Development of Benefit Parameter Research Approaches

Transfund New Zealand Research Report No.197

Development of Benefit Parameter Research Approaches

Booz•Allen & Hamilton

Transfund New Zealand Research Report No. 197

ISBN 0-478-25055-X
ISSN 1174-0574

PO Box 2331, Lambton Quay, Wellington, New Zealand
Telephone 64-4-473-0220; Facsimile 64-4-499-0733

Booze•Allen & Hamilton 2001. Development of Benefit Parameter Research Approaches. *Transfund New Zealand Research Report 197.* 142 pp.

Keywords: travel time valuation, level of service, environmental valuation, stated preference, stated choice, conjoint analysis, valuation methods, transport evaluation, New Zealand.

An Important Note For The Reader

The research detailed in this report was commissioned by Transfund New Zealand.

Transfund New Zealand is a Crown entity established under the Transit New Zealand Act 1989. Its principal objective is to allocate resources to achieve a safe and efficient roading system. Each year Transfund New Zealand invests a portion of its funds on research that contributes to this objective.

CONTENTS

EXECUTIVE SUMMARY 9

ABSTRACT 12

1. INTRODUCTION 13
   - 1.1 Project Background 13
   - 1.2 Project Purpose and Objectives 13
   - 1.3 Report Structure 15

2. REVIEW OF CURRENT PRACTICE AND RESEARCH 17
   - 2.1 Travel Time Aspects 17
   - 2.2 Level of Service Aspects 31
   - 2.3 Vehicle Operating Costs 36
   - 2.4 Accident Aspects 36
   - 2.5 Environmental Effects 49

3. KEY METHODOLOGY ISSUES AND APPRAISAL 53
   - 3.1 The Basis for Evaluation 53
   - 3.2 Benefit Valuation Principles 54
   - 3.3 Monetary Valuation Techniques 55
   - 3.4 Issues in Stated Preference Survey Design And Analysis 71
   - 3.5 Review of Recent New Zealand Stated Preference Practice – Transmission Gully 83
   - 3.6 Methods for Valuation of Life 91
   - 3.7 Treatment of Taxation 92
   - 3.8 Key Concepts and Issues in Valuation of Travel Time Savings 94

4. DEVELOPMENT OF RESEARCH APPROACHES 101
   - 4.1 Overview – Parameters For Consideration 101
   - 4.2 Level o Service Factors 108
   - 4.3 Opportunity Cost of Personal Time 110
   - 4.4 Oportunity Cost of Business/Commercial Time 111
   - 4.5 Opportunity Cost of Freight 114
   - 4.6 Vehicle Operating Costs 114
   - 4.7 Accidents 114
   - 4.8 Environmental Effects 116
   - 4.9 National Strategic Factors 118

GLOSSARY 121

REFERENCES 130

APPENDIX

Categorisation of Road Factors Contributing to Road User 'Level of Service' Perceptions 137

Executive Summary

1. Project Background

In 1999, Transfund New Zealand initiated a major review of the unit benefit parameters and their values used in the Transfund Project Evaluation Manual (PEM) for the evaluation of transport projects throughout New Zealand. This review arose from concerns relating to the unreliability, inconsistency and incompleteness of the current parameters. It was designed to address these concerns using social and market research and surveys, drawing on international experience and practice, and to then incorporate the results into the PEM.

The review was to be undertaken in six stages. The first stage was to determine a plan of surveys and research designed to address the concerns identified. This research project comprises the major part of this first stage. It involved review of techniques for the valuation of benefit parameters and determination of the most appropriate market research approaches for valuing these parameters.

2. Project Objectives and Scope

The overall objective of this research project was to develop the most appropriate market research techniques for deriving improved values for the unit benefit parameters specified by Transfund for use in transport project evaluation throughout New Zealand, with a particular emphasis on the use of 'stated preference' and related techniques for the valuation of parameters for which market-based valuations are not available.

The scope of the work covered:

- Documentation and appraisal of the techniques currently used to derive the present PEM unit benefit parameters.
- In association with Transfund, determination of which unit benefit parameters would be most appropriately determined through willingness-to-pay and similar approaches.
- Documentation and appraisal of the techniques currently used in a selection of other countries to derive the unit parameters used in transport project evaluation.
- In the context of the relevant benefit parameters, review of international developments, practice and experience in the use of stated preference (SP) and related techniques and determination of:
    - situations in which the application of such techniques is appropriate
    - situations in which such techniques are not recommended (indicating alternative techniques which are more appropriate)
    - for each relevant parameter, what specific SP designs are most effective.
- Development of recommendations on the survey method that should be used to derive values for unit benefit parameters in a robust and consistent manner.

