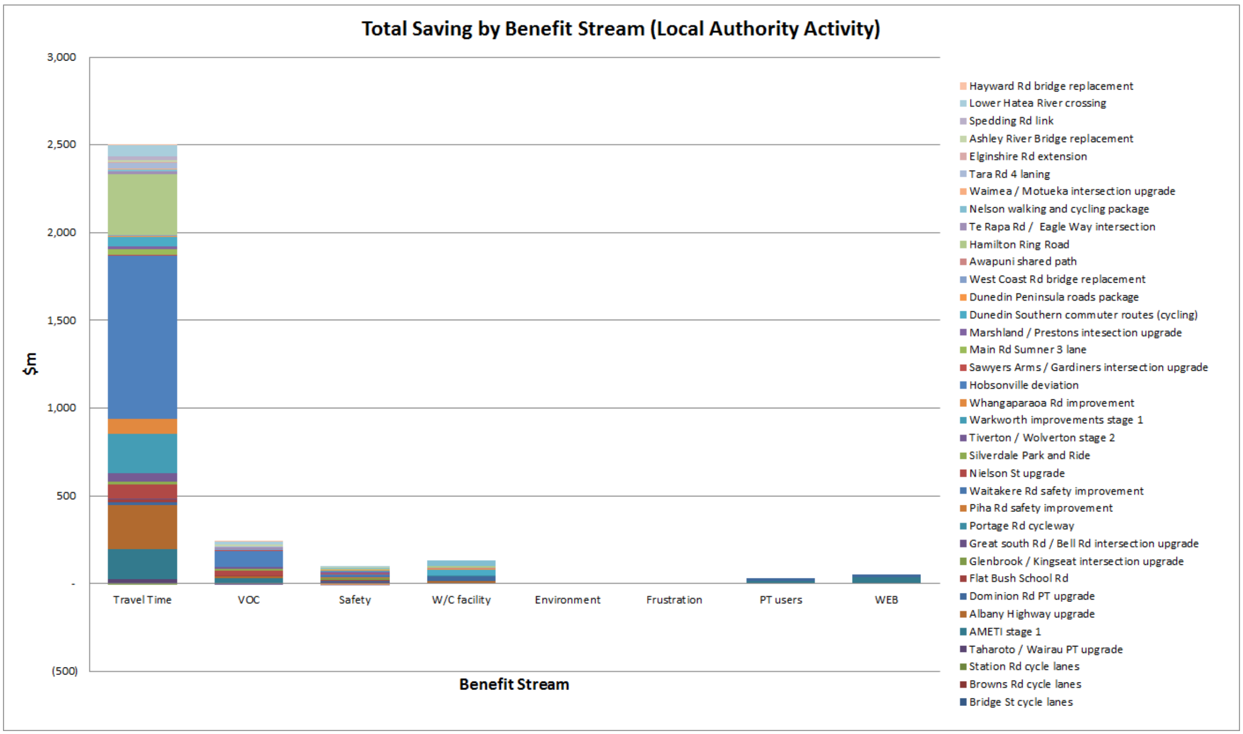


Figure A.2 shows the Hobsonville deviation as the project with the highest individual travel time component of all local authority projects considered (approximately 40% of the overall travel time benefits). Approximately 90% of the scheme benefits are contributed by travel time savings with the remaining benefits being crash and vehicle operating cost savings.

Figure A.3 Percentage of project benefits per benefit stream (weighted over all projects) – state highway

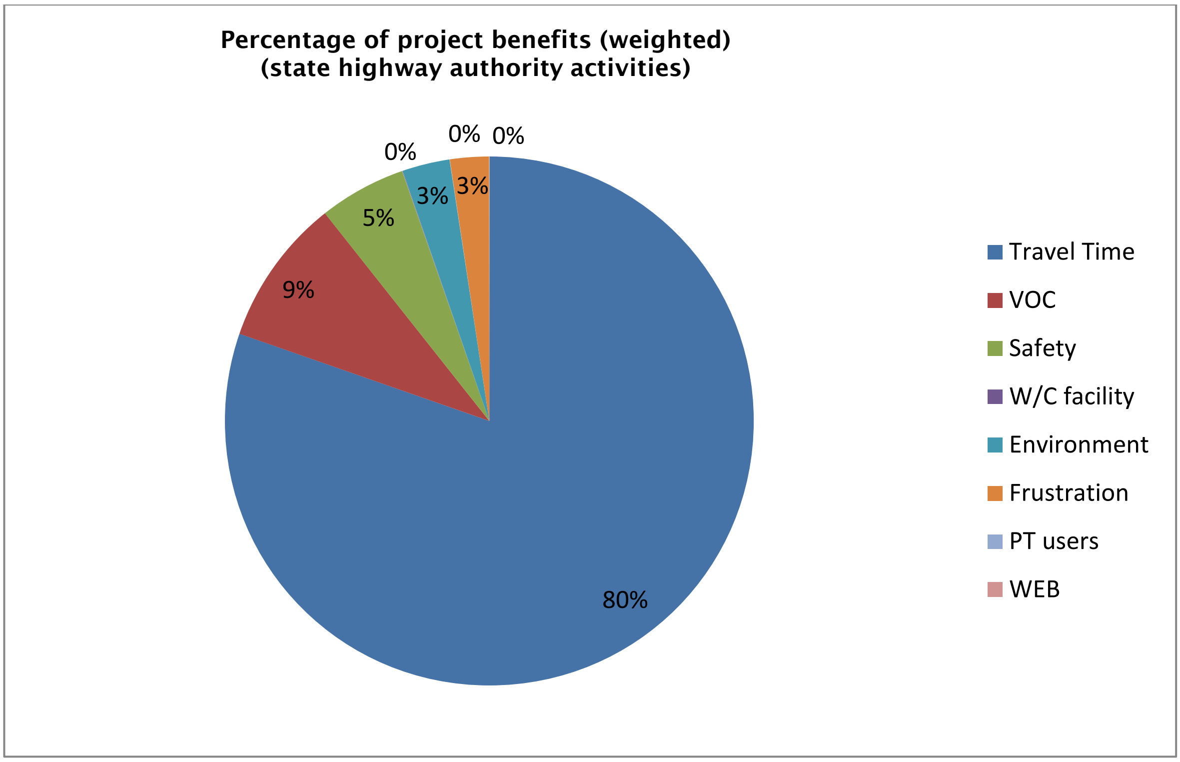


Figure A.4 Percentage of project benefits per benefit stream (weighted over all projects) – local authority

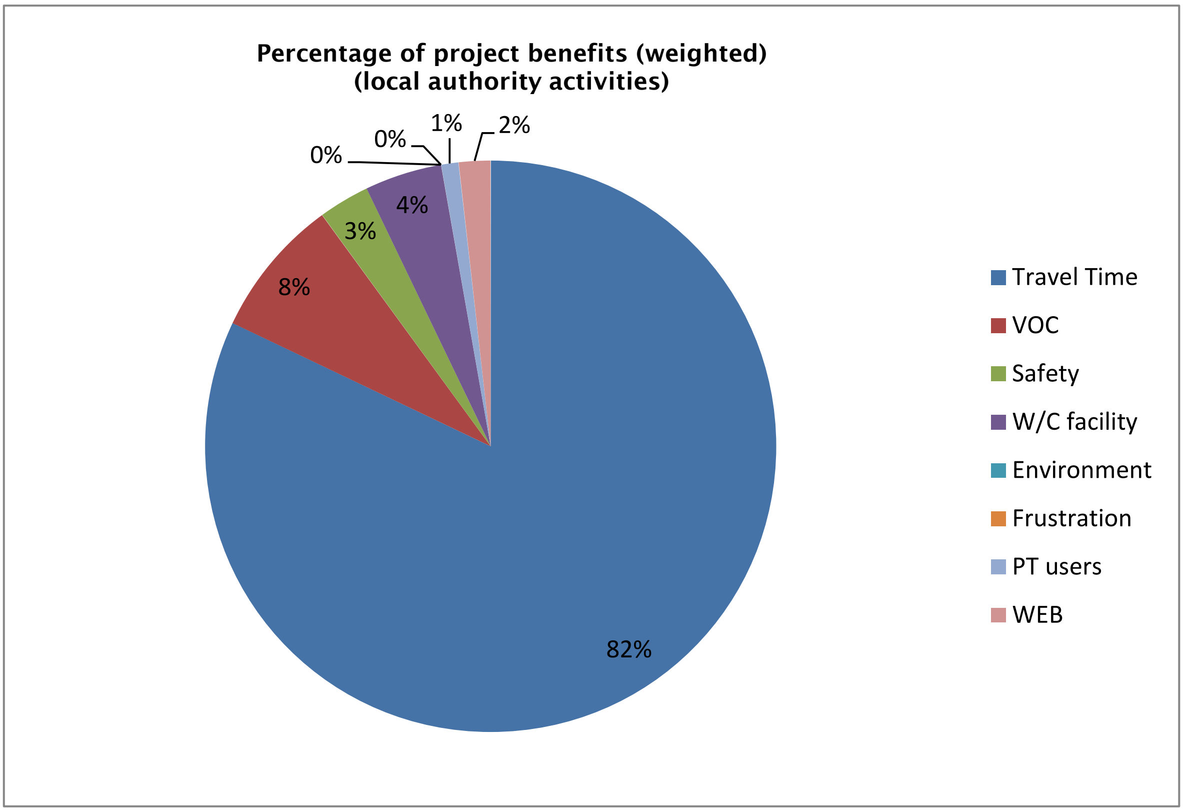


Figure A.5 Dominion Road public transport upgrade (overall benefits composition)

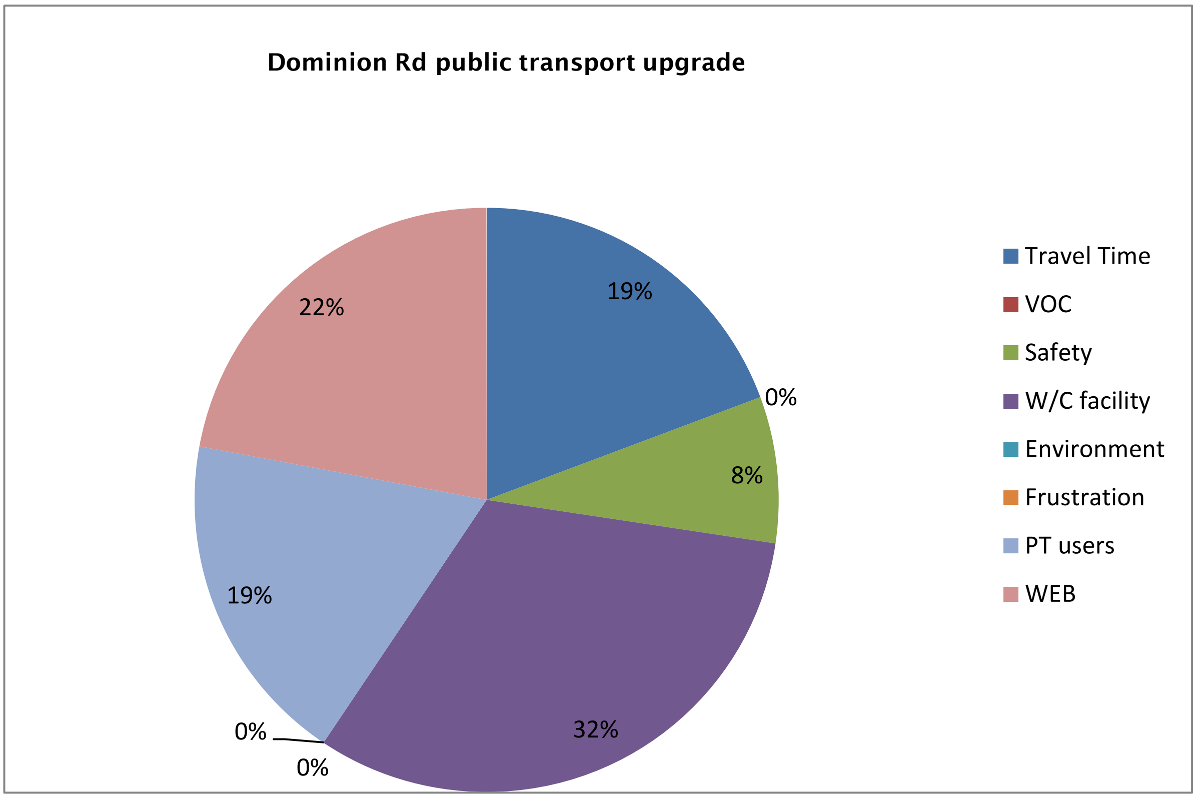
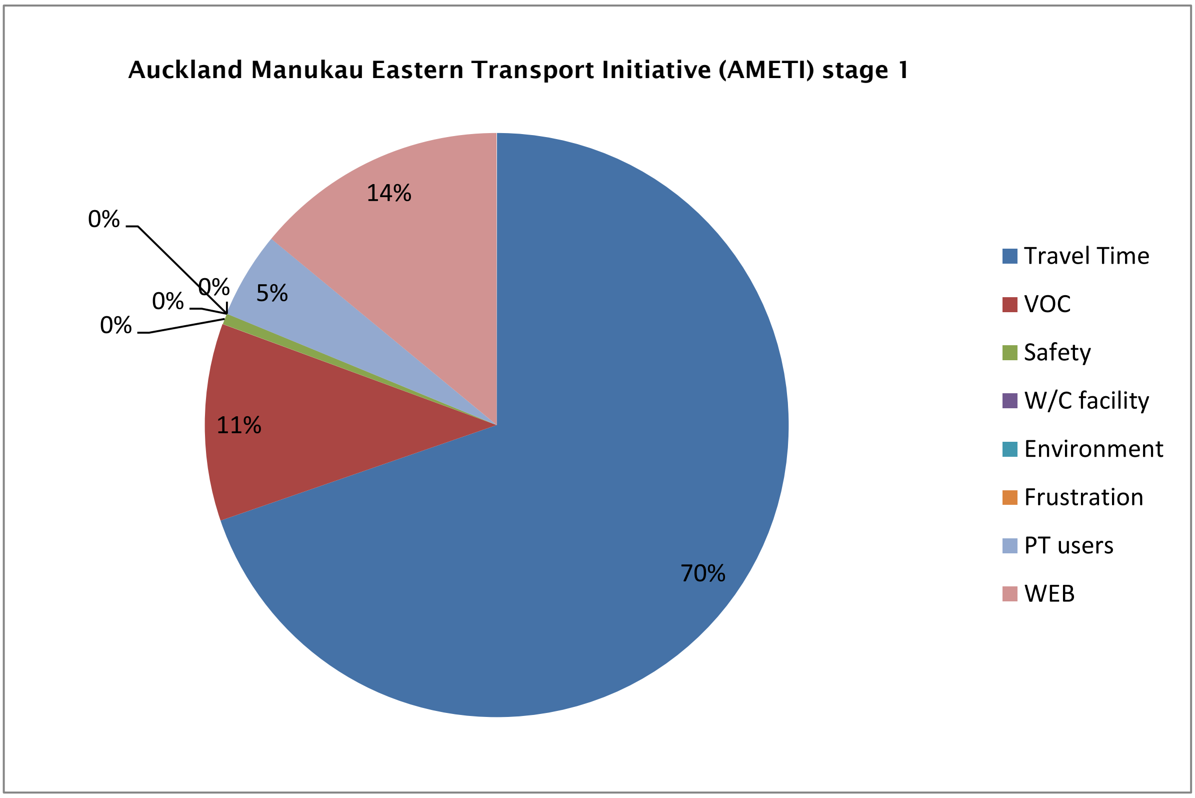


Figure A.6 Auckland Manukau Eastern Transport Initiative stage 1 (overall benefits composition)



Appendix B: VTTS vs trip duration – detailed literature/practice review

B1 Introduction

This appendix presents and assesses the market research evidence (from New Zealand and internationally) on whether, and to what extent, people's valuations of travel time savings (per minute) vary significantly with the overall length or duration of their trip[14], and, if so, what is the pattern of variation?

All the evidence examined relates to car drivers: there is an almost complete dearth of information in the international literature on car passenger VTTS variation with trip duration, and very limited similar information for PT passengers.

This appendix provides supplementary material to the summary of evidence on how VTTS varies with trip duration in section 3.1. It is structured as follows:

- Section B2 summarises New Zealand market research evidence and previous New Zealand-based international reviews.
- Section B3 covers UK studies and evidence.
- Section B4 covers other European studies and evidence (from Denmark, Sweden, Norway, the Netherlands and Switzerland).
- Section B5 sets out international evaluation practices in regard to any variations in unit VTTS with trip duration (or distance).

B2 Previous New Zealand research and review

B2.1 Market research

BCHF et al (2002) undertook SP-based market research in 2001 with a sample of New Zealand car drivers, requiring them to make a series of hypothetical choices between alternative routes for a recent trip they had made: these routes differed in terms of travel time and costs (vehicle operating costs plus parking charges).

The survey was analysed by fitting logit models to the choice dataset. One set of models expressed the utility of each option as a function of both journey cost and journey time, with the time term being a function of income and journey distance. The results of the analyses demonstrated that the car driver VTTS did indeed vary with trip length and income, increasing with both of these.[15]

Further details of the survey are given in appendix D. The BCHF results for car driver VTTS against trip length (and income) are outlined, together with some further analyses, in chapter 4. The key results relating to trip lengths were as follows:

[14] The literature adopts various measures of relative 'trip' duration, including travel time, travel distance and travel cost.

[15] The BCHF model formulation differed from that used in (eg) the UK Mackie et al (2003) study, where it was assumed that unit VTTS would vary with distance and income according to a power function. Without going back and re-analysing the original survey data, it is not possible to derive distance and income elasticities from the New Zealand data.

- BCHF developed an equation expressing unit VTTS as varying with the reciprocal of trip length (so that VTTS increased with increasing trip length).
- This relationship was valid only for trips with a distance in the range of 5km–100km, as (i) no short trips (<10 mins) were surveyed; and (ii) the report notes that the formula should not be applied for trips longer than about 100km.
- Further analysis of this relationship (without going back to the original dataset) indicated that, for commuter trips approximating to the survey average trip length (19km), the implied elasticity of VTTS for trip length was around 0.05 for trips of 10km–20km and around 0.10 for trips of 20km–40km.
- These results should be taken as indicative only. To derive best estimate elasticities for trip duration, it would be necessary to re-analyse the original survey records.

B2.2 International review of empirical evidence

The BCHF project also included a review of international evidence on the variation in unit VTTS with trip duration:

> *At the time of the last major review of NZ practice, Miller (1989) noted "the evidence on the variation in travel time value with trip length or length of time saving is quite modest and technically marginal." Some early studies showed declining VoT with trip distance whereas others showed an increase, and there were methodological problems with some of the studies. Added to this, the practicality of introducing a varying value of time with trip length poses significant difficulties."*
>
> *However, through the 1990s the accumulating body of evidence from empirical studies has shown an increase in VoT with trip duration and/or distance. This is often synonymous with urban travel and inter-urban travel in the context of the surveys from which these results are derived. This evidence is slow to have been adopted into practice, no doubt due in part to the practical problems of implementation.* (BCHF et al 2002, pp2–9)

BCHF et al (2002) provides brief summaries of the (then) recent evidence, focusing on studies in the UK (AHCG 1999; Wardman 2001; Norway (Ramjerdi et al 1997) and Sweden (Algers et al 1996).