The project's primary focus was on unit benefit parameters relating to transport user behaviour and perceptions which require non-market valuations (e.g. willingness-to-pay methods); lesser attention was given to parameters for which widely-accepted market valuations exist (e.g. vehicle operating costs), or to situations for which standard unit parameters are inappropriate (e.g. some environmental effects).

3. Appraisal of New Zealand and International Practice

This Part of the work involved an appraisal of the evaluation parameters, and their basis, used for transport project evaluation purposes in New Zealand and key countries internationally; together with a review of more recent research developments (not yet incorporated into standard practices) in these countries. It covered key evaluation parameters within five groupings: travel time, level of service, vehicle operating costs, accidents, and environmental effects. Given the focus of Transfund's wider review, particular attention was paid to international practice and research developments in the assessment of level of service and travel time parameters.

4. Methodology Review

This art of the work defined and appraised key issues relevant to the development of research approaches, including the following:

- The basis and principles for valuation of benefits, within a social cost-benefit analysis framework.
- Review of the range of monetary valuation techniques, covering
  - market valuation approaches
  - non-market valuation approaches, divided into indirect (revealed preference) and direct (stated preference) approaches.
- Detailed review of practice, issues and merits of stated preference approaches divided primarily into contingent valuation methods (CVM) and conjoint analysis (CA) methods.
- Detailed appraisal of two recent 'state-of-the-art' market research projects in New Zealand that provide practical examples of the application of non-market techniques: the Transmission Gully Willingness-to-pay Surveys, and the Land Transport Safety Authority Value of Life research.
- Appraisal of issues in the valuation of travel time savings (and related level of service effects), including the roles for market and non-market valuation techniques.

5. Development of Research Approaches

The following table presents an overview of:

- The benefit evaluation parameters that are suggested for inclusion in the updated PEM, and hence need to be covered in the proposed research programme. Compared with the current PEM, the main change relates to the inclusion of a wide range of 'level of service' variables relating to road/traffic conditions: these variables affect motorists' utility of time spent travelling, for both private travel and business/commercial travel.

TABLE: PARAMETERS FOR INCLUSION IN RESEARCH PROGRAMME – SUMMARY (1)		
Parameter	**Proposed Valuation Basis**	**Proposed Survey Approach (2)**
A. PRIVATE TRAVELLER – TIME & LEVEL OF SERVICE A1. Personal Disutility of Travel A2. Personal Opportunity Cost	• Non-market (WTP), by road traffic conditions, traveller/trip characteristics.	• CA approach • Range of (overlapping) surveys to establish full range of valuations in different conditions. • Will need to be preceded by focus groups, piloting etc to establish best methods in detail.
□	• As per (A) above. • Market valuation – MPL/wage rate approach (for business travel, based on Hensher, refer Section 3.8.4). • Market valuation.	• As per (A) above. • For business travel, research to assess extent to which savings in travel time will translate into increases in output/reductions in employer costs. • For commercial vehicle travel, generally base on pay rates + over-heads (to extend time savings may be put to productive use).
C. VEHICLE OPERATING COSTS C1. Direct Operating Costs. C2. Capital – Depreciation. C3. Capital – Fleet.	• Market (resource) valuation (net of taxation). • Market (resource) valuation. • Market (resource) valuation (commercial vehicles only).	• Determine financial cost structures (as now). • Adjust for fuel duties, taxes etc. • Assessment of use-related (distance/time) component of depreciation (as now). • Assessment of any fleet savings through time savings (as now).
D. ACCIDENTS D1. Human Costs D2/3 Medical Costs, Lost Output D4. Accident-related Costs (property damage, police, insurance costs.)	• Non-market (WTP) – fatalities, injuries. • Market (resource) – fatalities, injuries. • Market (resource) – all accidents.	• Further research needs defined in this review. • Resource assessment (as now). • Resource assessment (as now).
E. ENVIRONMENTAL EFFECTS E1. CO2 (Global) E2. Air Pollution (CO2, NOx, Lead, PM10) E3/4 Noise/Vibration E5. Water Quality E6. Special Areas E7. Ecology E8/10/12 Visual, Isolation, Site Specific Discomfort. E9. Community Severance E11. Psychological Distress (Forced Purchase).	• Non-market (3) • Non market • Market (resource) – PM10 • Non-market • Non-market • Non-market (situation specific) • Non-market • Non-market (situation specific) • Non-market • Non-market (situation specific).	• Dose response/shadow pricing. • HP or CVM/CA • Shadow pricing or CVM/CA, depending on how the factor is defined and whether the impact is on the population or ecology. • CVM/CA • Shadow pricing • Recreational areas –TCM • Shadow pricing or CVM/CA depending on the ecological impact. • HP or CVM/CA • HP or CVM/CA • CVM/CA