BCHF et al's conclusion on this topic was as follows:

> *It was not a specific objective of the study to determine trip length effects on VoT. However, the body of evidence points to a very significant difference between short and long distance travel which, if acknowledged, would lead to higher VoT being applied for rural state highways than urban roads. The magnitude of the differences is likely to be in the range 1.5 to 2.0, so is as significant as other effects that the study is seeking to quantify.*

B3 'Recent' UK studies

B3.1 Scope

This section summarises the evidence and findings from market research and analyses undertaken in the UK over the last 15 years. The primary source is the second[16] UK value of time study (AHCG 1999), and the subsequent reappraisal of this work by Mackie et al (2003). That work was followed by a more recent

[16] What is commonly referred to as the first UK study was that by MVA et al (1987).

update for the UK DfT undertaken by Batley et al (2010), and a subsequent peer review of this by Laird et al (2013)[17], as a prelude to a further potential UK national VTTS study.

This section also summarises the findings from the M6 toll route study (Wardman et al 2008) and from an updating of earlier meta-analyses undertaken by ITS, which were also summarised and discussed in the Batley et al 2010 report.

B3.2 The second UK VTTS study (AHCG 1999) and the Mackie et al reappraisal (2003)

The second UK national study, specifically for road traffic values, was initiated in 1994 and undertaken by Accent Marketing and Research and Hague Consulting Group (AHCG 1999). The research methodology was based entirely on SP data: three different forms of SP experiment were used, with the main one involving a direct route choice trade-off between time and cost changes, starting from a reported base position.

The analyses were carried out in considerable detail and identified a wide range of covariates influencing the values of time: for practical purposes, averages were calculated for three trip purposes (business, commuting, other non-work). Investigations were made into the 'size and sign' characteristics of time savings, and it was concluded that VTTS was dependent on the direction and magnitude of the savings.

The DfT had some difficulties in responding to the conclusions of the study, and in 2001 appointed ITS Leeds with John Bates Services to help resolve some of the outstanding issues. This work involved a substantial re- analysis of the AHCG (1999) data and was reported in Mackie et al (2003). These re-analyses examined the merits of a number of alternative model formulations: details of these models and their consideration are provided in box B.1.

In terms of non-working VTTS, a value function was recommended, with values varying with income levels and journey cost levels, each to the power of an elasticity value, for example:

$$VTTS\ per\ minute = A * (trip\ distance)^{elasticity} \quad \text{(Equation B.1)}$$

The best estimate elasticities with respect to distance were 0.42 (commuting purpose) and 0.31 (other purposes). On the basis that the journey cost is approximately linear with distance, the cost elasticity and the distance elasticity would be identical. Based on this assumption, considerable work was then undertaken to estimate representative (average) VTTS for economic appraisal purposes, given the mix of trips made by distance and income group.

While the VTTS was expressed as a function of distance, it was generally recognised that distance itself would not really explain the variation. It was suggested that the interaction should be with travel time instead of distance, given that the two are generally not perfectly correlated: Mackie et al (2003) was based on elasticities with respect to generalised costs (incorporating time, distance and toll). There was also some uncertainty about the actual sign of the elasticities in relation to distance: Mackie et al (2003) using the AHCG (1999) data, found that cost sensitivity decreased with distance while time sensitivity stayed constant. The net outcome was the VTTS increased with distance.

[17] The 1999 reappraisal and the subsequent updates/reviews did not collect new data, but re-analysed and reinterpreted the data from the AHCG (1999) study.

B3.3 Meta-analyses

ITS Leeds had been undertaking meta-analyses on VTTS evidence since the late 1990s; the original 1997 analyses were updated in 2000 and then again in 2003 for DfT. A further update was undertaken as part of the 2010 work for DfT (Abrantes and Wardman 2011).

The emphasis of all these meta-analyses has been on UK evidence, with a focus on different variables in different updates. The 2003 update focused on in-vehicle time, walk time, wait time and headway; the 2010 update focused on a number of other attributes, including departure time shift, time spent in congested and free-flow traffic, and late arrival time. It covered 225 studies with some 930 observations of in-vehicle time.

BOX B.1: MODEL FORMULATIONS ASSESSED IN ITS/BATES REVIEW [MACKIE ET AL 2003]

Any variations in VTTS with trip length are unlikely to be due to distance per se, but of course both trip duration (travel time) and trip cost will vary monotonically with distance. The following summarises alternative model formulations and their testing, taken from the ITS/Bates review.

Starting with a basic specification (from ITS WP561) of Model (M11):

$$U_{ikj} = \beta_c.\ c_{ikj} + \beta_t.\ t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M11)}$$

Five variants were proposed using the actual time T and cost C as covariates:

a) Cost and time effects

$$U_{ikj} = (\beta_{c0} + \beta_{c1}\ C_i).\ \Delta c_{ikj} + (\beta_{t0} + \beta_{t1}\ T_i).\ \Delta t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M6a)}$$

b) Time effect on both cost and time coefficients

$$U_{ikj} = (\beta_{c0} + \beta_{c1}\ T_i).\ \Delta c_{ikj} + (\beta_{t0} + \beta_{t1}\ T_i).\ \Delta t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M6b)}$$

c) Time effect on cost coefficient only

$$U_{ikj} = (\beta_{c0} + \beta_{c1}\ T_i).\ \Delta c_{ikj} + \beta_t.\ \Delta t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M6c)}$$

d) Cost effect on cost coefficient only

$$U_{ikj} = (\beta_{c0} + \beta_{c1}\ C_i).\ \Delta c_{ikj} + \beta_t.\ \Delta t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M6d)}$$

e) Time effect on time coefficient only

$$U_{ikj} = \beta_c.\ \Delta c_{ikj} + (\beta_{t0} + \beta_{t1}\ T_i).\ \Delta t_{ikj} + \Omega\ ltc_{kj} \qquad \text{(Equation M6e)}$$

The results indicated that all the specifications were very similar. The theoretically expected form (M6a) performed the best[(a)], but it was only marginally better than form (M6d), which for all three purposes produced a better fit than all the remaining specifications. Model (M6d), which confines the journey length effect to the cost variable, was therefore used as the base for the subsequent analysis. Since the basic cost coefficient [β_{c0}] was negative and the "incremental" coefficient [β_{c1}] was positive, the implications of this were that the variation in VTTS was due to the impact of a given increment in cost being less onerous as the overall journey cost increases. Nonetheless, it should be noted that other competing models were not strongly rejected.

Given that VTTS has been demonstrated to vary with distance, it is convenient to estimate the elasticity with respect to distance directly, provided the form assumed gives a reasonable fit to the data. However, in the AHCG study, the distance was not available. Hence, the cost (of the observed journey to which the SP related) was taken as the appropriate variable, and the term $(\beta_{c0} + \beta_{c1}\ C_i).\ \Delta c_{ikj}$ in Model (M6d) above was substituted by the term $b_c \cdot \left(\frac{Cost}{Cost_0}\right)^{h_{Cost}} . Dc_{ikj}$, where $Cost_0$ is an arbitrarily defined base or reference value for the purpose of stabilising the estimation (an income term was also included). This form performed better than (M6d). Note that in this formulation the elasticity is negative, since the effect is to reduce the size of the (negative) cost coefficient β_c: however, since β_c is in the denominator for the VTTS calculation, the impact of higher base cost on VTTS is positive.

Note: (a) Although the time covariate was not significant for business and commuting.

In terms of the relationship between VTTS and distance, the later UK meta-analyses gave a distance elasticity on car driver in-vehicle time of 0.21[18], compared with 0.26 in the previous meta-analysis (Mackie et al 2003). These results imply that the VTTS for a journey of around 100 miles is around double that for a journey of two miles[19]. The analyses did not find any effects on the value of time, additional to this distance effect, according to whether or not the journey was inter-urban (rather than other longer-distance travel).

A recent extension of the ITS Leeds UK meta-analyses covered the whole of Europe, although noting that some 60% of the values analysed relate to the UK – hence it is covered here (Wardman et al 2013). For car travel, the meta-model gave a unit VTTS elasticity with respect to trip distance of 0.14. An additional analysis was undertaken (at the client's request) to assess the effects of replacing the distance function with a simple split between urban and inter-urban travel. This found that the VTTS parameter for inter-urban travel was 53% greater than that for urban travel.

B3.4 M6 toll study

The M6 toll route (M6T) is the UK's first toll motorway, opened in 2004. It runs 43km in a SE–NW direction, north of Birmingham, and provides an alternative route to the often-congested M6 motorway. The route was the subject of extensive studies on travel demand and WTP in 2007–08 (refer Wardman et al 2008; AECOM 2009; Wardman and Ibanez 2013).

The variation in VTTS with journey duration was estimated using a 'banded' functional form: a base coefficient was estimated for journeys of 45 minutes together with increments for longer durations, divided into time bands: the estimated elasticities then varied for each band.

The unit VTTS was found to increase significantly and systematically with journey duration, eg from about £7.50/hour for a 30-minute trip to about £9/hour for a two-hour trip and to £10/hour for a five-hour trip. The equivalent point elasticities of VTTS for trip duration increased from about 0.06 for the 30-minute trip to 0.14 for the two-hour trip and 0.22 for the five-hour trip (AECOM 2009).

The report notes that these elasticities were significantly lower than the estimates derived from the reanalysis of the AHCG data (0.41 for commuting, 0.32 for other non-work purposes) and those derived from the updated meta-analyses (0.21), as above. It suggests that those results seem implausibly high in the context of the large range of travel times relevant to inter-urban travel.

The report examines whether the results might be affected by variations in journey purpose or income. Generally those with higher incomes tend to have higher values of time and to travel further. However, in the M6T case, the leisure travellers travelled furthest and there was no indication that income differences were affecting the results. Further analyses showed that the duration effect remained significant in models which also accounted separately for journey purpose and income effects.

B3.5 Summary of UK findings

The findings from the UK studies outlined in the previous sub-sections were brought together and considered further in the Batley et al (2010) report. The relative merits and interpretation of the VTTS versus distance (or duration) evidence from the AHCG re-analyses, the updated meta-analyses and the M6T studies were discussed, and some supplementary analyses were presented. It is noted that:

[18] Or 1.16 including rail passenger data (Abrantes and Wardman 2009).

[19] Derived as VTTS(100)/VTTS(2) = $(100/2)^{0.22} \approx 2.36$.

- There are some very sound reasons why the marginal utility of time might increase with journey length. These include: (i) longer journeys involve more travel time and therefore leave less time for other activities, hence we might expect time savings to be relatively highly valued; (ii) discomfort may well set in at longer journey lengths and could be expected to increase with duration; and (iii) the opportunity cost of time spent travelling can be expected to be large if an individual is prepared to invest a large amount of travel time to undertake an activity.
- The argument of proportionality would indicate that a given time saving (in minutes) would have lesser value on longer distance journeys: this certainly has intuitive appeal, but detailed analysis of such effects has not been undertaken.
- SP exercises which deal with longer distances tend to offer larger time savings, which could impact on the implied distance effect.

The report goes on to summarise its findings on trip duration/distance effects as follows:

> *It is clear that the value of time increases with journey distance, and that there are no methodological barriers to the examination of such effects in future work.*
>
> *However, there is little explicit evidence on whether an individual would value a specific time saving more or less on a longer journey, and why. Nor is there direct evidence on individuals' attitudes to proportional time savings.*
>
> *There would seem to be some uncertainty as to the cause of the variation in the value of the time, and confounding effects from income, the size of time savings offered and purpose need to be isolated, whilst proportionality arguments also need to be tested.*

In part in response to these UK findings, it was decided that this project would undertake an exploratory survey of market preferences between saving a given amount of time on longer vs shorter duration trips, thus examining the proportionality argument in particular. The findings from this survey are presented in chapter 5, with further details in appendix E.

B4 European studies

B4.1 Scope

This section summarises the main evidence and findings from market research and analyses undertaken in selected European countries (apart from the UK), mainly over the last 10 years. The countries covered, all of which have carried out national value of time studies during that period, are Denmark, Sweden, Norway, the Netherlands and Switzerland. There has been considerable cross-fertilisation of methods between these various studies, and also with the UK studies.

B4.2 Denmark

The 2006 Danish value of time study (Fosgerau et al 2007) estimated a model with separate time values for short and long trips: the dividing line between 'short' and 'long' was based on the median trip lengths, approximately 25km for car trips.

It was found that the mean VTTS for driving in free-flow conditions was 98DKK/hour for the shorter trips, 78DKK/hour (c.20% lower) for the longer trips.

The authors of the study comment on the subsequent selection of values for economic appraisal, based on the market research/modelling, as follows:

Note that we then (do) not make a distinction between short and long distance trips, the average is for all trips. This was an explicit wish from the Steering Group, since the segmentation by trip length is hard to handle in practical applications.

B4.3 Sweden

The 2008 Swedish value of time study (Borjesson and Eliasson 2012) used SP methods to survey car, bus and train trips of all lengths and trip purposes (apart from employer's business). It applied and built on the methodological advances of the equivalent Danish study above (Fosgerau et al 2007).

The model estimation results indicated that unit VTTS varied with travel time to the power 0.13 (ie elasticity of unit VTTS variation with travel time = 0.13).

Table B.1 shows the unit values of time for car users derived in the study and intended for use in applied transport appraisal. It should be noted that:

- The dividing line between 'short' and 'long' trips was 100km (as had been used in previous Swedish appraisal practice).
- The values represent the average VTTS for all individuals in the estimation sample, weighted by travel distance.
- The left side of the table shows 'raw' values, the right side gives values controlled for income differences (ie the income effect is taken out by estimating the mean VTTS at the mean income of the sample). However, it is evident that this adjustment has had little effect on the relative values.
- The values in the Stockholm region are around 30% higher than in the other regions. The likely reasons for these differences are discussed in the report (they are not primarily the result of income differences). After significant debate, the Swedish Transport Administration decided not to differentiate the VTTS by region in the Swedish appraisal guidelines (the report indicates that such regional differentiation is not adopted in any other country, to the authors' knowledge); but it did decide to adopt the income-adjusted values (on the right side of the table).[20]
- For the 'all regions' figures, the long distance values (all purposes) are around 20%–25% greater than the short distance commuter values and 85%–90% above the short distance 'other purposes' values[21]. The car values finally adopted for evaluation purposes involve longer distance trips being valued (per minute) c.24% higher than shorter distance trips.

[20] Refer sections 6.1.5.1, 6.2.4.2 for further discussion on the merits of adopting the 'income-adjusted' approach.

[21] The long distance values were not available disaggregated by trip purpose.

Table B.1 Swedish values of time by car for use in applied appraisal (€/hour). Actual values (left) and values controlled for differences in income (right)

Region	True values of time			Values of time evaluated at mean income of the sample		
	Short distance, commute	Short distance, other purposes	Long distance, all purposes	Short distance, commute	Short distance, other purposes	Long distance, all purposes
Stockholm	12.1	7.8	14.9	10.9	7.6	14.0
Other regions	9.2	5.9	11.4	8.3	5.7	10.6
All regions	9.8	6.1	11.7	8.8	5.9	10.9

Source: Borjessen and Eliasson 2012, table 3.

B4.4 Norway

Table B.2 summarises estimated car driver valuations from the most recent Norwegian value of time study (Samstad et al 2010). Values are given for commuter travel and other private travel, split by distance bands, on two alternative bases: (i) less/more than 50km; (ii) less/more than 100km.

It is seen that:

- Commuter values are 15%–35% greater than values for 'other private' purposes.
- Based on the 100km dividing line, values for the longer distance trips are around double (94%–122%) those for the shorter trips.
- Based on the 50km dividing line, values for the longer distance trips are around 80%–85% greater than those for the shorter trips.

Table B.2 Norwegian value of time study: driver unit VTTS for long vs short trips

Trip purpose (non-business)	Values by trip length (2009 NOK/hour)			
	<100km	>100km	<50km	>50km
Commuter	90	200	84	151
Other private	77	146	70	130
All private	80	150	73	136

Source: Samstad et al 2010.

B4.5 Netherlands

There appears to be no published material from the most recent Dutch study (Significance et al 2012) relating directly to trip duration. The results from the 'advanced MNL mean-dispersion models' are very difficult to interpret in this regard.

B4.6 Switzerland

The Swiss value of travel time savings study (Axhausen et al 2004) was carried out using various datasets collected during the period 2000–06. The study applied the basic multi-nomial logit formulation, along with extensions that allowed for taste differences between individuals and for error scale differences between the different SP experiments. The models included a formulation expressing the unit VTTS as a power function of both income and distance, the power terms representing elasticities (eg for VTTS with respect to distance): this formulation was based on that used in the Mackie et al (2003) re-analyses of the AHCG (1999) results.

Distance elasticity functions were estimated for the mode choice experiment, the route choice experiment and the combined experiment, with respective distance elasticity values of (-)0.61, (-)0.37 and (-)0.36.

B5 International evaluation practices

Table B.3 presents a summary of practices adopted for economic evaluation (appraisal) purposes in the national economic evaluation manuals of a number of countries. It is evident that:

- In most countries, the unit VTTS used does not vary with any measure of trip length (distance, duration, etc).
- In Norway and Sweden, the car user VTTS figures differ between ‘shorter’ and ‘longer’ trips, with a dividing line at 100km distance. For the longer trips, the Norwegian values are c.90% higher than those for shorter trips, and the Swedish values are 24% higher.
- In the USA, the differentiation is between inter-city and local travel: inter-city values are 40% higher for commuting, 90% higher for other (non-work) purposes.

Table B.3 Non-working VTTS variations with trip duration/distance – international evaluation practices

Country	Standard evaluation practice	Notes, comments
New Zealand	No variation	
Australia	No variation	
England	No variation	UK experts comment as follows (Guhnemann et al 2013): There is a fair amount of evidence that VTTS is higher for long-distance journeys than for short distances for a combination of reasons: • Longer journeys tend to be made by higher-income people. • Tedium and fatigue set in on longer-distance trips. • The length of time taken to make a long-distance trip can cut into the time available at the destination. In adjusting from behavioural to standard values, it would be appropriate to take account of the second and third of these factors. So far the evidence base has not been considered sufficiently secure to do this robustly, so VTTS is not taken to vary with journey length in the appraisal.
Germany	No variation	
Netherlands	No variation	
Denmark	No variation	The 2006 Danish value of time study found that car driver VTTS in free-flow conditions was somewhat lower for longer-distance (>25km) trips than for shorter trips. It was decided not to apply this distinction for evaluation purposes 'since the segmentation by trip length is hard to handle in practical applications' (Fosgerau et al 2007).
Sweden	Differentiated according to trip shorter/longer than 100km: car user values c.24% higher for longer trips than for shorter trips[a]	It is noted that (Eliasson 2013) 'The value of travel time savings are based on a recent national study. The study was a stated choice survey. The values are differentiated with respect to mode, travel purpose and trip length (shorter or longer than 100km). Income effects are removed from the valuations; however this is possible due to recent econometric advances which give much better possibilities to include covariates such as income in the value of time estimation'.
Norway	Differentiated according to trip shorter/longer than 10(?)km: value for longer trips 90% higher than for shorter trips[1]	Source Welde et al (2013). This states that the dividing line short vs long trips is 10km (probably an error – should be 100km?).
USA	Inter-city travel uses higher values than local travel: for commuting, c.40% higher; for other non-work c.90% higher.	