Notes: (1) Further details given in Chapter 4/Table 4.1.
(2) CA = conjoint analysis, CVM = contingent valuation method, HP = hedonic pricing
(3) Recent literature suggests that factors such as global warming (and other irreversible aspects felt by future generations) are not amenable to monetary valuations.

- The proposed basis for valuation of each parameter. In particular, this distinguishes between those parameters for which a market price assessment is available; and those for which such a market price is not available and hence a non-market (willingness-to-pay) valuation is necessary. As a generalisation, one parameter category (C:Vehicle Operating Costs) is primarily appropriate for market price (resource) assessment; two categories (A: Private Travel Time/Level of Service, E: Environmental Effects) are appropriate for non-market (WTP) assessment; while categories B: Business & Commercial Time/Level of Service and D: Accidents require a combination of the two approaches.
- Proposed research/survey approach for each parameter. This provides brief notes on the type of market research/survey approach appropriate for each parameter. The most appropriate non-market survey approach for most parameters is the use of stated preference techniques, generally involving conjoint analysis (CA) methods. CA methods are most appropriate for categories A, B and D. Category E (Environmental Effects) is best researched through a combination of direct methods (particularly contingent valuation) and indirect methods (primarily hedonic pricing).

The work has developed outline specifications for the recommended research on travel time and level of service aspects (for both private and business/commercial travel) in particular, and discusses key issues relating to experimental design. It also provides further appraisal of the relative merits of alternative techniques for the valuation of environmental effects.

6. Application of Project Findings

The findings and recommendations from this research project have played a central part in Transfund's specification of a major programme of market research to derive improved parameter values. This research was undertaken in 2001.

ABSTRACT

This project developed market research techniques for deriving improved values for the unit benefit parameters specified by Transfund New Zealand for use in transport project evaluation throughout New Zealand. It focused on the use of stated preference and related techniques for the valuation of parameters for which market-based valuations are not available: particular attention was paid to level of service and travel time parameters.

The project included: appraisal of techniques used in selected countries to derive unit benefit parameters for use in transport project evaluation; review of international developments and experience in the use of stated preference and similar techniques, including appraisal of experimental design methods; and development of recommendations on research approaches and survey methods for deriving improved unit benefit parameters in the New Zealand context.

1 Introduction

1.1 Project Background

Transfund recently initiated a major review of the unit benefit parameters and their values used in the Transfund Project Evaluation Manual (PEM) for the evaluation of transport projects throughout New Zealand. This review arises from the following concerns relating to unreliability, inconsistency or incompleteness of the current PEM benefit methods:

- Some evaluation parameters, such as the value of time, have been taken from research in other countries and/or are based on old data.
- There is a need to reconcile different approaches to benefit parameter estimation, such as willingness-to-pay, resource valuations, revealed preference data and budget-constrained choice contexts.
- The evaluation process may be incomplete in its coverage of benefit sources.
- Parameter valuation methods are subject to uncertainty and there is therefore a wish to obtain more than one source of values: international benchmarking would be one such additional data source.

The objective of Transfund's major review is to address these issues using social and market research and surveys, drawing on international experience and practice, and to incorporate the results in the PEM.

The first stage of the six-stage review is to determine a plan of surveys and research designed to address the above concerns.

This research project involves review of techniques for the valuation of benefit parameters and determination of the most appropriate market research approaches for valuing these parameters. It is thus central to Stage 1 of the Transfund project.

1.2 Project Purpose and Objectives

The **overall objective** of this project is to develop the most appropriate market research techniques for deriving improved values for the unit benefit parameters specified by Transfund for use in transport project evaluation throughout New Zealand, with a particular emphasis on the use of 'stated preference' and related techniques for the valuation of parameters for which market-based valuations are not available.

Specific **sub-objectives** are:

- To document and appraise the techniques currently used to derive the present PEM unit benefit parameters.
- In association with Transfund, to determine which unit benefit parameters would be most appropriately determined through willingness-to-pay and similar approaches.

- To document and appraise the techniques currently used in a selection of other countries to derive the unit parameters used in transport project evaluation
- In the context of the relevant benefit parameters, to review international developments, practice and experience in the use of stated preference (SP) and related techniques and to determine:
  - situations in which the application of such techniques is appropriate
  - situations in which such techniques are not recommended (indicating alternative techniques which are more appropriate)
  - for each relevant parameter, what specific SP designs are most effective.
- To provide broad indications of the survey resources (including sample sizes) and costs for application of SP survey methods to determine the relevant parameters.
- To develop recommendations on the survey methods that should be used to derive values for unit benefit parameters in a robust and consistent manner.

In the context of these objectives, the following points should be noted:

- The project is concerned with the development of **appropriate market research** approaches and techniques to value user (and, to a lesser extent, non-user) benefits associated with changes to the land transport system in NZ.
- The primary focus is on benefit parameters relating to **transport user behaviour and perceptions,** with a lesser degree of attention being given to 'externality' factors (e.g. most environmental impacts of the transport system).
- In this regard, most attention is given to parameters requiring **non-market valuations** (e.g., willingness-to-pay methods): lesser attention is given to factors for which widely-accepted market valuation methods exist (e.g., vehicle operating costs).
- In assessing appropriate market research approaches, the project's primary concern has been with techniques to derive unit benefit parameters: these involve standard or average values, applicable to a wide range of situations, as contained in the current PEM. However, for some parameters standard unit values are inappropriate (e.g., ecology, visual and some other environmental effects): for such cases situation-specific surveys would be necessary to derive appropriate values. While the report comments on situations where standard unit values are not appropriate, it does not address the most appropriate survey approaches in such cases in detail.

1.3 Report Structure

This report is structured as follows:

Chapter 2 - sets out our review of current practice relating to research methods for evaluation benefit parameters: this covers international practice, current New Zealand practice (as incorporated in PEM), and recent research developments in New Zealand.

Chapter 3 - defines and appraises key issues relevant to the development of research approaches: these include the appropriate roles for market/shadow prices and willingness-to-pay valuations within a national CBA framework; and a range of issues relating to market research techniques for determining willingness-to-pay valuations.

Chapter 4 - draws on the appraisal of Chapter 3 to develop appropriate research approaches for the determination of the required benefit parameter values.

A glossary and a list of references completes the report.

2 Review of Current Practice and Research

2.1 Travel Time Aspects

2.1.1 International practice

Table 2.1 presents a summary for two Australian states, and three other countries internationally, of the value of travel time savings (VTTS) parameter basis and values used in project evaluation and (where available) the research methods used to derive these values.

Comments on key features of these parameters and (particularly) research methods are as follows:

- Only the UK has undertaken a substantial programme of primary market research in this field. This occurred in the mid-1980s, using a combination of SP and RP survey approaches. However, despite the extensive surveys, the results were inconclusive or insignificant on many VTTS aspects.
- Despite this extensive research, the set of parameter values used for VTTS in the UK remains relatively simple, with limited disaggregation: a single standard value is adopted for non-work IVT, with double this value for walking, cycling and waiting/transfer time. There is no allowance for driver stress/level of congestion or uncertainty of travel time.
- Only in British Columbia are the base parameter values modified in situations of congestion or unreliability. The modification factors are related to levels of service (D, E, F, stopped) and apply (although differently) to both in-work and non-work travel time. The research basis of the factors is unknown [to us].

2.1.2 Recent international research developments

In the last five or so years, a number of European countries have carried out major national VTTS studies. These include UK, Netherlands, Norway, Sweden and Finland.

Table 2.2 summarises the methodologies used for these national studies and other recent major studies, to the extent information is available (more to come). It also provides brief comments on key features of the results.

In terms of recent methodologies, key themes that emerge from these studies are as follows:

- The 1990s European VTTS studies have largely used the survey and analysis methodologies developed in the 1980s studies in UK and Netherlands. The three Scandinavian studies (Norway, Sweden, Finland) in particular have been co-ordinated and adopted similar methodologies.
- The surveys have largely used the SP approach, with logit models of the generalised cost of travel applied to derive values of time.