Source: Mackie and Worsley 2013, except as noted.

Note: [a] Source Welde et al (2013) gives Swedish values for private car (driver) VTTS of €5.9/hour for trips <10km, €13.7/hour for longer trips, but notes these values have since been increased. The reference to the dividing line of 10km seems likely to be in error (should be 100km?).

Appendix C: VTTS vs extent of time saved – detailed literature/practice review

C1 Introduction

This appendix addresses whether, and in what manner, behavioural unit VTTS (for non-business travel) varies with the size (extent) of the time savings in question. The key issue under this theme, which has been the topic of considerable empirical research and debate during the last 20–30 years, relates specifically to small time savings: Are 'small' time savings valued less (per minute) than larger savings? Hence the primary focus of this appendix is on the small time savings issue, but it also covers evidence on variations in unit VTTS for larger time increments. A summary of the evidence and findings from this appendix is provided in section 3.2 of the main text.

The small time savings literature does not provide a precise definition of 'small': some commentators consider any saving of less than 10 minutes as 'small', others use a five-minute threshold, while others only count savings of two minutes or less as small. As in the literature, we do not attempt to adopt a specific definition here, but rather follow the approach of the authors whose work we are reviewing/ summarising.

This appendix focuses on a country-by-country review of the relevant research evidence, its analyses and interpretation. It starts with UK evidence (section C.2), then covers other EU countries (section C.3), followed by Australia (section C.4), New Zealand (section C.5), USA (section C.6), Canada (section C.7) and guidance from international agencies (section C.8). We also provide (section C.9) a summary of the standard procedures adopted in leading countries for economic appraisal purposes in valuing time savings of differing magnitudes.

C2 'Recent' UK studies

C2.1 Overview

This section summarises the empirical evidence and findings from market research and analyses undertaken in the UK since the 1980s (but with a primary focus on the more recent work). It covers in turn:

- the first UK national VTTS study (MVA et al 1987)
- the second national study (AHCG 1999)
- Mackie et al (2003) re-analyses/reviews of the AHCG work
- the more recent update for UK DfT undertaken by Batley et al (2010), and a subsequent peer review of this by Laird et al (2013), as a prelude to a further potential UK national VTTS study.

This section also summarises the findings from the M6 toll route study (Wardman et al 2008), which was also summarised and discussed in Batley et al (2010).

C2.2 First national VTTS study (MVA et al 1987)

This study does not appear to have explored the empirical evidence on variations in unit VTTS with the extent of time savings (and particularly small time savings) in great depth, and does not present any empirical findings on the issue.

The report does comment (p210) on the importance of this issue, in the following terms:

> *Of the criticisms made which refer specifically to the practical application of values of time, undoubtedly the most worrying is that related to the issue of small time savings. ACTRA (1978), in their enquiry into the Department's practice, heard a number of criticisms of the fact that the same value of time is applied to time savings regardless of how small they may be:*
>
> *...The commentators feel that the empirical support... is weak and that it is wrong to regard the saving of one second by 3600 people as equivalent to 1 person saving an hour. These criticisms rest on the basis that small time savings have no value because they cannot be put to productive use, or because such savings are not perceived, or both.*

It goes on to comment that:

> *While it is probably fair to say that most of the critics of this particular aspect of current practice would argue that time savings should be given zero value below some assumed threshold (of perception or usability), the criticism in fact relates to a more general issue – the assumed constancy of the marginal value of time. Current practice starts off by assuming model forms which are linear in time and cost, from which only a constant value of time can be derived, and then applying modifications of this constant value regardless of the size of time saving. Nonetheless, it is at least plausible to suggest that the unit values of the time savings may be a function of the time saved, and further, that the evaluation may not be symmetric between time savings and time losses.*

In the report's conclusions and recommendations section, MVA states the following (p185):

> *The current convention that time savings have constant unit value irrespective of the absolute or proportionate size of the saving involved has been subject to much criticism. On the one hand our theory would lead us to expect very large time savings to have smaller unit values than small savings due to the effect of diminishing marginal utility. On the other hand it has been argued that very small time savings are of lower value: our own exploratory surveys and some evidence from other researchers lend support to the idea than small time savings should have a lower unit value, when considering individuals in the short term."*
>
> *"Despite these relatively weak theoretical and empirical indications we would recommend that the existing convention be retained."*

C2.3 Second national VTTS study (AHCG 1999)

C2.3.1 Study overview

This study was commissioned by the UK Department of Transport in 1993 and awarded to a consortium of Accent and Hague Consulting Group, who reported in 1996 (updated report published in 1999, following a peer review process (AHCG 1999)).

The focus of the AHCG study was entirely empirical: it was a market research exercise designed to produce measurements of the WTP of road users under a variety of external circumstances relating to travel conditions and in a variety of contexts concerning journey purposes (the activities to be visited), time of day and so on.

Through the methodology developments made in the first UK VTTS study and a number of European studies in the late 1980s/early 90s, the AHCG study had several significant advantages over these earlier studies. First, controversy within the profession over the theory was much less evident, as was controversy over the potential usefulness of SP methods. In regard to the latter, evidence had amassed during the previous 10 years to give confidence that a well-mounted survey with a well-designed questionnaire and proper analysis could yield reliable results, though this was preferably in conjunction with a supporting base of revealed preference (RP) data if actual forecasts were to be made.

Given the limitations of RP methods (including availability only for limited situations, low precision in parameter estimates), this study adopted primarily SP methods. Three different SP experiments were undertaken for car drivers: 'Experiment 1' was the most general, and looked at the response of different categories of road user to time/cost trade-offs in the broadest sense, under a range of travel conditions (the results below have all been derived from Experiment 1).

C2.3.2 Key findings (car drivers)

The key findings relating to how unit valuations of car driver VTTS vary with size (and sign) were as follows:

Short-run results:

- For any variations around the original journey time, gains (savings) are valued less than losses.
- For non-work related journeys, time savings of five minutes or less have negligible value.
- A given time (or cost) change has a larger effect when it is large relative to the duration (or cost) of the present journey. (This effect is stronger for travel costs than for travel time, generally resulting in higher values of time for longer, more costly trips.)

Longer-run effects:

- In the longer run, any differences between the valuations of gains and losses will tend to reduce. The long-run VTTS should lie between the short-run VTTS for time losses and the short-run VTTS for time gains. (On this basis, it is suggested that the long-run value will approximate the average of the two short-run values; and that this value can be taken to apply to the proportion of the market (becoming dominant over time) that has not experienced the 'before' situation.)

The report goes on to conclude:

> *These results indicate a need for a complete re-examination of current methodology, and the use of an average linear form for 'generalised cost' in particular. This applies to both forecasting and evaluation. The evidence of the SP experiments is clear, their interpretation against the background of other reported evidence is obviously more judgemental, and our conclusions are presented in that light.*

In the light of the evidence on the low/zero values for small time savings, it then suggests the following in terms of future demand forecasting and economic appraisal (evaluation) approaches:

> *For the purpose of forecasting demand, this points towards a need for testing non-linear combinations of time and cost as well as simpler linear 'generalised cost' measures.*
>
> *For evaluation purposes, where separate improvements to the system themselves lead to an immediate marginal impact with some estimated distribution of time differences varying between small, medium and large, we have advocated using some single average value for VOT (preferably by differentiating by market segments), as is now standard practice, not distinguishing between different sizes of time savings.* [For reasons of practicality, which are outlined in the report].

C2.4 Reappraisal of AHCG findings (Mackie et al 2003)

C2.4.1 Study overview

Following the completion of the initial AHCG study in 1996, a major international seminar was held to discuss the findings of the work. Three parallel peer reviews were also commissioned by DfT, focusing on three inter-related issues: unit values for small vs large time savings; long-run vs short-run values; and differences between valuation of gains and losses (refer Bates 1999; Fowkes and Wardman 1999; Glaister 1999). The final AHCG report together with these peer reviews was then published in 1999.

Subsequently, ITS Leeds together with John Bates Services was commissioned by DfT to review the AHCG reports and provide advice on how best to implement its recommendations. The scope of this commission was to review the AHCG report's evidence, relevant principles and practical considerations, and to make recommendations for change where this was considered to be justified. It involved a re-analysis of the AHCG data, and included a meta-analysis drawing on evidence from many other market research studies.

The summary report of the ITS/Bates work was published in 2003 (Mackie et al 2003b) supported by a technical report (Mackie et al 2003a). A detailed set of ITS working papers was also prepared in 2001. In addition, an updated meta-analysis of the British evidence on VTTS was undertaken by (Wardman 2001b) and its results made use of for the 2003 report.

The summary/main report consolidates the findings from all these working papers plus the three earlier peer reviews of the AHCG report. Its approach and key findings, relevant to the valuation of time savings by size (and sign), in the light of the AHCG evidence, are summarised below.

C2.4.2 Key findings

For the valuation of non-working time, the ITS/Bates approach to the assignment was to draw as far as possible on the AHCG evidence for car users, given that the AHCG study was a purpose-built study commissioned by DfT and subject to international peer review. The meta-analysis was used as a cross-check, and also to provide evidence in areas such as PT and 'out of vehicle' values which were not covered by the AHCG report. The review considered the evidence for variations in VTTS by sign and size of time savings, journey length, mode and socio-economic status.

The relevant findings (Mackie et al, 2003) are set out in Box C.1.

C2.5 M6 toll study (sources Wardman et al 2008, AECOM 2009)

The M6 toll route (M6T) is the UK's first toll motorway, opened in 2004. It runs 43km in a SE–NW direction, north of Birmingham, and provides an alternative route to the often congested M6 motorway. The route was the subject of extensive studies on travel demand and WTP, in 2007–08 (Wardman et al 2008; AECOM 2009).

Tests were undertaken on both SP and RP data to assess whether unit VTTS varied significantly with the extent of time saved; the following provides a summary of the findings.

C2.5.1 SP appraisal

> *The SP exercises covered a wide range of time savings offered by the M6T, and its extended variants, over the current M6 and A roads... The utility function in the logit model was specified in terms of time differences between alternative routes.*
>
> *In summary, the data does not support the presence of a size effect. Some of the models are quite clear that there is no such effect. Whilst others are more suggestive of an effect, the results are not entirely consistent with each other and the amount of variation in the unit value of time tends to be relatively small.*

Box C.1: Conclusions from Mackie et al (2003) report on *Values of Travel Time Savings in the UK* relating to size and sign of time savings[(a)]

We believe that the AHCG conclusion relating to significant differences in valuation according to the sign of both time and cost changes is invalid, due to a model specification error. This in turn relates to that part of the SP design which allowed direct comparisons with the 'current journey'. Although in our view it would be better not to include such comparisons, it is possible to make an appropriate allowance for them in the model specification. When this is done, the 'sign effect' effectively vanishes.

This does not mean that the idea that gains are less valued than losses is inherently implausible: what it does mean is that over the range of changes examined in the AHCG study, which would certainly cover the vast majority of highway schemes, there is not significant evidence of an effect.

With regard to the "size" effect, there is no doubt that the data strongly indicates that a lower unit utility attaches to small time changes (whether positive or negative). There is nothing apparently illogical in the data or the design which could have contributed spuriously to such an outcome, nor is it an artefact of the model specification.

There must be some doubt, however, as to whether stated preference is a suitable vehicle for carrying out the investigation of responses to small time changes. Consequently, any recommendations in this area (both for modelling and evaluation) must rely on a mixture of theory interpretation and pragmatism. It will be important to examine critically any other evidence especially RP data which can be brought to bear, as well as the question of what is actually to be defined as "small" in the context of time changes.

In the circumstances, our considered view is that the correct approach, both for evaluation and for forecasting models, is to reject the hypothesis of a low or zero value of small time changes and to base the values of time on the implied rate of trade-off between time and money for the larger time changes. This avoids the difficulty of a high marginal value of time below the threshold of 11 minutes. As Appendix D demonstrates, the resulting implied values of time are broadly consistent with what would have been obtained if all observations relating to time changes of 5 minutes or less had been dropped. We emphasise, however, that we have preferred to use a model form which provides a good explanation to all the data, and then to interpret the results carefully.

Source: Mackie et al (2003), section 4.3.

Note: [(a)] Further details behind these survey findings are provided in Bates and Whelan (2001).

C2.5.2 RP appraisal

Two sets of RP models were developed. One set was estimated on network data while the other was based on reported travel times and costs, supplemented by network data where reported data was missing. It was found that:

> *Analysis of how the unit value of time varies with the size of the time saving did not uncover any effects in either the network or reported data. The relatively minor savings in time offered by the M6T according to the network data may have been a contributory factor here, although these findings are in line with the findings of the SP analysis.* (AECOM 2009)

The overall conclusion from the M6T studies in terms of variation in unit VTTS with the extent of time savings was:

> *We have here offered time savings which are large by the standards of typical SP studies. In place of time savings of the order of 2, 5, 10 and 15 minutes, we have offered savings of 15, 30, 45 and 60 minutes and indeed some in excess of an hour. Despite this, we have not found any compelling support for the unit value of time varying by the size of the time saving. This is not though to say that the unit value of time does not differ for very small time savings.* (Wardman et al 2008)

C2.6 ITS/Bates updating study (Batley et al 2010)

C2.6.1 Study overview

In 2010, the Department for Transport commissioned a team from the Institute for Transport Studies (ITS) at the University of Leeds in collaboration with John Bates Services and the Department of Transport at the Technical University of Denmark, to scope a possible national value of travel time and reliability study. Such a study would provide material to update WebTAG, which sets out the basis for the appraisal of transport schemes in the UK.

This scoping study ('phase 1') was concerned with specifying the research activities that would be required in the main ('phase 2') study. More specifically, it was required to deliver a range of options for the conduct of phase 2, along with outline specifications for the design and resourcing of each such option. It was also expected to include recommendations on which options should be taken forward in phase 2, and on the planning of phase 2 more generally.

The following section sets out the phase 1 study comments relating to how unit VTTS might vary with the size of the time saving (in particular for small time savings) and how this issue would best be addressed in the phase 2 study. The treatment of small time savings was identified as one of the three primary 'areas of concern' to be addressed in the main study.

C2.6.2 Valuation of small time savings – summary and discussion on empirical evidence

The following is taken from Batley et al (2010):

> *The argument that STS have zero value, for example because little use can be made of them or indeed they are not actually perceived, is a longstanding one with intuitive appeal. This is a part of a more general point that the unit value of time might not be constant, and indeed conventional economic theory would imply that larger time savings would have lower unit value. There are well rehearsed arguments, such as the 'threshold argument' (Fowkes' peer review of AHCG (1999)), why STS should still be valued at the standard rate if, because of thresholds in the use of saved time, they often have zero value (ACTRA, 1978). Indeed, in the context of appraisal, there is good reason to adhere to the Common Unit Value (CUV) assumption. That said, there might still be an issue relating to the functional form of the value of travel time savings, whereupon we might wish to estimate values for small changes in time. We here focus on the empirical evidence relating to small time variations independently of the arguments surrounding appraisal issues.*
>
> *The second national study (AHCG et al., 1999) found that, in terms of SP choices, the unit VTTS was smaller when small changes in time were offered – and to the extent that time savings of five minutes or less did not have any value. This is an astonishing finding, since 5 minute differences between time attributes is not uncommon in urban SP studies. However, if we define STS to be one or two minutes, or even less, then it would be difficult to draw a clear conclusion from the AHCG study.*

The Mackie et al (2003) study, which conducted further analysis of the 1999 data, found the sign effect apparent in the previous work to be the result of model mis-specification. However, it concluded that:

> *With regard to the "size effect", there is no doubt that the data strongly indicates that a lower unit utility attaches to small time changes (whether positive or negative)". It went on to state that, "there must be some doubt, however, as to whether Stated Preference is a suitable vehicle for carrying out the investigation of responses to small time changes"; and that "We feel that the lower values for the small time savings arise because of the artificial nature of*

SP exercises, and the large imaginative leap the respondent is required to make to answer the question in a long-term rather than an immediate term manner.

A more recent contribution on this topic is the work of de Borger and Fosgerau (2008), who offer a theoretical explanation for the small time savings phenomenon.

C2.6.3 Issues in assessing valuations of small time savings

Experience in the use of SP methods in trading-off STS

The following sub-section is largely taken from Batley et al (2010, p76).

We are not aware of recent studies that have specifically addressed the issue of STS, (here defined as being up to two minutes but most certainly including less than one minute). However, we are aware of studies that have offered STS when valuing what might be termed 'soft factors' or 'secondary variables', which are expected to have relatively low values and hence small time variations must be offered if robust valuations in time units are to be obtained. This issue of STS does not seem to be a particular issue in these studies. It is routine practice to value soft factors in terms of equivalent amounts of time, and it is clearly then sensible to offer only small time variations, otherwise the time variation dominates and the SP exercise provides us with little useful information."

…Another instance when small time variations are offered is with respect to walk and wait time, since these are by their very nature often small. However, the time savings tend not to be as small as one minute and, in any event, there are concerns about the reliability of walk and wait values obtained in SP studies.

Time savings can also be small simply by chance. Where the SP design is based on difference between two options, then typically small differences will not be selected, with a minimum difference of 5 minutes of in-vehicle time being typical, although as we have said, differences in walk and wait time can be less. However, in order to estimate alternative specific time valuations, some exercises select different sets of journey times for each alternative. Whilst some studies might still use values defined in 5 minute intervals, whereupon the smallest non-zero difference will be 5 minutes, there is still the chance that in some studies differences are relatively small. This is more likely to occur with SP designs where the journey times offered are pivoted around current levels and particularly where percentage variations on current levels are offered.

In RP data, there is the possibility that some of the time differences are small, and hence could be examined. However, any analysis would have to be based on reported data, but whether these are normally reported to the level of detail required, instead of rounding to, say, 5 minutes, is very questionable. Any data collection in studies with the purpose of addressing time savings would have to address such issues.

Suitability of SP methods for small time savings valuation

The Batley et al (2010) report raises the question as to whether SP methods are appropriate for valuing STS, without coming to a clear conclusion. It noted that the three peer reviews of the AHCG report all questioned the adequacy of SP for this purpose. In this context, the significant evidence of threshold formation by respondents in SP surveys is also of relevance (refer Cantillo et al 2006). Another relevant area is the literature on prospect theory and reference-dependent preferences generally (see De Borger and Fosgerau 2008 for an application to discrete choice models).

While Batley et al (2010) makes the case for using RP methods for small changes, in practice it is very often difficult to find appropriate case studies.

Arguably one of the greatest concerns relating to the use of SP methods is the typically short-run focus of the survey method. Unless specific instructions to the contrary are given to respondents, they are likely to assess the options presented as having a one-off, short-term nature, so they perceive little or no opportunity to adjust their behaviour to make good use of any time savings. In the context of regular (eg commuting) trips, this may be addressed in part by expressing any time savings on a monthly or annual, as well as a daily basis.