- Car travellers have been surveyed either by telephone interview or by MOMB questionnaire.
- Attributes for car travellers were selected from in-vehicle time, fuel cost, toll charges, level of congestion, type of road, frequency of speed cameras.
- The SP games generally involved choice between two scenarios, with up to 3-4 attributes differing between these alternatives.
- For business travel, the Hensher formulation was generally adopted, with surveys covering both the utility to the employer (increased output) and the utility to the employee from time savings.
- Particular survey design lessons relate to:
  - sample sizes, to permit adequate market segmentation and defined accuracy of estimates
  - tailoring the SP questionnaire to respondents' actual trips
  - definition of car cost variables (fuel, tolls, etc).

2.1.3 Review of stated preference methodologies in VTTS research

This section provides a summary of UK experience in the use of SP in VTTS research: this is based very largely on a review by Wardman of available British evidence from surveys in the period 1980-1996 (Wardman, 1998).

The main findings are as follows:

- Surveys involved three forms of SP data presentation:
  - Choice exercises
  - Standard ranking exercises (8-12 alternatives)
  - Rank 4 – ranking of a limited number of alternatives (typically 4)
- Surveys involved three choice contexts:
  - Mode choice
  - Route choice
  - Abstract choice (differences in travel attributes only).
- The use of choice exercises dominated in the SP surveys identified. Choice exercises are said "to provide more reliable data since they are simpler than ranking exercises and more closely resemble actual decision processes".
- Mode choice exercises were the largest category in terms of choice contexts, which reflects the importance of forecasting in the studies identified. However, it is noted that "there are attractions in adopting an abstract choice context if the aim of the study is valuation..."
- Over the period considered, there has been a trend away from ranking exercises towards choice exercises. Choice exercises are considered better able "to mimic the real decision-making situations that travellers face", and were also seen as easier for respondents. The Rank 4 methods were popular for a period in the early 1990s, but have since been discontinued in favour of the choice approach.

TABLE 2.1 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: TIME, COMFORT AND RISK ASPECTS

Country	Parameter Summary	Valuation Methods
NSW	• In RTA (1999), values based on ARRB (1999) • Base values are for: Car – working time Car – non-working time CV (occupants) CV (freight time). • Derives value per vehicle hour for differing traffic situations. • Notes that value for all other forms of non-work travel (including cycle, pedestrian, PT) and including waiting time is equal to that for car non-work travel.	• Refer ARRB (1999) and Austroads (1996). Austroads recommendations based on review of international practice (especially UK) without primary MR. • Unpaid private travel time: value at 40% of average hourly earnings of employed population. Applied to all modes (including waiting time). • Paid private travel time: value at average hourly earnings of employed population (including overheads, excluding PRT) – all modes. • Paid commercial travel time (commercial drivers): value at relevant award rate plus overheads (excluding PRT). • Freight (payload) travel time: value at 25% of hourly VOC. This recommendation subsequently amended by ARRB TR (1999).
Queensland	• In Qld Department of Main Roads (1999), values based on ARRB (1997/1999) • Base values similar to NSW (above) • Values per vehicle hour derived for differing traffic situations.	• As for NSW.
United Kingdom	• In UK DMRB – COBA/HEN2 (1996). Refer also UKDoT (1987). • Working time: values for vehicle occupants by mode (based on average incomes of mode users). Same values for walking, waiting etc time • Non-work time: single standard value for all in-vehicle time, equal to 43% of average hourly earnings of FT adult employees, which is equivalent to 40% of mileage-weighted hourly earnings of commuters. Also provides disaggregated values by people of working age, retired people and children, for use where traveller composition differs from national average. Walking/cycling values and PT waiting/transfer values are double in-vehicle time values • Notes issues of driver stress and travel time uncertainty, but that further research on this is required. • Future (real) values assumed to increase in line with growth in real GDP/capita. Notes that values are for use in evaluation only, not appropriate for forecasting.	• Developed from extensive MR program by UKDoT (MVA et al, 1987). Derivation of values from research findings is explained in UKDoT (1987) • Research programme involved 6 surveys relating to non-work time: - Car drivers with choice tolled/untolled route (RP/SP) - London commuters with choice coach/train (RP/SP) - W. Yorks commuters with choice car/bus/train (RP) - Long distance car drivers - choice between actual route and hypothetical free-flow routes with tolls (SP) - Long distance rail/coach passengers – choice between actual journey and hypothetical changes to fares, journey times, frequency, reliability (SP) - Local bus passengers – choice between actual journey and hypothetical changes in fares, journey time and waiting times/frequencies (SP) • Did not cover car passengers, cyclists, pedestrians (except for PT access) or children. • Key survey findings: - All surveys found higher IVT values than the previous DoT value (based on 25% of wage rate) - Values increased with household income - Values lower (c.25%) for retired people - Some evidence of higher values in congested conditions

TABLE 2.1 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: TIME, COMFORT AND RISK ASPECTS

Country	Parameter Summary	Valuation Methods
		- Other disaggregations mostly insignificant - Walking, waiting and unscheduled time for PT all valued more highly than IVT. • In deriving appraisal values from the survey findings, it was determined that: - A single standard value should continue to be used for appraisal purposes, based on the survey model results and the proportion of total travel time spent on each mode - Car passengers were treated as travellers generally - Average values for children were taken as 25% and for retirees as 67% of values for working age adults - Public transport access values (walking/waiting) taken as twice rate for IVT. • Empirically derived values were reduced by 17.3%, representing the proportion of indirect taxes (net of subsidies) in consumer expenditure in 1985.
British Columbia	• In BC Ministry of Transportation & Highways (1992) • Working time: base values for vehicle drivers/passengers by vehicle type (car/light truck, bus, medium truck/heavy truck) • Driver working time increased by factors for poor levels of service (D, E, F, stopped): maximum factor is 1.33 • Non-work time: separate base values for adults, retired, under 16. • Non-work time increased by factors for poor levels of service (D, E, F, stopped): maximum factor is 2.00.	• Values said to be based on a 1991 literature review (University of British Columbia). Noted that "surveys are being conducted in the province to validate these estimates". • Working time-base values: based on wage rate plus fringe benefits and some overheads. (Working time savings which translate into additional leisure are valued at the non-work rate.) • Working time factors (drivers) represent cost of personal annoyance or inactivity of these drivers in highly congested traffic. • Non-work time - base values: taken as 40% of the wage rate.
South Africa	• In SA Roads Board (1994) • Single value for all situations.	• Value said to be GDP per capita divided by 8760 hours per year(!).

- There was a trend towards making choice exercises simpler because of concerns about respondent fatigue and resistance. Early applications often involved 16 or more comparisons, but more recently 9 or 12 comparisons has become typical.
- There was also a trend away from the presentation of SP choices with cards to the use of a questionnaire approach, which has now become the most common method. There has also been increasing use of computers for presentation.

In general, encouraging correspondence was found between the VTTS results from SP surveys and the results from RP surveys (refer Wardman 1998 for details).

2.1.4 Current New Zealand (PEM) Practice

This section sets out and describes the basis of the present unit values of travel time savings (including level of service aspects) contained in the PEM.

Table 2.3 sets out the unit values (at July 1998 prices) set out in the current PEM. The following paragraphs (updated from BAH 1997) discuss the basis of these values.

2.1.4.1 *Work travel*

The present calculation of VTTS during working time is based on Cox (1979). The marginal productivity of labour (MPL) approach is used: VTTS is estimated as the gross hourly wage rate plus any employment-related on-costs borne by the employer.

The data requirements to calculate the MPL are:

(i) average hourly gross wage rates, for the range of occupational groups;

(ii) information on employment related on-costs for each occupational group, which include: ACC levy; fringe benefits; and overheads related to employing an extra person.

In addition, for different evaluation contexts, the proportion of work travellers in the traffic stream and the distribution of these travellers by occupational group are required.

In 1978, the main source of data was the latest half-year employment survey (Supplementary Tables to the Labour and Employment Gazette) for gross wages. Additions for employment-related costs were estimated approximately, with the recommendation that these be the subject of more detailed study, which does not seem to have been followed up. The analysis then goes on to suggest a distribution of occupational groups for each vehicle type (urban car occupants, rural car occupants, light commercial vehicle occupants, heavy commercial vehicle occupants), again without any clear substantiation and to be the subject of further study.