Other points that would warrant consideration in the use of SP methods for small time savings valuations include:

- *Treatment of variability*. One reason for apparently low valuations of small time savings may be that respondents assume the time savings will be imperceptible given the day-to-day variability in the time taken for typical trips. This might be addressed through specific statements about trip time variability, or including variability as a specific SP variable.
- *Effects of trip duration*. Valuations of small time savings for longer duration trips seem highly likely to be lower than for shorter trips (eg one minute saving on a one-hour trip vs a five-minute trip). This point can be tested by appropriate interaction specifications, and relates to the question of whether respondents process VTTS choices in terms of absolute or relative savings.
- *Impacts of range of travel time savings*. In SP surveys with a mix of large and small savings in travel time, the response to smaller savings may well tend to be understated. It may therefore be preferable to focus on different sizes of time savings in different surveys.

C2.6.4 Summary of findings on valuation methods for small time savings

The Batley et al (2010) study report summarises the evidence on small time savings and approaches to valuation as follows:

> *Small time variations in SP exercises could be more prevalent than we might first think, but we are not aware of separate analysis of their utility effects. There might be scope in identifying and re-analysing some suitable data sets as part of any further work in this area.*
>
> *There is some concern about whether SP exercises are appropriate for dealing with small time variations, but this has not been demonstrated through detailed appraisal, such as through the use of focus groups or specific studies which have thoroughly tested whether SP exercises purposely designed to look at small time variations are credible.*
>
> *Some studies naturally offer small time variations because they are dealing with soft factors which have low values. There are also some real world choice contexts where travellers are routinely dealing with small variations in attributes, such as applies in queuing or its avoidance, detouring to avoid congestion, or waiting a short while for the next service to avoid overcrowding. SP exercises could be built around such contexts.*
>
> *Indeed, many would contend that the 'proof of the pudding' would lie in RP data and some 'outside-the-box' thinking should be devoted to identifying relevant contexts offering a continuum of time savings.*
>
> *We are not aware of in-depth research that has examined travellers' reactions to STS, along with other factors such as proportionate savings and savings on long and short journeys or journeys of different purposes.*

C2.7 Nash paper (2010)

In a paper on 'Current debates on the cost-benefit analysis of transport projects in Great Britain', Nash summarises issues relating to the valuation of 'small' time savings in the following terms:

> *Of more concern is the fact that these same valuations are applied to very small time savings (small road projects often yield benefits of less than a minute) even though there is evidence that such small time savings are valued at a lower rate per minute than larger savings, if indeed they are perceived at all. There are two counter arguments. Firstly, that where people or firms are subject to constraints such that, for example, only a ten minute time saving can be usefully employed, then some people will already have idle time. If this is evenly distributed between zero and ten minutes, then whilst nine people will be unable to use a one minute saving, for the tenth it will be worth ten minutes, so for the population as a whole the valuation will be correct. Secondly, even where there is no such constraint, in the long run such time savings may be aggregated with other time savings and losses from a wide variety of causes, transport and non-transport, and thus the magnitude of the ultimate effect may be greater than the initial impact. Nevertheless, these arguments do not seem persuasive politically, and it must be accepted that in the short run such small time savings may not even be perceived let alone usefully employed.*

C3 Other European studies

C3.1 Scope

The following sections cover national VTTS studies in four of the leading European countries in this field: Netherlands (C3.2), Denmark (C3.3), Sweden (C3.4) and Norway (C3.5). They focus on the evidence from these studies on small time savings empirical research and analysis, with an emphasis on the more recent studies.

C3.2 Netherlands

C3.2.1 First Netherlands study

Timetable

Initiated 1987; data collection 1988; largely completed 1989; further data analyses 1996.

References

Cheung et al 1989; Hague Consulting Group 1990; Kleijn 1996.

Scope and methodology

- **RP data:** largely based on earlier surveys, covering time vs cost trade-offs of individual travellers.
- **SP data:** involved purpose-designed surveys, involving time vs money trade-offs in various contexts, differing by journey purpose, income group, current travel mode, occupation group, personal circumstances, travel conditions, extent of leisure time. Recruitment questionnaire investigated the current trip being made, followed by a postal questionnaire on time/cost trade-offs appropriate to the mode and journey distance (revolved around actual journey, specified when recruited). More than 2,000 usable questionnaires were returned.

Analyses, results and comments

- Survey design and analysis methodology was essentially similar to that used by AHCG in the second UK study, so it is expected that results for analysis gains/losses would suffer from the same 'specification error' issue (refer section C2.4/box C.1).
- There was strong evidence that travellers valued time savings at a much lower rate than time losses. For commuters in particular, losses were valued around twice as high as savings. It appeared the general pattern of time valuations (eg variations with income and purpose) was similar to that between losses and savings, but the absolute levels were very different.
- It was unsurprising that savings and losses were perceived differently – this sort of effect has frequently been found in other market research exercises using similar techniques. The result can be rationalised, at least as a short-term response, in the sense that rigidities of schedules (communal eating, meetings outside the home etc) can be such that increases in travel time can cause severe disruption in the short term (ie until the schedules are rearranged). Further, the same sort of phenomenon can mean that time savings from travel are often not used effectively, once again in the short run.
- The study also found that larger time savings were valued (per minute) more highly than smaller savings (although little detail on this is provided in the study report).

Conclusions and recommendations

- In regard to the differing valuations of time savings and time losses, the report stated:

  This is not totally unexpected. As a result of increases in journey time, travellers will experience extra inconvenience and loss of productive work; in contrast, expected time savings often cannot be readily put into effective use. In our opinion, however, this asymmetry should be treated as a short term phenomenon. In the longer term, the traveller can readjust his schedules such that time loss and gain would tend towards the same value.

- Under the heading of policy implications, the report stated:

  We have found evidence that unit time loss is more valuable than unit time gain. Despite this, in general, it is recommended that a single average value be used as the most appropriate 'long-run' value for both. However, for projects, measures or occurrences of a temporary nature (eg delays due to road maintenance or accidents) it may be possible to argue for a higher value, since the re-scheduling of activities that is necessary to minimise the effects of the time loss cannot take place for such unplanned and unexpected events.

C3.2.2 Second Netherlands study

Timetable

Initiated 1997; reported 1998.

References

Gunn et al 1998.

Scope and methodology

- ***Objectives*** (i) To provide unit VTTS for person travel based on updated information (on trade-offs, person/household attributes, trip patterns, travel conditions etc), for use in project evaluation; (ii) to compare VTTS over time, to improve predictive procedures.

- ***Surveys***. SP surveys, replicating those in the earlier study as closely as possible. Sample sizes increased so as to be able to detect changes in VTTS, estimated from the previous study, of 10%.

Analyses, results and comments

- Like the earlier (1989) study, the analyses used purely linear models, ie no allowance was made for the size of time savings/classes or for any difference between savings and losses. Hence, like the earlier study, the analyses in this study are believed to suffer from the 'specification errors' issue identified in the UK review (refer section C2.4/box C.1).

Conclusions and recommendations

- The official advice in regard to 'sign' and 'size' aspects remained unchanged following this study, although it did note that time losses are valued more heavily than time savings.

C3.2.3 Third Netherlands study

Timetable

Initiated 2009; data collection 2009; reporting 2012.

References:

Significance et al 2012; Kouwenhoven et al 2012; Kouwenhoven et al 2014.

Scope and methodology

- ***Objectives.*** To update official unit VTTS for passenger and freight transport in the Netherlands, and to deliver the first values of reliability based on an empirical foundation.
- ***Surveys.*** Three SP experiments, involving choices between hypothetical alternatives (for a trip actually made by the respondent), defined in terms of travel time, cost and reliability.
- 5,760 person interviews completed in 2009, using an existing internet panel. However, the resulting unit VTTS were found to be much lower than the adjusted 1997 values; and therefore additional data was collected in 2011 using the same recruitment method as in 1988 and 1997 (it was found that the results from this additional data were much more consistent with the 1997 values, and therefore these results have been used for reporting purposes).

Analyses, results and comments

- Estimates of unit VTTS for person travel were made using advanced choice models (panel 'latent class' models), that allow values to depend on actual travel time and cost, on the size and sign of the time and cost changes offered in the SP experiment and on other respondent attributes.
- It was reported that 'We also confirm that smaller time differences are valued less per minute than larger time differences' (but no further details are given) (Kouwenhoven et al 2014).
- The analyses included additional tests to check whether gains and losses were valued differently (Significance et al 2012). It was concluded that the values were not significantly different.
- Interestingly, it was found that respondents had an increased sensitivity to small cost changes. The reasons for this are unclear: it may be an artefact of the complex utility functions used (which had not been attempted in any previous studies).

C3.3 Denmark (Danish value of time study)

C3.3.1 Timetable

- Initiated (preliminary studies) 2004; data collection 2005; final report 2007.
- Three phases: phase 0 – preliminary study re methodology and data collection/analysis methods; phase 1 – data collection and preliminary analysis; phase 2 – establishment of official values of time.

C3.3.2 References

Fosgerau et al 2007

C3.3.3 Scope and methodology

Surveys. Involved four SP experiments:

- SP1 – abstract time vs cost exercise – examined trade-offs of IVT vs cost.
- SP2 – disaggregated time components – examined trade-offs between hypothetical alternatives by the chosen mode containing both in-vehicle and out-of-vehicle journey components (eg access–egress, parking search, interchanges).
- SP3 – alternative modes – covered time vs cost trade-offs for an alternative mode (other than chosen mode).
- SP4 – transfer price question.

SP1 was used to estimate the central value of IVT. Data was collected for car driver, car passenger, bus, metro, S-train and train. Business trips were excluded.

SP1 data:

- All respondents had to choose between two alternatives, described by travel time and cost, and defined relative to a recent actual trip made by the respondent.
- The methodology is described in detail in the study report.
- Effective sample sizes were c.6,000 respondents (all modes), with eight choice situations covered by each respondent.

C3.3.4 Analysis methodology

Based on previous research by Fosgerau (2007), a mixed logit model was formulated directly in terms of a random VTTS function (rather than the more 'conventional' approach of a model specified with random marginal utilities of time and cost).

The details and advantages of the model formulation adopted are set out in the study report.

C3.3.5 Small time savings issues and the selection of appropriate unit VTTS

Like other similar studies (eg UK) using SP methods to investigate unit VTTS, the Danish study results indicated relatively lower unit values for small time savings. The study report sets out the procedures used to derive a 'true' unit VTTS from the raw results, to use as the basis for economic appraisal purposes.

Given the high degree of relevance of this issue to the current project, and the clarity of the discussion provided in the Danish study report, we reproduce an abbreviated version of the relevant report text in box C.2.

C3.3.6 Conclusions and recommendations

As noted in box C.2:

- The study team recommended that the appropriate unit VTTS for economic appraisal should be that resulting from the study analyses for a time difference of between 10 and 20 minutes. The steering group decided to adopt a time difference of 10 minutes for the purpose (this being a conservative choice).
- The study team noted that the issue of the valuation of 'small' time savings was not satisfactorily resolved and remained an important topic for future research.

Box C.2: STS issues and selection of appropriate unit VTTS – edited extracts from the Danish Value of Time Study Final Report(a)

Recall that subjects had to choose between two alternatives differing in travel time and cost. Our analysis shows that the VTT as measured by the econometric model increases significantly with the difference in travel times. Thus, in the data the VTT per minute is smaller when the difference in travel times is, e.g., 3 minutes than when the difference is 15 minutes.

Our analysis has revealed that the increase of the VTT with the size of travel time difference may be assumed to stop at some travel time difference. For each mode, we have estimated the minimal threshold, T * , at which the increase may be assumed to end.

Table 5 illustrates the effect of different level of time savings on the mean calculation. Numbers in bold indicate where the mean VTT can be assumed to be constant.

Table 5: Mean VTT (in DKK per hour) for different levels of time savings (Δt)

	Mean VTT						
	|Δt|=3	|Δt|=5	|Δt|=10	|Δt|=15	|Δt|=20	|Δt|=30	|Δt|=45
Car driver	50	55	66	81	98	98	98
Car passenger	38	40	47	55	64	86	86
Bus	22	24	30	37	37	37	37
Metro	35	41	62	94	94	94	94
S-train	28	31	37	45	45	45	45
Train	40	42	48	56	64	85	128

For time differences in the range 3 to T * minutes, the unit value of travel time increases with the size of the time difference. Hence a 10-minutes time saving is worth more than two 5-minutes time savings. This is not unexpected, as the same pattern was found in the Dutch and British Value of Travel Time studies. When evaluating transport projects, however, a lower unit VTT for small time changes is not appropriate, and a constant unit value should be assigned to all time changes.10 Otherwise the evaluation of a transport improvement would depend in an illogical way on whether the project was evaluated as a whole or as a series of smaller projects each resulting in smaller time savings.

Hence the mean VTT we wish to calculate must not depend on the size of the time change. This means we have to choose a level of time change for which to evaluate the mean VTT. This choice is a crucial point in the mean calculation: Since the effect of the size of the time change is quite large, different choices of time saving sizes are likely to produce very different mean VTT values.

The distribution of time differences within the sample is a result of the experimental design and not a feature of the underlying population. It is therefore not appropriate to use an average over the sample to account for the size of the time difference.

In accordance with the British Value of Travel Time Study (Mackie et al 2001), we shall base our choice on the assumption that the observed lower unit VTT for small time changes is not a 'true feature' of the value of travel time but is caused by the artificial nature of the experimental design. This assumption rests on the following propositions regarding the observed value of small time changes:

- When making choices in an experiment, people ignore time savings that are too small to "matter" – i.e. that are negligible compared to the entire journey time or to the variation in journey time (delays) they experience from day to day. This type of effect can also be thought of as editing in the sense of Kahneman and Tversky (1979), whereby subjects simplify the choice task prior to choosing.

- People may find that small time savings are of very little value, because it is not possible for them to reschedule their activities in order to make use of the extra time. This is a short-run perspective, and we expect that a permanent time saving would over time be incorporated into people's schedules, such that they would eventually benefit from it. However, the experiment has a tight focus on an actual trip recently made by the subject (subjects are explicitly instructed to imagine that they should undertake this same trip again), and this focus on a single trip may cause people not to consider long term consequences. Another important feature of our data is that the reference trip is not a frequently made trip. In 57% of the cases it is a trip made once a month or less frequent. It is likely that this makes it even more difficult for people to imagine the long term consequences of a change in travel time.
- Even if there are certain time savings that are too small to be of use, because most activities take a certain 'minimum' time, Fowkes (1999) shows that a procedure taking this into account and only valuing time savings if they contribute to disposable time intervals of a certain size, will yield the same average value of time as a constant unit value procedure.

In the British Value of Travel Time Study, Mackie et al. (2001 and 2003), estimate a model where VTT depends on dummies for each size of time change, and find that time changes of less than 10 minutes have very small VTT. Based on this, they estimate a model where VTT is constant for time changes greater than or equal to 11 minutes, and is allowed to vary with the size of the change for changes less than 11 minutes. The mean VTT is based on the latter model and evaluated at what corresponds to a time change of 11 minutes.

Adopting the same procedure as in the UK study, our results indicate thresholds that vary by mode. The minimum threshold that we estimate is 15 minutes and the largest is 45 minutes. We would however not feel comfortable in recommending these thresholds, since we cannot rule out that they are affected by the distribution of travel time differences presented to subjects. The travel time difference presented was a function of the actual travel time such that changes both up and down relative to the reference trip would be meaningful. This implies that the large travel time differences occur only for long trips. The share of long trips varies considerable by mode. Thus we have many long trips by train where we also estimate the largest threshold. Conversely we have mostly short trips by bus, metro and S-train where we also estimate the lowest thresholds.

We cannot rule out that the fact that we are able to accept a threshold where the effect of the travel time difference disappears is a consequence of the data and that the estimated thresholds would have been higher if we had more observations of long trips. This points towards using lower values for the travel time difference.

On the other hand the travel time difference should be large enough to eliminate "disturbance" from the effects discussed above. We feel that this requires at least a difference of 10 minutes in accordance with the UK results, and possibly more since we estimate higher thresholds.

Consequently we have recommended to the steering group that a level for the time difference of between 10 and 20 minutes should be used to compute the mean VTT for cost benefit analyses. The steering group has then chosen a time difference of 10 minutes on the grounds that this is the conservative choice. This value is used for all computations in the following.

Finally, we note that the issue concerning the value of small travel times is still not satisfactorily resolved and remains an important topic for future research.

Note: [(a)] Extracts from Fosgerau et al (2007), section 3.4.

C3.4 Sweden

C3.4.1 First Swedish study

Overview

- Initiated 1994, main surveys 1994

References

- Algers et al 1996; Hultkrantz and Mortazavi 2001
- Original study followed similar methods to those used in the preceding UK and Netherlands studies (using linear utility functions). It did not consider the size or sign of time savings.

Subsequent analyses

- Subsequent analyses (Hultkrantz and Mortazavi 2001) of the original SP survey data derived a RUM-model from a second order approximation to the utility function, using probit analysis. Relative to the original survey analyses it was found that: (i) the VTTS estimates were considerably lower; and (ii) there were signs of a cognitive threshold relating to small time savings, with very low VTTS for savings of less than 10–15 minutes.

C3.4.2 Second Swedish study

Overview

Initiated 2007, main surveys 2007–08.

References

Borjesson and Eliasson 2012; Borjesson et al 2012

Discussion on 'reference dependence'

- SP choice experiments are almost always framed as variations around a 'reference' situation, relating to a real-world trip made by the respondent. But this approach affects the estimated valuations in the form of size and sign effects. The sign effects (known as loss aversion) mean that gains (shorter travel times) are valued less than losses (longer travel times or higher travel costs). Size effects refer to the common empirical finding that the VTTS depends on the size of the differences between the alternatives offered, and in particular to the common finding that small time savings are valued less (per minute) than larger time savings.
- When evaluating policies that will have a life of several decades, it is not usually meaningful to compare these against a reference case: welfare evaluations need to be based on the underlying, long-run stable preferences. How to estimate a long-run stable reference-free VTTS from stated choice data is still not a fully resolved issue, although progress has been made in recent years through this study and other European studies. At the very least, it is necessary to control for variables relating purely to the experimental design, such as size and sign of changes relative to the reference situation. In the absence of such control, the design will in effect determine the resulting VTTTS, and inexplicable differences in valuations will result from different surveys.

Analysis of size effects

- Size effects are one type of reference-dependent phenomenon, which needs to be controlled for. Typically, size effects will cause the estimated VTTS to be higher the larger the time difference is between alternatives. Even if this effect is real, in the sense that it is not solely the result of the hypothetical setting, it is not relevant for appraisal purposes – over time, the original reference situation becomes irrelevant as trip contexts, individuals and the transport system change.