TABLE 2.2 : RECENT INTERNATIONAL VTTS STUDIES – SUMMARY OF RESEARCH METHODS

Country	Methodology Summary	References
USA	• SP survey of auto commuters in major US metro areas who regularly drive to work and face some degree of congestion. • Conducted with survey respondents who are members of a well-known nation-wide mail panel • 67% response rate (mail back), 1,170 responses. • Abstract choice survey (not mode or route choice). • Asked to rank 13 cards. Each defined a scenario in terms of congested travel time, uncongested travel time, toll charge, whether trucks use the road. Also distinguished whether toll route was public or private, and use of toll revenue. • Findings: - Uncongested time – valued at very low rate (perceived as opportunity for commuters to relax between home and work) - Congested time – average value 19% of hourly wage rate, not sensitive to use of tolls - Congested time values increase slowly with income (income elasticity c.0.1) • Low VTTS results have major implications for urban road pricing and investment policies.	Calfee and Winston, 1996
Finland	• 1995 research to investigate car driver perceptions of attractiveness of different routes. • Stage 1: MOMB questionnaire to sample of Helsinki car owners. Respondents asked to show on map their normal commuter route and an alternative route. Used as basis of RP analysis. • Stage 2A: MOMB SP questionnaire on general factors influencing route choice, relating to home-work trip. Attributes were travel time, cost, frequency/duration of unexpected delays, type of roads. Respondents required to make 10 sets of choices between two alternative routes. • Stage 2B: Similar MOMB questionnaire but including toll charge. Attributes were travel time, fuel costs, toll, level of congestion, type of roads. Half the questionnaires referred to 'toll', the other half had the toll embedded in the travel cost. Again 10 sets of choices were offered per respondent. • All choices were between 2 alternatives, in each case with 3 or 4 attributes differing between the alternatives. • C. 450 responses, used to estimate logit route choice models. • Relevant findings: - SP VTTS results similar to RP results (Stage 1) - Time savings and time losses of similar value - Unit value for small savings/losses same as for larger savings/losses - Disbenefit from driving 1 minute on local road is equal to 2 minutes on a motorway - Mention of the 'toll' word corresponds to a disutility of 4 minutes in time (relative to equivalent in travel costs). • Main lessons learned relative to VTTS SP research - Desirable to combine RP and SP data - Tailor SP questionnaire to respondents by using RP data - Carefully designed MOMB questionnaires are satisfactory - Sample sizes need to be sufficient to allow segmentation by trip purpose and socio-economic factors - Special attention needed to the definition of the car cost variables.	Pursula and Kurri ,1997
Norway	• Major national Norwegian VTTS study, 1994-97. • Similar approach to British (1987) and Netherlands (1990) studies. • Used SP approach, with logit model applied to generalised cost of travel. • Also transfer price (TP) approach, with regression models used to estimate VTTS distribution.	Ramjerdi et al, 1997

	• Covered all modes: car travel through home interview (recruited by telephone), with 900 interviews and 79% response rate. • For SP, each respondent offered 9 paired choices, each involving alternative modes. Car mode specified in terms of cost, in-vehicle time and frequency of speed cameras (3 attributes in all games). • For TP (same sample), respondents were asked their WTP or WTA for specific improvements or deteriorations in travel time. Some of respondents were reminded of their budget constraint (other transport improvements; or improvements in other goods and services). • SP results - private travel (car travel): - VTTS lower for local trips, higher for non-local trips – but decreases for longest trips (>300 kms) - VTTS generally increases with income - VTTS higher for those who travel frequently (may be related to income effect) - VTTS lower for small time savings. • TP results: - Substantial proportion of respondents stated zero WTP/WTA for small time savings (greater percentage for WTP than WTA) - Values from SP and TP studies are comparable: SP values generally between WTP and WTA values from TP study.	
Sweden	• Major national Swedish VTTS study 1994. • Similar theoretical base and survey approach to the UK (1987) and Netherlands (1990) studies. • Used SP approach, with logit model applied to generalised cost of travel. • Covered all modes (car, air, long distance/regional train, long distance/regional coach). • For car travellers, recorded licence plates at selected locations, then contacted car owners, identified drivers and arranged telephone interview. • Samples of car travellers were 1,000 for private values (private/business trips), 200 for behavioural values (business trips) and 200 self-employed people. Response rates were 65% for private cars, 50% for company cars, 30-40% for self-employed. • Survey collected socio-economic information (respondent/household), trip information and responses to SP scenarios. For car users, SP scenarios simply involved in-vehicle time and cost factors. Each game involved choice between base alternative and a change from this. Careful attention paid to randomising factors to avoid bias. • Main results – private trips: - For local trips, value for commuting c.25% higher than for other purposes. Value for longer trips (> 50km) over double that for local trips. - Generally values increased with income, with this more pronounced if using individual incomes. • Main results – business trips: - Used Hensher formulation. - Found high proportion of travel time was used productively (even for car travel).	Algers et al, 1996
UK	• Major national UK VTTS study, 1993-94 following and updating the earlier (1985) UK study. • Involved following surveys: (i) Car drivers/passengers: 12 different questionnaires covering 5 SP games: - VTTS (journey time v cost) - Road characteristics (travel time, lorry access, number of lanes, hard shoulder). - Departure time (departure time, travel time). - Chance of delay (travel time, chance of unexpected delay, delay information). - Road tolling choice (journey time, travel cost).	Hague/Accent, 1999