- Size effects can be readily controlled for in the model specification applied, by introducing the differences in time and cost between the binary alternatives as covariates. Figure C.1 illustrates how the VTTS estimates derived from the surveys vary according to the extent of the time saving hypothesised: the x-axis shows the hypothesised time savings (for car trips and long-distance PT trips); the y-axis shows the corresponding VTTS mean estimates and confidence intervals, relative to the estimates at 20 minutes (set = 1.0).
- For car travel, the VTTS for a five-minute saving is about 70% of the base (20-minute) value, while for PT trips, the five-minute value is about 50% of the base value. For small time savings, values are still significant, down to savings of one to two minutes. For larger savings, it appears that VTTS keeps increasing with the hypothesised time savings, up to about 45 minutes for car travel and up to about 25 minutes for long-distance PT (for local/regional PT, the sensitivity of values to the extent of the hypothesised time savings was much less).
- Multiple authors have discussed the reasons for the effects on values of the hypothesised time savings, and how best to deal with these effects in appraisal. A number of different, partly overlapping, interpretations have been conjectured:
  - Individuals may actually value small time savings less per minute than larger savings, because small time savings cannot readily be used for any meaningful activities in the short run, when schedules are already constrained (and it is not possible to retain any time savings for future use, unlike money savings).
  - The size effect could arise because respondents simplify the choice process by disregarding small differences between alternatives. Generally, it is found that individuals make increasingly rational choices when differences are larger and stakes are higher. In the present context, this would imply that the size effect does not arise because passengers value smaller time savings less per minute than large ones, but because of a simplification error in how they respond to the choice questions.
  - If travel times are regarded as unreliable, it is possible that respondents do not consider, or heavily discount, travel time savings that lie within the normal variation of the mean travel time.
  - Analysis of the Norwegian VTTS data found the size effect could be explained by reference-dependence, but still not eliminated.
- This last point means it is necessary to decide on a ‘base’ level of time savings and derive a unit VTTS consistent with this. In the two diagrams, this ‘base’ level has been set (rather arbitrarily) at 20 minutes. The first three interpretations given above all suggest that the relevant, reference-free VTTS will tend to be under-estimated at smaller values.
- In summary, the results of this work provide a better understanding of **how** the hypothesised extent of time savings affect the unit values of time, but do not explain **why**. Even if there is no certainty about how size effects should be dealt with in applied CBA, it is often extremely important to control for them. If not, the researcher runs the risk of getting results that depend crucially on the SP design – the larger the time differences offered, the higher the estimated valuations are likely to become. Several major SP surveys have produced strange and counter-intuitive estimates as a result of this problem.

Figure C.1 Swedish value of tine study: estimates of influence of size of time saving on VTTS (car trips)

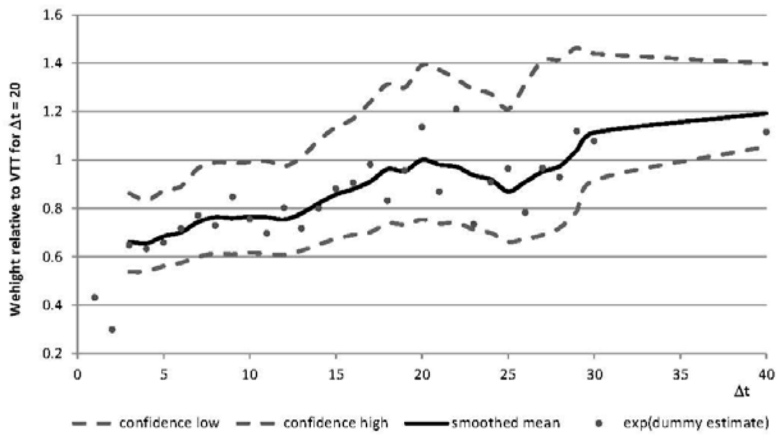


Figure 3 Non-parametric estimates of the influence of Δt on VTTS, car trips.

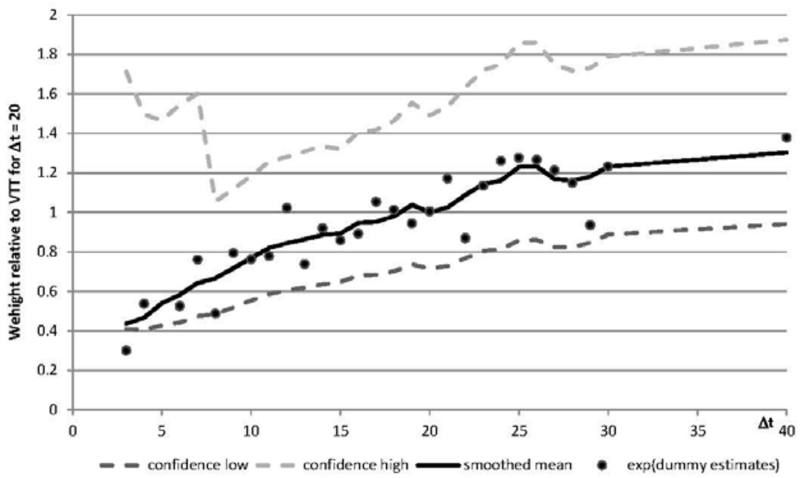


Figure 4: Non-parametric estimates of the influence of Δt on VTTS, long-distance public transport.

C3.5 Norway

C3.5.1 First Norwegian study

Overview

Initiated 1994, surveys 1994–95–96, study completion 1997

References

Ramjerdi 1993; Ramjerdi et al 1997.

Approach/methodology

- Approach was based on that used in the UK study (MVA et al 1987), Netherlands study (HCG 1990) and Swedish study (Algers et al 1996).

Relevant findings

- No significant variations in VTTS by size of time savings were identified. (The SP surveys did not allow for any time savings/losses less than two minutes for urban travel, five minutes for interurban travel.)

C3.5.2 Second Norwegian study

Overview

Initiated 2007, main surveys 2009, study completion/reporting 2010

References

Ramjerdi et al 2010

Approach/methodology

- For motorised trips, the choice experiment designed to estimate VTTS mean and distribution was based on only two attributes – time and costs. The design was similar to that of the Swedish (second) study, and allowed estimation of utility functions that do not conform to ordinary consumer survey (but allow for loss aversion). The experiment was analysed using non-parametric and semi-parametric methods (after Fosgerau 2007).

Relevant findings

It appears that, apart from tables of recommended values in a summary report, Ramjerdi et al (2010) is available in a Norwegian language version only.

C4 Australian studies

C4.1 Overview

The topic of valuation of small time savings has been given significant attention in the Australian literature, most recently and relevantly through an Austroads (2011) project set out in section C4.4.

A number of earlier Australian reports also addressed the valuation of small time savings, including those summarised briefly in sections C4.2 and C4.3.

C4.2 BTE (1982) The value of travel time savings in public sector evaluation Occasional paper 51.

Points made in this paper included the following relating to valuing small time savings:

> *The Leitch Report (1977) on trunk road assessment in the UK pointed out that inter-urban roads are generally improved on a piecemeal basis and that the time savings gained on a typical journey comprises an aggregate of small piecemeal savings. It would then be inconsistent to value the overall time saving differently from its component parts. This is a powerful argument, and if rejected could lead to a major shift in thinking on the economics of stage construction as the net benefits from a total project could be less than those from the same project developed in stages, with small time savings being ignored at each stage.*
>
> *...If however, the practice of attributing the same unit value to all time savings is incorrect, the rates of return from urban road investment (where small time savings may be enjoyed by a large number of travellers) could be over-estimated when compared with the returns from inter-urban road investment where traffic flows may be lower but individual time savings greater because of the greater journey length.*

...In a number of standard operational evaluation procedures, the methods of calculation do not permit the separation of small time savings per traveller. This happens where such procedures analyse a system as an aggregate of network links. . . It is only in complete origin-destination based methods of analysis (eg McIntosh & Quarmby, 1970) that such exclusions and small differences can be made.

...The evaluation methods for roads developed by the former Commonwealth Bureau of Roads (Commonwealth Bureau of Roads, 1969) and those adopted for non-urban roads by most State Road Authorities (eg NSW Department of Main Roads, 1981) are among the methods which prevent exclusion or separate treatment of small time savings.

...In general, travellers may only be aware of large time savings; many savings will be too small to be used for economic activity. Such savings may still have considerable value though if the disutility of some 'unpleasant' form of travel is reduced.

...The critical feature then of small travel time savings theory is that small time changes are not necessarily fully perceived. As a result, the perceived value of small time changes is less than would be predicted by a linear utility function. The inclusion of small travel time savings in evaluations (say, less than five minutes) could then lead to erroneous results and an overestimation of the benefits or losses to existing demand.

C4.3 Austroads (1995) Value of travel time savings

One of the conclusions of this report was:

The Project Team could not reach a consensus agreement on the value to be applied to small time savings. Consequently it was agreed to retain the current convention that time savings have a constant unit value irrespective of the magnitude of the savings for individual trips.

C4.4 Austroads (2011) Small travel time savings: treatment in project evaluations

This comprehensive report on the valuation of small time savings for economic appraisal (evaluation) purposes was prepared for Austroads (by ARRB) in 2011. Given that this report was (i) prepared relatively recently; (ii) involved a comprehensive international review on the topic; and (iii) was commissioned by Austroads (of which the NZ Transport Agency is a member), the following text reproduces the major part of the 'Concluding remarks' and Recommendations' sections of the report[22].

C4.4.1 Concluding remarks

The evidence found in the literature and discussed in this report regarding the way 'small' travel time savings are defined is mixed. There appears to be some consensus in this literature that the way one defines small travel time savings affects the valuing and the outcomes of the appraisal of any particular infrastructure investment scheme. However, this evidence provides stronger support for defining small travel time savings in terms of the percentage of the trip the time savings account for. In comparison, the absolute definitions of small travel time savings (e.g. the actual number of time units saved), are regarded as difficult to interpret and can be misleading.

[22] A more detailed 'commentary' on the report's key findings from its international research is provided in the Austroads (2012) update to its *Guide to project evaluation – part 2: project evaluation methodology*.

A comprehensive survey of the literature and of the associated debate regarding 'small' travel time savings by the US Department of Transportation (DoT 1997) found that most of the evidence given in support of valuing approaches, which discount or otherwise reduce the value of small travel time savings below that of larger travel time savings, is based on early papers that are no longer deemed to be reliable. They also find that neither the underlying theory nor empirical evidence provides reliable guidance for identifying a threshold to distinguish between small and large time savings. These findings would tend to support the need for better definitions and measurement of travel time savings, rather than arguments of 'small' vs. 'large' time savings.

The findings of the DoT (1997) survey are also supported by a significant move in practice to the 'constant or non-zero unit value' (CUV) approach and away from the 'discounted unit value' (DUV) approach. Although shortcomings in the use of CUV have been noted, it is still the preferred approach in many instances, and it is widely favoured to use in cost-benefit analyses. The CUV approach appears to be the methodologically robust approach.

Findings from a number of studies in the literature indicate that many travellers, especially intra-urban travellers, enjoy small travel time savings (Powell & Bowers 1996). Also, considering small travel time savings made on different stages of a single journey can show how a small travel time saving made at one stage of the journey, may contribute significantly to an overall time saving for the entire journey. Leitch (1977) indicates that it is inconsistent to value the overall time saving differently from the sum of its parts.

'Distribution of slack time' argument also shows that any given time saving will push at least some travellers over a 'small' travel time threshold, and, as such, their total time saving would be useful and therefore valuable. Furthermore, the long-term value of small travel time savings, which is likely to be greater than the short-term value because of the ability of travellers to reschedule over the longer term, also supports the argument that even very small time savings can be put to some productive use.

There have been long standing debates about which factors affect the value of travel time savings. These … include the following:

- *the perspective that is taken when valuing travel time savings*
- *the consistency of the occurrence and size of the travel time saving*
- *whether the value required is a short-term or a long-term value*
- *the mode of travel*
- *the nature of the journey purpose.*

The nature of the journey purpose could have a large impact on the usefulness of small travel time savings made, from both an objective and subjective perspective. The nature of the journey purpose could be determined by its characteristics, which are suggested as being the flexibility or inflexibility of scheduling, the value of the journey purpose (either objective or subjective) and the routine or non-routine nature of the purpose. The extent of flexibility surrounding the trip purpose might affect the value that small travel time savings would have, but larger values would be gained from an objective measurement of the economic benefit gained from the small travel time saving.

The individual's valuation of a small travel time saving could be seen to be largely dependent on their current conditions or context. One individual may not perceive a five minute travel *time saving as being very valuable, but for another, whose situation is slightly different, a five minute travel time saving may have a high perceived unit value. Perception thresholds are therefore not standard or consistent measures from which to derive values of small travel time savings.*

Valuing the additional access as opposed to simply valuing savings in time, as suggested by Metz (2008), might be another way in which small travel time savings could have significant value. Theory of increased accessibility being the real source of the value provided by travel time savings also requires values to be considered in a long-term context. It is debatable whether small travel time savings (defined in absolute terms) could provide increased accessibility, but in the long-term, travel time savings of any size are likely to have greater utility than when considered in a short-term context.

Small travel time savings are likely to have more value if they occur on a regular basis and have a low degree of variability in their size. In the long-term, full or productive use can be made of travel time savings because of gradual rescheduling on the part of the individual, then it must be acknowledged that for this to happen, the small travel time savings should occur on a regular basis for a particular journey, and that there is a low degree of variability in the size of the travel time saving.

Finally, in relation to travel time savings and public transport, there may be a relatively high utility associated with a small in-vehicle travel time saving, because of the effect that the travel time saving may have on the conditions of the out-of-vehicle travel time. In particular, if a traveller had to use public transport to travel to a destination for an activity which had a fixed starting time. There is also the possibility that a traveller using public transport has to make one or more connections. In the event that a small travel time saving reduces the chance of a missed connection and the associated disutility, small travel time savings for public transport journeys may have significant unit values, even when considered in a short-term context.

C4.4.2 Recommendations

This comprehensive review of the literature regarding the definition and measurement of 'small' travel time savings points to the following recommendations:

1. *Austroads research should focus on the need for improving definitions and measurement of travel time savings, and recognise the potentially misdirected nature of the arguments surrounding the notion of 'small' travel time savings.*
2. *Focus on the development of a more appropriate methodology that defines, specifies and measures the concept of travel reliability instead of the measurement of absolute quantities (e.g. minutes) of time saved.*
3. *Austroads research resources to be applied in providing robust evidence and advice for performing comprehensive benefit cost analyses of projects, including improved estimation of travel time savings for passengers and freight.*

C5 New Zealand studies

C5.1 Overview

Valuation issues for small time savings have been given surprisingly little attention in the New Zealand literature, and the extent of previous New Zealand-based market research specific to this topic has been minimal. As an introduction to this section, we make the following comments:

- Two recent Transport Agency research reports address the topic to some degree, although it was not their main focus. Summaries and comments on the relevant material from these two reports are given in the following two sections (C5.2, C5.3).
- Surprisingly, the BCHF et al (2002) report, which reports on the most recent New Zealand primary market research on VTTS and includes a summary of international evidence up to that time, does not mention the topic. However, a paper prepared before the BCHF surveys were undertaken states the following:

  It has been found that when small time variations are offered in stated preference surveys they tend to be valued disproportionately less than larger variations. Respondents may perceive little value in very small time savings, even though these may accumulate to substantial amounts. Consequently, the stated preference survey designs for this exercise will exclude time variations of less than one minute.
- The topic is discussed in quite a number of New Zealand reports dating back to the late 1980s and the 1990s. However, these reports were essentially reviews of international evidence and arguments, with no New Zealand-specific material, and thus are not covered here (use is made of some of their material elsewhere in this paper).

C5.2 'Economic evaluation of the impacts of safe speeds' (RR 505)

This Transport Agency research report (Frith 2012) focused on a literature review of approaches to trading off time savings, crash costs and fuel/emission savings, within the context of a 'Safe System' approach to road safety.

In regard to small time savings valuation, the report includes a review of a number of international studies undertaken during the previous 15 years (most of these are commented on elsewhere in this paper), covering in particular the evidence and arguments for the use of a constant unit value (CUV) approach versus a discounted (DUV) approach. The report provides very little empirical evidence on this topic, but does note the findings from various studies indicating that a large proportion of total time savings estimated, using the CUV approach, for most (primarily urban) road schemes relate to 'small' time savings (typically less than three minutes).

The executive summary of the report includes the following:

> *Within these aggregations, constant averages are used without any discounting of the values of small lengths of time. The discounting of small lengths of time has been frequently mooted but little has been done, notwithstanding evidence that such discounting might be appropriate in some circumstances. This is linked to difficulties in defining what a short length of time is and in deciding what type of discounting protocol to use from a number available. In particular it is arguable as to whether an approach without any discounting for small time savings properly allows for the interests of vulnerable road users by over-emphasising the costs of small-time losses associated with slowing for vulnerable road users*

in urban areas. As discounting may be applicable in some circumstances this is a liberal rather than conservative approach.

C5.3 'A wider look at how travellers value the quality and quantity of time savings' (RR 469)

The purpose of this Transport Agency research report (O'Fallon and Wallis 2012) was to explore the utility of travel time when commuting to work or tertiary study, by a range of modes. It involved a review of international literature and experience, and an on-line survey of c.500 commuters to validate/verify the composition of any travel time utility and distribution of travel time saving valuations. The research particularly addressed how the (dis)utility of time spent commuting varied with the total commute time involved, rather than addressed the valuation of STS directly.

The literature review suggested that there may be an 'ideal minimum' commute time for travel to work, which commuters may or may not consciously acknowledge. The survey results were consistent with this, indicating an ideal commute time of around 10 minutes, and with very few respondents indicating an ideal commute time of zero.

The implication of this is that, while most commuters (who now have commute times greater than 10 minutes) will gain positive utility from reducing their commute times, a proportion of commuters (who now have commute times of about 10 minutes or less) would gain no utility, and indeed may experience some disutility, from reducing their commute times. For this latter group, this indicates that any time savings (whether small, eg one to two minutes, or larger, eg five minutes +) may have little or no value to them.

Survey respondents commonly reported their estimated commute time and their ideal commute time in five-minute intervals. While this could indicate that small time savings (eg up to two to three minutes) may be relatively meaningless to them, and hence of little value, this cannot be concluded with confidence from the survey evidence.

C6 USA studies

C6.1 Overview

The extent of US literature and empirical research on this topic appears to have been very limited, especially in more recent years.

In the following sections we summarise:

- current US DoT policy relating to valuing STS and the rationale for this
- an early study by Thomas and Thompson on VTTS for commuting motorists
- a study by Small on motorists' relative VTTS in a range of conditions.

C6.2 US evaluation guidelines relating to small time savings

The current US guidance (manual) titled *Revised departmental guidance on valuation of travel time in economic analysis* (US DoT 2012) does not distinguish valuations for small time savings from general values of (non-work) time savings. It states:

Another subject of discussion has been whether VTTS should be ignored below some threshold increment of time saved. Some research has suggested the conclusion that discrete,

> *small savings may have negligible benefits. See Australian Bureau of Transport Economics, Fosgerau et al, Mackie et al (2001, 2003).*
>
> *There is no persuasive evidence of where such a threshold might be for any population or how it could be used to predict an appropriate threshold for another. A more important problem is that all changes in travel time resulting from government actions are composed of many smaller changes, and it would be impossible to identify particular changes considered big enough to affect each individual decision. To evaluate the aggregate impact of any action, therefore, we must assume that the value of each minute of saved time is constant, regardless of the total time required for a trip.*

The initial US DoT guidance on the topic (US DoT 1997) put the argument in these terms:

> *Although economic theory provides some support for the idea that the hourly value of small travel time savings should differ from average values per hour over larger changes in trip duration, it provides insufficient guidance for estimating the magnitude of any such differences, or even for anticipating their direction. At the same time, empirical evidence on the relative unit valuations of large and small time savings implied by travel behaviour is mixed, and the lower hourly values for small time savings that appear to be supported by a few early studies are no longer believed to be reliable.*

C6.3 Thomas and Thompson study (1970)

This early study involved a survey of US motorists who had the choice between a free route and a toll route. VTTS was established as a function of the amount of time saved through using the toll route and the motorists' income level. A logit model was used to analyse the survey results.

The analyses concluded that the relationship between the extent of time savings and the unit value of time saved followed an S-shaped curve: unit values were relatively low for savings of around five minutes, then increased for savings up to about 15 minutes, and then gradually decreased for larger time savings.

The resulting value function was adopted by AASHTO (1977) for a number of years. However the model has been criticised on the grounds that:

- the survey evidence gave little information about the pattern of valuations for savings of less than five minutes
- the survey and analyses took no account of trip lengths
- a number of other studies gave results conflicting with this model.

C6.4 Small study (1982)

This study assessed estimate valuations of time savings in a variety of situations, finding there was a considerable range in values according to circumstances. In general, unit values of time savings were relatively low for early arrival by one minute, moderately low for late arrival by one minute, then increasing for arrivals more than one minute late. However, it appears that, on average, these relative values reflect responses to unreliability rather than to time savings for trips.

C7 Canadian studies

C7.1 Overview

Current Canadian practice on VTTS variations with size of the time saving, and in particular variations for small time savings, are summarised in table C.1.

We have identified only one useful reference source that discusses the small time savings valuation issue in some detail, and relevant material from this source is now summarised.

C7.2 'Value of time savings for the economic evaluation of highway investments in British Columbia' (Waters at al 1992)

This report reviews the rather limited empirical research evidence on small time savings valuation, including the following:

- Thomas and Thompson (1970), refer section C6.3.
- Small (1982), refer section C6.4.
- Heggie (1976). This study found that time savings of less than five minutes appeared to be valued less than larger time savings, but no data was available about the valuation of time savings within the five-minute period.
- Bloomquist and Miller (1990). This study of seat belt use concluded that a 4 seconds saving was valued at approximately 63% of the relevant wage rate (this being a relatively high percentage compared with VTTS for non-work travel generally).

The report than summarises the various arguments which have been advanced for using a uniform value of time (CUV):

- Spread of opportunity costs. While many people may have a low opportunity cost for small time savings, their low valuations might be offset by the smaller number of people with high opportunity costs for such savings.
- Indivisibilities in VTTS. While many people would place a very low value on small time savings, for other people the small amount of time saved could be pooled with other small amounts of time and thus be much more valuable.
- Even small time savings augment road capacity and, especially in congested conditions, enable more journeys to be completed; and thus the time savings measure the benefits of this improvement.
- Compounding effects. Regular travellers would gain time savings on a recurrent basis and be able to assimilate these into normal routines, thus gaining significant benefits.
- Advantages of additivity. If VTTS were regarded as varying with the size of time savings, this route would mean that the sum of individual benefits from upgrading several portions of a route are not the same as the total benefits from upgrading the entire route. The benefits of a specific upgrade scheme would thus depend on whether it was built in several separate sections or as a combined project, and could vary over time as additional parts of the route are upgraded. This is a strong practical reason for adopting the CUV approach.

The report also makes two additional comments on VTTS aspects:

- Many studies support the view that unit VTTS is as much a function of the percentage of the total travel time saved as it is a function of the size of the time saved (eg saving 10 minutes on a 20-minute trip may be regarded as more valuable than saving 20 minutes on a two-hour trip). However no empirical evidence is presented to substantiate that 'many studies support the view…'.

- For many projects, the extent of time savings will have a highly skewed distribution, ie most people will experience very small time savings whereas a few may save a large amount of time. This implies that the mean time saving may not be a good indicator of overall impacts, and the median or mode may need to be used in addition.

The report's conclusions on the 'size' issue are as follows:

> *In sum, despite some misgivings, we recommend that the VTTS **not** vary with the size of time saving in evaluating highway investment decisions. This is a topic which warrants further research. In the meantime, if it is possible to record the distribution of time savings by its size, it could prove to be useful for sensitivity analysis of projects.*

C8 International agency studies and guidance

C8.1 Overview

The main international aid agencies that provide funding for transport investment in developing countries have developed manuals/guidelines on economic evaluation procedures and in particular, in the current context, on the basis on which time savings should be valued. The following provides material from two reports relating to the World Bank valuation of time savings for evaluation purposes.

C8.2 'Valuation of time savings for urban transport appraisal for developing countries: a review' (Bates and Glaister 1990)

The following is an extract from this report relating to 'size and sign of time savings':

> *There has been continuing controversy about a possible variation of values of time with both the size and the sign of time savings: it might be argued that the unit rates should be lower for small changes in travel time (because of perception problems and the restricted possibilities of using small savings of, say, less than one minute), and that it should be higher for time losses than for time gains (because increases in travel time may have serious scheduling consequences, at least in the short-term). Both these arguments are superficially appealing.*
>
> *If they were shown to be justified, their application would lead to strange effects in project appraisal: they would imply that disaggregating a proposed transport change into a series of small changes adding up to the same total, would lead to a different valuation, and that implementing a change and then restoring the status quo would lead to a change in overall welfare.*
>
> *A practical difficulty would be that the evaluation would depend to an important degree on the distribution by size of time savings, which would impose a severe requirement for difficult and expensive data.*
>
> *Such properties are highly inconvenient, and there would need to be substantial evidence in demonstrating the way in which unit time values depend on their size to justify the complexities involved in taking account of them.*
>
> *We do not believe that such substantial evidence exists. McFarland et al (1990) came to the same conclusion in a useful discussion of the topic. They note that the procedure adopted in*

> *the 1977 recommendation by the AASHTO that the unit value of small savings be discounted, was based on scant and unconvincing evidence. They also note the need to distinguish a separate phenomenon: variation with trip length. Although the evidence on this is again weak and contradictory it may have had an effect in confounding the estimates of values of small time savings. Small (1990) also comes to similar conclusions.*
>
> *While the issue of variation by size, sign and trip length will continue to be raised, we recommend that the practice of constant unit values of time, irrespective of the amount of time saved or lost, should be maintained. It should only be modified when the evidence is convincing and sufficiently clear about the precise nature of the change, and when it is judged that the additional complication and expense in appraisal is worthwhile.*

C8.3 'Value of time in economic evaluation of transport projects: lessons from recent research' (Gwilliam 1997)

The following is an extract from the report section on 'journey length, small time savings, gains and losses':

> *The most troubling results are in the UK and Dutch studies which showed very small or zero unit values for very small time savings (< 5 minutes), and greater unit values for time losses than time savings. As small time savings and losses comprise a large proportion of the effects in many projects, this would make the ERR dependent on the size of the project and would discourage sensible examination of projects on an incremental basis. However, these results may be an artefact of the research procedure as it is more difficult for respondents in SP experiments to imagine adjustment of activity patterns which would allow a small time saving to be put to beneficial use by activity rescheduling, than to see the immediate problems caused by a time loss on an existing tightly scheduled activity pattern. In the long run such savings are likely to be used (otherwise we should expect all individuals to be carrying increasing buffers of valueless unutilised 'slack 'in their schedules). Given also the practical difficulties of using any different convention* ***it is recommended that the same unit values be attributed to time differences irrespective of the size or sign of the difference.***

C9 Economic appraisal procedures – international summary

Table C.1 provides a summary of practices used in economic appraisal manuals in selected countries in relation to VTTS variations with the size of time savings.

For the countries covered, the main findings are as follows:

- With the exception of Germany, all the countries adopt the constant unit value (CUV) approach, ie values of time are taken as constant, independent of the size of the time saving.
- The German procedures adopt a diminishing unit value (DUV) approach. The 'standard' values of time savings are reduced by 30% for time savings of less than five minutes (for non-work trips).
- Previously, more countries had adopted the DUV approach, ie with lower time values for smaller time savings. Notable among these countries that have now switched to CUV, are the USA and (at some levels of government) the Netherlands.

Table C.1 Non-working VTTS variations with size of saving – international economic appraisal procedures[(a)]

Country	Standard evaluation practice	Notes
New Zealand	No variation (CUV)	
Australia	No variation (CUV)	BTE (1982) notes that the exclusion or separate treatment of small time savings in road project evaluations had been rejected by the (former) Commonwealth Bureau of Roads and by most state road authorities.
England	No variation (CUV)	TAG requires travel time benefits to be classified according to the size of the time saving, as a supplementary table. As minimum, six bands of time savings are specified: >5 mins, 2 to 5 mins, 0 to 2 mins, 0 to -2 mins, -2 to -5 mins, < -5 mins. Refer Box C.3 for further details.
Germany	Reduced values for small savings	For road traffic (non-work trips), travel time savings of <5 mins are discounted by 30% from the 'standard' unit values[(b)]
Netherlands	No variation (CUV)	Formerly, different levels of governments applied different methods (CUV or DUV).
Denmark	No variation (CUV)	The Danish value of time study (Fosgerau et al 2007) recommended that an 'underlying' value of time could be found that was independent of the direction of time change; but that a normative value should be chosen for the size of time change that would be used to determine the constant value that would be adopted for appraisal. The figure of 10 minutes was selected: the unit value for smaller time savings appeared to be lower, while the unit value for larger savings did not seem to increase greatly.
Sweden	No variation (CUV)	It is noted that (Eliasson 2013) 'The value of travel time savings are based on a recent national study. The study was a stated choice survey. The values are differentiated with respect to mode, travel purpose and trip length (shorter or longer than 100km). Income effects are removed from the valuations however - this is possible due to recent econometric advances which give much better possibilities to include covariates such as income in the value of time estimation.'
Norway	No variation (CUV)	Ramjerdi et al (1997) analysed both the DUV and CUV approaches.
France	No variation (CUV)	Used DUV for a while
EU	No variation (CUV)	DG REGIO recommends CUV default values, taken from the HEATCO (2006) study. That study recommends that the proportion of economic benefits based on time savings of <3 mins should be identified. The HEATCO study report presents arguments for and against a 'constant unit value'. It concludes that the issue associated with aggregating the benefits of incremental upgrades provides a strong argument for the use of a constant unit value. However, it recognises that 'measurement error may be large in comparison to the size of small time saving' and therefore recommends that the proportion of economic benefits derived from time savings that are less than 3 minutes should be identified.
USA	No variation (CUV)	Previously used DUV. US DoT (2012) notes that: (i) empirical evidence on the relative unit valuations of large and small time savings implied by travel behaviour is mixed; (ii) lower hourly values for small time savings that appear to be supported by a few early studies are no longer believed to be reliable; and (iii) economic theory provides insufficient guidance for estimating the magnitude of any such differences (between small time savings values and average values), and even for anticipating their direction'.[(c)]
Canada	Small time savings should be identified	Transport Canada (1994, cited in Daly et al 2011) discusses STS treatment, along the following lines. Any travel time savings of <5 mins

Country	Standard evaluation practice	Notes
	and valued, but not included in net present value calculations	(per 1-way trip) are regarded as 'small'. 'Small' time savings are to be valued the same as other savings, but are not to be included in the net present value and BCR performance calculus. The justification for excluding small time savings from the benefit calculations (for both work and non-work trips) is stated as: 'The ability to turn these small time savings into real labour cost savings depends on whether the freed-up resources can be used to perform other productive activities... Unless there is a high degree of confidence that these kinds of benefits can be achieved, they should be identified as conditional.'

Source: Austroads (2012), except as noted. All material taken from Daly et al (2011).

Notes:

[a] CUV = constant unit value; DUV = diminishing unit value (for small time savings).

[b] Gühnemann (2013) states the following: 'The BVWP 2003 applied a 30% deduction to account for small travel time savings in private road transport. For the review in 2010, BVU et al recommended to apply the procedure from the Standardisierte Bewertung which applies a declining function for time savings below 5 minutes'.

[c] A uniform VTTS is recommended by the US DoT for the reason set out in its guideline documents (US DoT 1997 and 2012): '… a constant value has decisive practical advantages in evaluating the cumulative effect of a number of simultaneous governmental actions. On the absence of strong evidence to the contrary, the assumptions of a constant value per hour for large and small time savings is probably appropriate (refer further comments in section C6.2)'

Box C.3: GB economic appraisal procedures (TAG): requirements on disaggregating travel time benefits by magnitude of time savings

New requirements for the disaggregation of travel time benefits by the magnitude of time savings were introduced into GB procedures as a result of the 'NATA Refresh' process. The NATA Refresh document (DfT 2009: UK76) states that:

31. The extent to which a proposal enhances economic efficiency through the creation of time savings is usually presented in an aggregate manner in appraisal summaries. However, there remains considerable interest in the distribution of these impacts, especially in respect of the size of time savings for individual trips. The Department reviewed the research in this area quite recently and recommended that more detail be presented.

32. During the consultation, respondents were keen that we explored what information could be provided about the composition of time savings and promoters could, using the results already available to them, provide supplementary tables about the distribution. Furthermore, incorporating tools to generate standardised tables about this aspect into the current appraisal software would be possible and we will develop this over the coming months.

Based on this document, the new requirements are specified in TAG (DfT 2014) as follows:

A3.1The Appraisal Summary Table requires time savings to be reported by magnitude in bans of: 0 to 2 minutes, 2 to 5 minutes; and more than 5 minutes. This requires the calculation of time savings by six time bands:

- Less than -5 minutes
- -5 to -2 minutes
- -2 to 0 minutes
- 0 to 2 minutes
- 2 to 5 minutes
- Greater than 5 minutes.

A3.2 The values calculated for the equivalent negative and positive time bands should be combined to give the net impact for the three time bands required in the AST. Analysts might wish to provide finer bands of travel time savings as deemed appropriate for their particular project.[a]

Source: TAG unit A1.3 May 2014.

Notes: [a] These bands are suggested to ensure comparability between project appraisals. There is no evidence to support valuing time savings in these bands at a different rate from time savings in other bands.

Appendix D: BCHF et al (2002) car driver travel time (SP) survey – key features and comments

D1 Overview

The project described in *Review of benefit parameter values for economic evaluation* (BCHF et al 2002) was undertaken for Transfund NZ by a consultant team led by BCHF during the period 1999–2002, with the main market research phase taking place in 2001.

The centre-piece of the market research phase was a multi-part SP survey covering:

- car drivers, to elicit information on values of (i) time savings; (ii) congestion and reliability changes; and (iii) perceived safety benefits
- PT users
- commercial vehicle operators.

This appendix supplements the material in chapter 4: it focuses on the SP research (survey and analyses) undertaken to establish car drivers' VTTS.[23]

D2 Key features of the 2001 survey

Table D.1 sets out the key features of the 2001 SP survey of car drivers, regarding the aspects relating to establishing VTTS.

The SP survey focused on a set of pair-wise comparisons of alternative routes, each defined in terms of drive time and trip cost (petrol plus car parking charges). Figure D.1 sets out the instructions given to the respondents. It was a typical 'game', in which the respondent was asked to give preferences between a number of two alternatives. (Laptop computers were used to present the questionnaire and to tailor the SP 'games' to a specified recent trip made by the respondent. However, a booklet of paper questionnaires could be used as an alternative.)

The SP experimental design specified 18 'games' in which drive time differences took one of three levels, and cost differences one of six levels. These incremental times and costs were chosen to accord with reasonable 'boundary values of time' (ie additional cost/time saved), based on 'an expected average value of time of 12 cents/minute and a fairly long tail to the distribution'. Table D.2 shows the experimental design used.

In practice, the design was applied in two halves, with each respondent being asked to play nine choice 'games'. An example of the SP game is shown in figure D.2.

[23] The material in this annex draws on previous work undertaken by IWA for the Transport Agency research programme (Ian Wallis Associates 2014).

D3 Other issues relating to the 2001 (SP) survey

We note in table D.1 a number of other issues relating to the 2001 car driver SP survey/analyses described in BCHF et al (2002), which may be relevant to interpretation of the survey results or to any future survey (eg of car passengers) where the results will be compared with the 2001 survey.

Table D.1 Key features of the 2001 value of time survey (Source: BCHF et al 2002)

Heading	Features
Overview	Random sample of New Zealand car drivers, to establish trade-offs between in-vehicle travel time and trip costs, and hence VTTS.
Consultants	BCHF with SDG (survey design) and Forsyte (survey administration and delivery) Peer review by David Ashley and John Bates
Survey method	Considered relative merits of door-to-door household survey vs an intercept/hall approach – decided on household survey. Used multi-stage cluster sampling of selected households, (up to 2 call-backs) with initial 'screening' questionnaire to identify households within scope. Computer-assisted personal interviews (CAPI) – although could do similarly with show-cards or web-based responses. Found an average of 6.0 door-knocks per completed interview. Two pilot surveys (c.60 interviews) undertaken prior to main survey.
Population and sampling basis	In the selected households, eligible respondents were those who, within the previous two weeks, had made a trip of >10 mins duration as a car driver. One eligible (with next birthday) respondent per household was then selected for interview [this gave a bias against households with more adults]. For the selected respondent, interview then focused on a single selected recent trip (categorised into commuter/non-commuter, urban/rural). Business trips were excluded. Trips <10 mins duration were excluded. [This was seen as overcoming the potential difficulty for respondents in trading-off very small time and cost changes for such short trips; however, it may result in significant bias in terms of reflecting the total New Zealand car travel market, especially in terms of trip numbers] Sample was to consist of 1,200 completed interviews across 11 interview areas (predominantly urban) in New Zealand. Minimum or indicative quotas were set by: (i) centre; (ii) trip purpose (split 50% commuter: 50% other); (iii) minimum 40% mainly rural trips; (iv) gender and age group.
Questionnaire	Focused on the recent trip identified through the 'screening' interview. Covered (for the one-way trip): • journey origin, destination, distance, driving time • road types (urban vs rural, motorways vs other) • trip purpose • number of vehicle occupants (adult vs child) • parking details (type of parking place, time parked, cost, who paid) • time between parking location and main destination • car characteristics – type of car, type of fuel, engine capacity • who owns the car (driver, other family member, employer, etc) • who paid for fuel costs • various stated preference 'games' (see below) • demographic, etc, aspects (age, sex, personal income, household structure)

Heading	Features
Time vs cost (SP) 'games'	SP 'games' involving two alternative routes and sets of costs, one representing the actual trip, and asking for respondent preferences (definitely A, probably A, cannot choose, probably B, definitely B). 'Base' cost was fuel cost (estimated based on engine capacity and distance) plus parking charges. 'Base' time was driving time plus(?) parking access, etc, time. Defined 18 'games' (for trips <1hr), with time savings 5/10/15 minutes, additional costs in range \$0.15–\$4.50 (together encompassing 'boundary' value of time in range 3–30 cents/minute for 1–2 hour trips. These increments were doubled; tripled for trips taking 2–3 hours, etc. Each respondent was asked to complete 9 of the 18 games. Respondents were asked to play the game as if they were paying the costs themselves. Figure D.1 shows the introductory screen and figure D.2 a typical game screen for the SP survey.
Respondent characteristics	*Group size:* Overall, 44% of the surveyed trips involved carrying one or more passengers (average c.1.7 passengers for these trips). For commuter trips, only 23% carried passengers; for other trips, 64% carried passengers. *Trip duration:* Average drive time 23 minutes for commuter trips, 51 minutes for other trips (after excluding any trips <10 minutes). *Car ownership:* About 80% of respondents owned the car they were driving; for 9% the car was owned by someone else in the household; for 6% it was owned by the respondent's employer. *Fuel costs:* 83% of respondents bore the fuel costs themselves. *Parking costs:* Only 10% of trips (12% urban, 6% rural) involved any parking costs. For such trips, in 85% of cases the costs were borne by the driver. *Total trip costs:* The average reported cost (fuel + parking) was \$5, with around 60% of trips having costs in the range \$0–\$2.50. (Total [1-way] trip costs were stated to be calculated as 1-way fuel costs + total parking costs: this appears to be an error – half the parking costs should be used).
Analysis approach	The analysis involved fitting logit models to the choice data. The logit model formulation is: $P_i = \text{Exp}(V_i)/\sum \exp(V_j)$ (Equation D.1) where P_i is the probability of option *i* being chosen and V_j is the utility of option *j*. This utility is a function of the attributes of that option (in this case cost and time) The simplest expression for the utilities is then a linear combination of cost and time, as in: $V_i = a_1 \cdot \text{In-vehicle time}_i + a_2 \cdot \text{Cost}_i$ (Equation D.2) where a_1 and a_2 are parameters to be estimated. An estimate of the 'value of time' is then given by the ratio a_1/a_2. In practice, a more complex formulation was applied to estimate the variation of the VTTS with income and trip distance.

Figure D.1 Introduction to VTTS SP

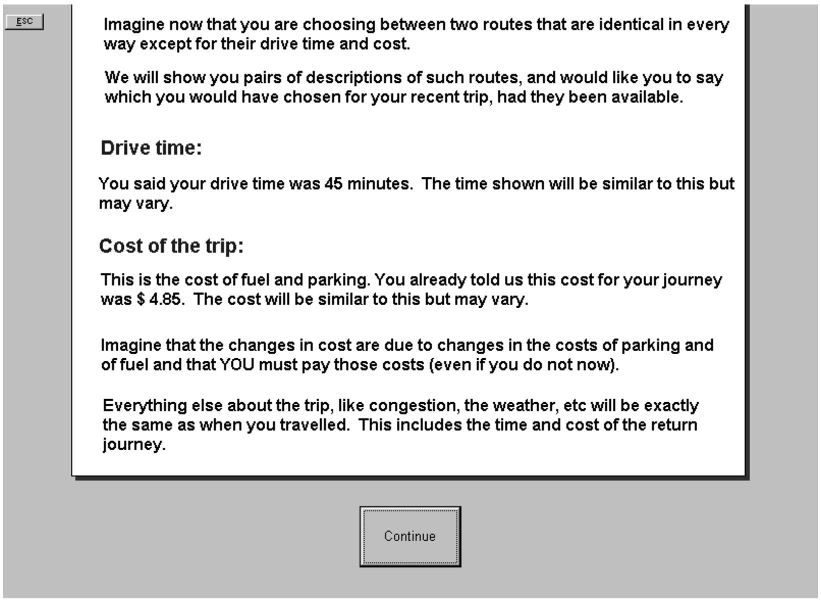


Figure D.2 Example of VTTS SP screen

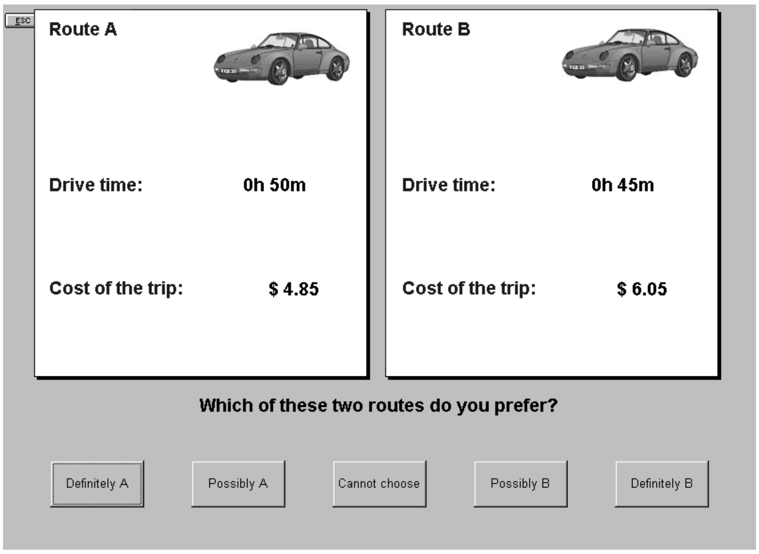


Table D.2 Experimental design for VTTS SP choice gains

Case	Time saved (mins)	Additional cost (cents)	Boundary VoT (cents/min)	Design allocation
1	5	15	3	1
2	5	30	6	2
3	5	60	12	1
4	5	90	18	2
5	5	120	24	1
6	5	150	30	2
7	10	30	3	2

Case	Time saved (mins)	Additional cost (cents)	Boundary VoT (cents/min)	Design allocation
8	10	60	6	1
9	10	120	12	2
10	10	180	18	1
11	10	240	24	2
12	10	300	30	1
13	15	45	3	1
14	15	90	6	2
15	15	180	12	1
16	15	270	18	2
17	15	360	24	1
18	15	450	30	2

Table D.3 2001 car driver SP survey – 'other' issues

Issue	Comments
Short trips	Trips of <10mins duration excluded from survey. This seems likely to comprise a quite substantial proportion of all car driver trips (a much lower proportion of driver hours and driver-km). Omission of these trips reduces the ability to examine values for small time savings/shorter-duration trips.
Business trips	'Employer business' trips excluded from survey/analysis – not necessarily a problem, but these should be covered somewhere if a full suite of VTTS is to be established.
Sample selection	While the BCHF report (2002, s5.1.1) states that 'The sample is thus designed to provide a representative sample of the resident driving population', we consider that biases are likely to result from sampling being based on only one respondent per household. For example, this will tend to result in under sampling of households with more adult drivers, which may lead to under-estimates of average car occupancy rates. It does not appear that any tests or sample adjustments have been made for this effect.
Urban vs rural trips	The report found that VTTS do not differ significantly between urban and rural trips, once account is taken of the other model variables (distance, income, etc). This suggests that it may not be necessary to set urban vs rural quotas in any future related research.
Treatment of parking charges	While the SP games were based on one-way trips, the total cost calculation for the trip appears to have been based on (i) fuel costs for the one-way trip; plus (ii) total cost of parking associated with the 2-way trip (refer to BCHF et al 2002, s5.1.26). This is an inconsistency: only half the total parking costs should have been included for the one-way trip. The effects on the results of this inconsistency appear likely to be small, as parking costs were incurred in only c.10% of the surveyed trips (BCHF et al 2002, table 5.1.15).

Appendix E: Exploratory survey on travel time savings – questionnaire and summary of responses

E1 Survey questionnaire

This section reproduces the survey questionnaire.

The survey was web-based, administered through SurveyMonkey.

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Travel Time Savings (Car Drivers) - Exploratory Survey

WHAT THIS SURVEY IS ABOUT:

The survey is to explore people's attitudes and preferences towards saving travelling time when driving (if you never drive, this survey is not for you).

Each question gives you a choice of two options (A, B), both of which would reduce the time you spend making particular trips. For each question, please mark in the relevant box whether you would:

- Definitely prefer option A
- Probably prefer option A
- No preference or can't decide between option A and option B
- Probably prefer option B
- Definitely prefer option B

Your response may relate to actual trips you make or hypothetical trips.

Next

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Travel Time Savings (Car Drivers) - Exploratory Survey

PART 1: SAVING TIME ON TRIPS MADE REGULARLY

In this part, ***please assume*** that:

• The trips concerned are ***trips that you make regularly*** (for any purpose), and are likely to continue to make regularly in the future.

• The travel time savings on these trips are ***completely reliable*** in every case (you can be confident that the time savings will be as specified on all occasions).

• Your answers may relate to ***actual trips*** you make or ***hypothetical trips***.

1. Question:

Option A: saving 1 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 10 minutes per week

Option B: saving 10 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 10 minutes per week

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

2. Question:

Option A: saving 1 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 10 minutes per week

Option B: saving 5 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 5 minutes per week

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

3. Question:

Option A: saving 2 minutes per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week

Option B: saving 20 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 20 minutes per week

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

4. Question:

Option A: saving 2 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week

Option B: saving 15 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 15 minutes per week

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

5. Question:

Option A: saving 2 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week

Option B: saving 10 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 10 minutes per week

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

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Travel Time Savings (Car Drivers) - Exploratory Survey

PART 2: SAVING TIME ON A ONE-OFF TRIP

The following questions relate to ***one-off or occasional trips*** that you might make (for any purpose).

In answering these questions, ***please assume*** that:

• The time savings specified apply on a ***one-off*** basis only.

• The travel times and time savings specified are ***completely reliable*** in every case (you can be confident that the trip will take exactly the time specified).

• Your answers may relate to ***actual trips*** you make or ***hypothetical trips***.

6. Question:

Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)
Option B: saving 5 minutes off a 1 hour trip (i.e. 8% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

7. Question:

Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)
Option B: saving 10 minutes off a 1 hour trip (i.e. 17% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

8. Question:

Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)
Option B: saving 5 minutes off a 2 hour trip (i.e. 4% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

9. Question:

Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)
Option B: saving 10 minutes off a 2 hour trip (i.e. 8% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

10. Question:

Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)
Option B: saving 5 minutes off a 2 hour trip (i.e. 4% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

11. Question:

Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)
Option B: saving 10 minutes off a 2 hour trip (i.e. 8% off current trip time)

Which would you prefer?

Definitely prefer A

Probably prefer A

No preference/can't decide

Probably prefer B

Definitely prefer B

12. Question:

Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)
Option B: saving 15 minutes off a 2 hour trip (i.e. 12% off current trip time)

Which would you prefer?

Definitely prefer A
Probably prefer A
No preference/can't decide
Probably prefer B
Definitely prefer B

13. Question:

Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)
Option B: saving 20 minutes off a 2 hour trip (i.e. 17% off current trip time)

Which would you prefer?

Definitely prefer A
Probably prefer A
No preference/can't decide
Probably prefer B
Definitely prefer B

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Travel Time Savings (Car Drivers) - Exploratory Survey

PART 3: COMMENTS ON SURVEY

14. Question:

In the space below please provide us with any comments you may have on the survey. We are particularly interested if you found difficulties in understanding any of the questions and options offered.

THANK YOU for your participation in our research.

This survey has been developed by Ian Wallis Associates Ltd and Jacobs New Zealand Ltd as part of research being undertaken for the New Zealand Transport Agency. Should you have any queries about the survey please contact Kerstin.Rupp@jacobs.com.

Prev Done

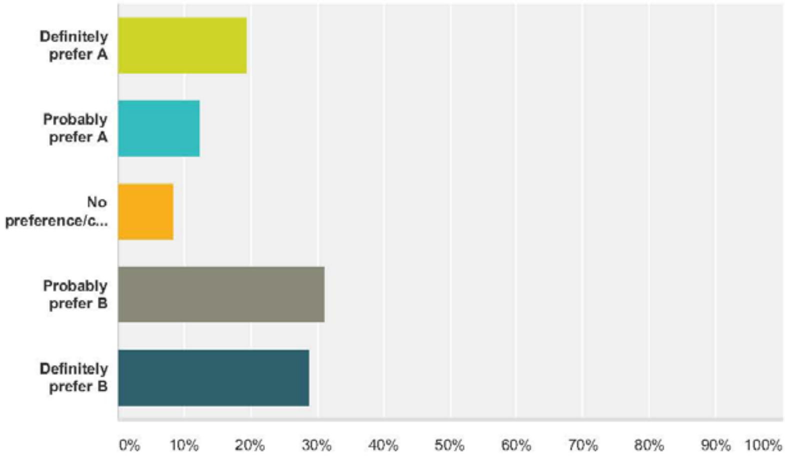
E2 Summary of survey responses

562 (non-random) responses were received to the survey. The following summarises the responses to each of the 13 choice questions: part 1 (Q1 – Q5) covers questions on preferences between small time savings on multiple trips versus larger time savings on a single trip; part 2 (Q6 – Q13) covers questions on preferences between specified levels of time savings on trips of different durations. At least 94% of the 562 respondents completed each of these questions. The last question (Q14) provides comments on the survey, particularly relating to any difficulties in understanding the questions or the options offered: comments were received from c.25% of respondents.

Travel Time Savings (Car Drivers) - Exploratory Survey

Q1 Question:Option A: saving 1 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 10 minutes per week Option B: saving 10 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 10 minutes per weekWhich would you prefer?

Answered: 562 Skipped: 4

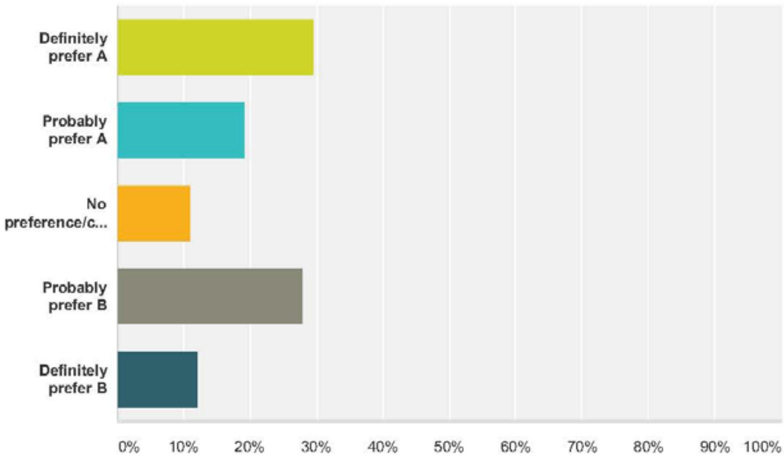


Answer Choices	Responses	
Definitely prefer A	19.40%	109
Probably prefer A	12.28%	69
No preference/can't decide	8.36%	47
Probably prefer B	31.14%	175
Definitely prefer B	28.83%	162
Total		562

Travel Time Savings (Car Drivers) - Exploratory Survey

Q2 Question: Option A: saving 1 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 10 minutes per weekOption B: saving 5 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 5 minutes per weekWhich would you prefer?

Answered: 558 Skipped: 8



Answer Choices	Responses	
Definitely prefer A	29.75%	166
Probably prefer A	19.18%	107
No preference/can't decide	11.11%	62
Probably prefer B	27.96%	156
Definitely prefer B	12.01%	67
Total		558

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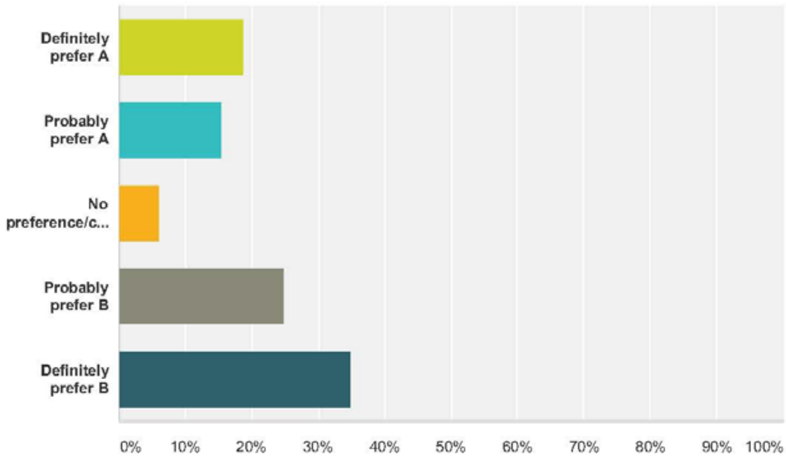
Travel Time Savings (Car Drivers) - Exploratory Survey

Q3 Question: Option A: saving 2 minutes per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week Option B: saving 20 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 20 minutes per weekWhich would you prefer?

Answered: 559 Skipped: 7

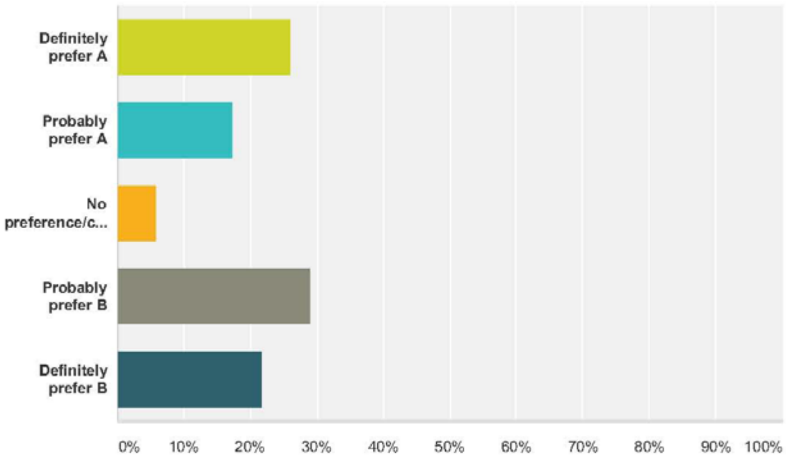


Answer Choices	Responses	
Definitely prefer A	18.78%	105
Probably prefer A	15.38%	86
No preference/can't decide	6.08%	34
Probably prefer B	24.87%	139
Definitely prefer B	34.88%	195
Total		559

Travel Time Savings (Car Drivers) - Exploratory Survey

Q4 Question:Option A: saving 2 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week Option B: saving 15 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 15 minutes per weekWhich would you prefer?

Answered: 555 Skipped: 11



Answer Choices	Responses	
Definitely prefer A	26.13%	145
Probably prefer A	17.30%	96
No preference/can't decide	5.77%	32
Probably prefer B	29.01%	161
Definitely prefer B	21.80%	121
Total		555

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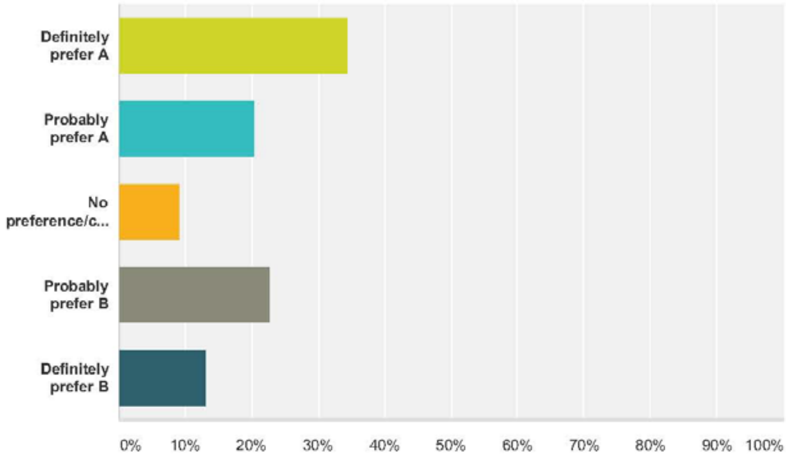
Travel Time Savings (Car Drivers) - Exploratory Survey

Q5 Question:Option A: saving 2 minute per trip on a trip you make 10 times per week (eg. travelling to/from work): total saving = 20 minutes per week Option B: saving 10 minutes per trip on a trip you make once per week (eg shopping or social trip): total saving = 10 minutes per weekWhich would you prefer?

Answered: 560 Skipped: 6

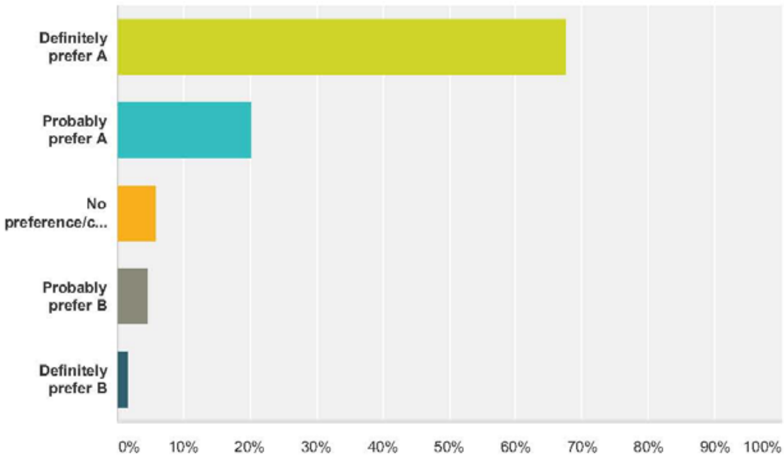


Answer Choices	Responses	
Definitely prefer A	34.46%	193
Probably prefer A	20.54%	115
No preference/can't decide	9.11%	51
Probably prefer B	22.68%	127
Definitely prefer B	13.21%	74
Total		560

Travel Time Savings (Car Drivers) - Exploratory Survey

Q6 Question:Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)Option B: saving 5 minutes off a 1 hour trip (i.e. 8% off current trip time)Which would you prefer?

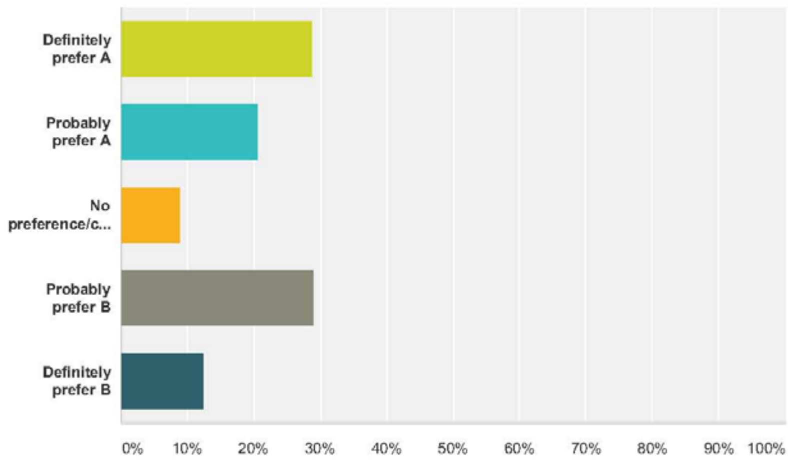
Answered: 541 Skipped: 25



Answer Choices	Responses	
Definitely prefer A	67.65%	366
Probably prefer A	20.15%	109
No preference/can't decide	5.91%	32
Probably prefer B	4.62%	25
Definitely prefer B	1.66%	9
Total		541

Q7 Question:Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)Option B: saving 10 minutes off a 1 hour trip (i.e. 17% off current trip time)Which would you prefer?

Answered: 537 Skipped: 29

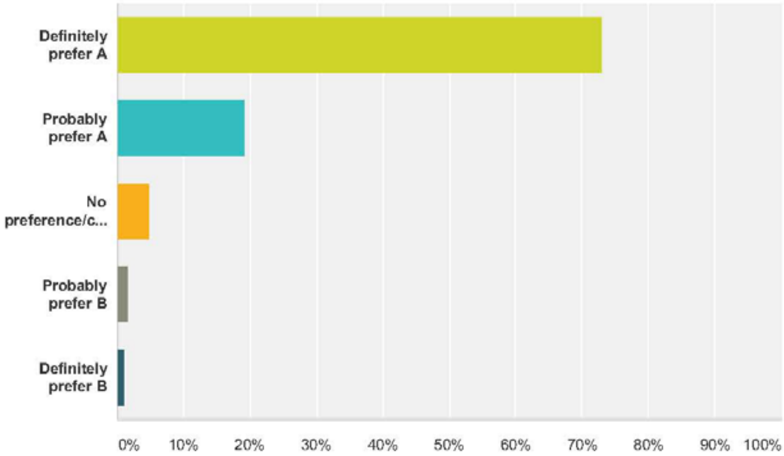


Answer Choices	Responses	
Definitely prefer A	28.86%	155
Probably prefer A	20.67%	111
No preference/can't decide	8.94%	48
Probably prefer B	29.05%	156
Definitely prefer B	12.48%	67
Total		537

Travel Time Savings (Car Drivers) - Exploratory Survey

Q8 Question:Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)Option B: saving 5 minutes off a 2 hour trip (i.e. 4% off current trip time)Which would you prefer?

Answered: 536 Skipped: 30

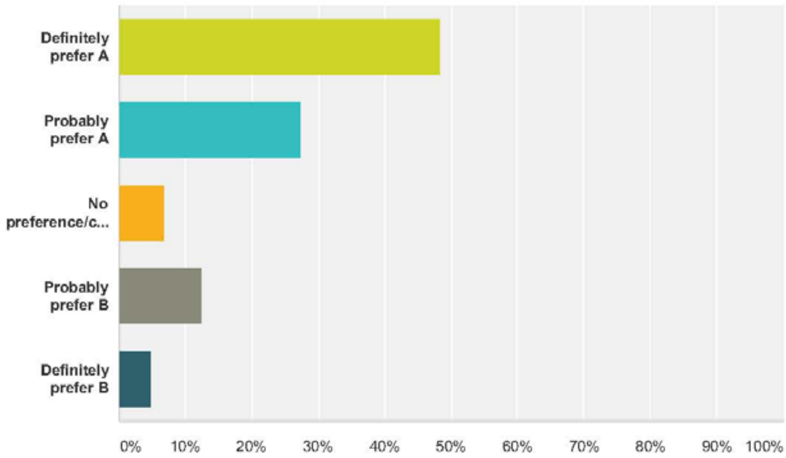


Answer Choices	Responses	
Definitely prefer A	73.13%	392
Probably prefer A	19.22%	103
No preference/can't decide	4.85%	26
Probably prefer B	1.68%	9
Definitely prefer B	1.12%	6
Total		536

Travel Time Savings (Car Drivers) - Exploratory Survey

Q9 Question:Option A: saving 5 minutes off a 20 minute trip (i.e. 25% off current trip time)Option B: saving 10 minutes off a 2 hour trip (i.e. 8% off current trip time)Which would you prefer?

Answered: 538 Skipped: 28

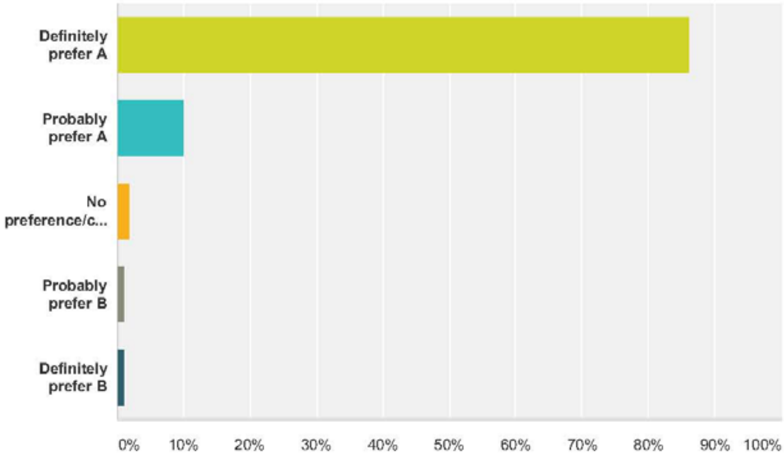


Answer Choices	Responses	
Definitely prefer A	48.51%	261
Probably prefer A	27.32%	147
No preference/can't decide	6.88%	37
Probably prefer B	12.45%	67
Definitely prefer B	4.83%	26
Total		538

Travel Time Savings (Car Drivers) - Exploratory Survey

Q10 Question:Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)Option B: saving 5 minutes off a 2 hour trip (i.e. 4% off current trip time)Which would you prefer?

Answered: 531 Skipped: 35

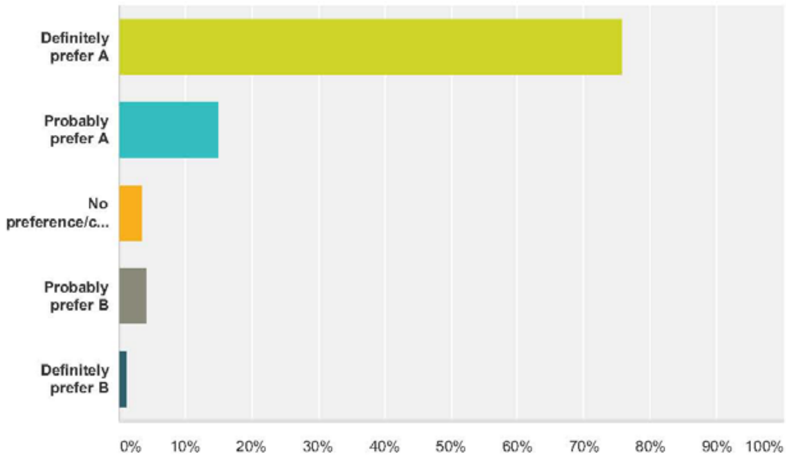


Answer Choices	Responses	
Definitely prefer A	86.25%	458
Probably prefer A	9.98%	53
No preference/can't decide	1.88%	10
Probably prefer B	0.94%	5
Definitely prefer B	0.94%	5
Total		531

Travel Time Savings (Car Drivers) - Exploratory Survey

Q11 Question: Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)Option B: saving 10 minutes off a 2 hour trip (i.e. 8% off current trip time)Which would you prefer?

Answered: 538 Skipped: 28



Answer Choices	Responses	
Definitely prefer A	75.84%	408
Probably prefer A	15.06%	81
No preference/can't decide	3.53%	19
Probably prefer B	4.28%	23
Definitely prefer B	1.30%	7
Total		538

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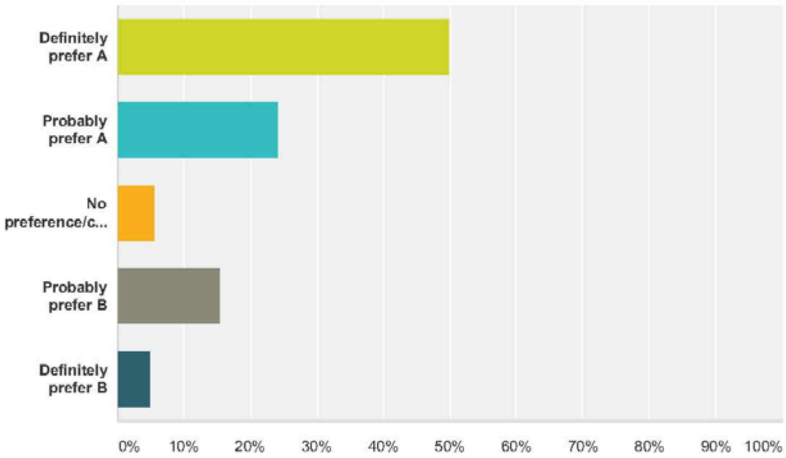
Travel Time Savings (Car Drivers) - Exploratory Survey

Q12 Question:Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)Option B: saving 15 minutes off a 2 hour trip (i.e. 12% off current trip time)Which would you prefer?

Answered: 538 Skipped: 28

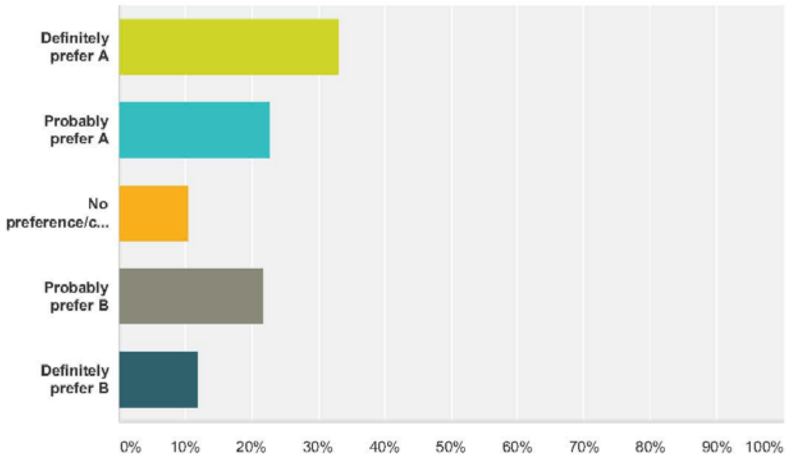


Answer Choices	Responses	
Definitely prefer A	49.81%	268
Probably prefer A	24.16%	130
No preference/can't decide	5.58%	30
Probably prefer B	15.43%	83
Definitely prefer B	5.02%	27
Total		538

Travel Time Savings (Car Drivers) - Exploratory Survey

Q13 Question: Option A: saving 10 minutes off a 20 minute trip (i.e. 50% off current trip time)Option B: saving 20 minutes off a 2 hour trip (i.e. 17% off current trip time)Which would you prefer?

Answered: 538 Skipped: 28



Answer Choices	Responses	
Definitely prefer A	33.27%	179
Probably prefer A	22.68%	122
No preference/can't decide	10.41%	56
Probably prefer B	21.75%	117
Definitely prefer B	11.90%	64
Total		538

Travel Time Savings (Car Drivers) - Exploratory Survey

Q14 Question:In the space below please provide us with any comments you may have on the survey. We are particularly interested if you found difficulties in understanding any of the questions and options offered.

Answered: 139 Skipped: 427

E3 Preference modelling of survey results

The survey questions were set up to understand the preferences in two areas:

1 Savings on a short trip compared with those on a long trip (variables of time saved and total trip time)

2 Frequent small savings compared with infrequent large savings (variables of time saved and frequency of time saving).

In order to establish an analytic relationship between the average preference and the savings, a model was set up for each set of questions.

For understanding the impacts of trip duration on the extent of time saved the preferences were given the following numerical values:

- 2: Definitely prefer A
- 1: Probably prefer A
- 0: No preference
- -1: Probably prefer B
- -2: Definitely prefer B

The preferences for the proportional time saving were then estimated using the functional form:

$$preference = \beta({S_A}^{\lambda} - {S_B}^{\lambda}) \qquad \text{(Equation E.1)}$$

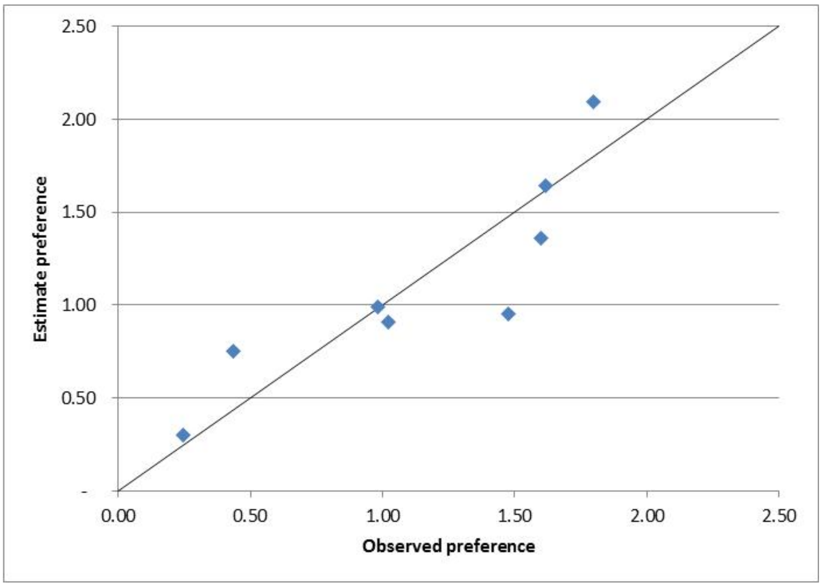
Where S_x is the proportion of trip time X that was saved (so for a five-minute saving on a 20-minute trip, S_x=0.25).

For this functional form, with the eight data points (reflecting the eight questions), the following parameters provide the best fit:

- **β** = -1.76
- **λ** = -0.28

The fit to the data is shown in figure E.1.

Figure E.1 Comparison between observed and estimated preference



A negative value of β (in conjunction with a negative λ) indicates that a positive correlation exists between proportional time savings and preference. This is demonstrated by a five-minute time saving on a 20-minute journey being preferred to a five-minute saving on a 60-minute journey.

The negative value of λ indicates a larger weighting on smaller proportional time savings. This means that doubling the time saving and trip duration on both sides of the comparison results in a weaker preference. This is demonstrated by a 25% saving compared with a 4% saving being preferred more than a 50% saving compared with an 8% saving, even though both savings are six times as much in percentage terms.

With the calculated value of λ, doubling the length of both proportional time savings results in the preference weakening by approximately 20%. A larger value of λ would indicate a stronger preference at lower time savings (for example λ =-1 indicates the preference halving when both proportional time savings are doubled). The absolute value of β is somewhat arbitrary and purely related to scaling to the ranking scores given to 'prefer A' and 'prefer B', which in this case are ± 2.

For the question with variables of time saved and frequency of time saving (with total time saved calculable), all three of these variables are important so aggregating them into a single 'savings' measure was not considered appropriate. By maintaining three variables and three corresponding parameters, it would not be appropriate to fit this model with only five data points.

Additional analysis could be completed on this exploratory data to reanalyse individual responses rather than aggregated by question. Additional questions could also be added, in particular in the first section, to establish a robust relationship and functional form. No further analysis was undertaken as part of this research project on the exploratory survey. The findings of this survey should be used to inform future quantitative surveys. A focus group held prior to further surveys could explore attitudes, preferences and rationales behind some of the survey choices and help inform the survey design.

Appendix F: Glossary

AHCG	Accent Marketing and Research and Hague Consulting Group, the Netherlands
BCHF	Beca Carter Hollings & Ferner
BCR	benefit-cost ratio
CBA	cost-benefit analysis
CBD	central business district
CUV	constant unit value
DDK	Danish kroner
DfT	Department for Transport (UK)
DoT	Department of Transport (USA)
DUV	diminishing unit value
EEM	*Economic evaluation manual* (NZ Transport Agency 2013 edition unless otherwise stated)
HEATCO	Harmonised European Approaches for Transport Costing
HHI	household income
ITS	Institute for Transport Studies (Leeds University)
IVT	in-vehicle time
LRT	light rail transit
MCA	multi-criteria analysis
MoT	Ministry of Transport (New Zealand)
NOK	Norwegian kroner
PEM	*Project evaluation manual* (now the EEM)
PPP	purchasing power parity
PT	public transport
RoNS	roads of national significance
RP	revealed preference
SP	stated preference
Transport Agency	New Zealand Transport Agency
VTTS	value (or valuation) of travel time savings
WEBs	wider economic benefits
WTP	willingness to pay