	(ii) Freight and bus/coach operator survey, involving 2 SP games: - Within route options (total time, total costs, chance of unexpected delay, real time information). - Road tolling/route choice options (total time, total costs, real time information). (iii) Newcastle SP/RP survey; initial recruitment questionnaire to Tyne Bridge/Tunnel users, followed by 5 questionnaires using a joint RP/SP approach. Variables were petrol cost, toll charge, travel time (moving freely v delayed). • Results were summarised for this study, earlier UK study and Netherlands study, and VTTS variations and their causal factors examined by: - Journey context (purpose; mode; distance, road type and congestion level; car occupancy; whether travel costs reimbursed). - Person/household characteristics (income, occupation, age/gender, household composition, free time). - Travel time change (time savings v losses; large v small changes).	
Netherlands	• Major national Netherlands VTTS study, 1986-90, updated using identical methodology in 1997. • Started with 1 page recruitment survey, covering car drivers (at petrol stations and car parks) and train travellers (at stations). This established willingness to participate in main survey, and recorded details of current trip. • Main survey was through postal questionnaire. Involved 3 parts: - Questions regarding the reference (recruitment) trip. - SP survey, with respondents asked to make 12 pair-wise choices between alternatives of changes in travel time and cost (choices varied to suit the reference trip). - Questions regarding the respondent and the household. • Survey covered car drivers, train users and bus/tram users. • 12 questionnaire variants based on 3 travel modes and 4 total travel time classes – as determined at the recruitment stage. • 1997 survey target was 5000 usable interviews (commuter 2500, business 1000, other 1500): target set so as to be able to detect a 10% change in group average VTTS estimates (at the 95% level). • Valid SP returns from 1997 survey were used to estimate four choice models of time v cost trade-offs: - Logit model on 1997 data, with full segmentation variables. - Logit model on pooled 1988 and 1997 data (with/without time trend term). - Logit model with less segmentation, estimated on both 1997 and 1988 data. - Same model on pooled data (with/without time trend term). • Summary results 1997 v 1988: results generally very similar, but with 1997 travellers somewhat less time sensitive than in 1988. • Summary results – personal VTTS values: - business > commuter > other - values increase with income, but less than proportionately. Summary results – employer VTTS values (Hensher formula): found that employer values for all modes substantially decreased 1988 – 1997. This is result of smaller proportion of time savings that would be converted into work, and an increased proportion of travel time spent working (mobile phones etc).	Hague Consulting Group 1990, Gunn et al, 1998

The revised values basically follow the same method of calculation. Information sources are the 1989/90 Household Incomes and Expenditure Survey, the Monthly Abstract of Statistics which gives wage rate indices and the Quarterly Survey of Employment, February 1990 figures. The index data are projected forward to the July 1991 base date.

There are a number of assumptions in the calculations which it was not possible to check at the time of production of the Project Evaluation Manual. These include the distribution of occupational categories in the working purpose mileage-weighted driving population, particularly for car and light commercial vehicles; and the on-cost rates, for which an attempt has been made to improve on the estimates but which require further work.

There has been no attempt so far in New Zealand to identify the proportion of working travel time savings devoted to leisure, the proportion of in-travel used for work activity and its relatively productivity, or the utility to the employee of travelling relative to time at the work site. The position which was taken in the preparation of the 1991 Project Evaluation Manual was that overseas empirical research has in general yielded values of work travel time of similar magnitude to the MPL value without any of these adjustments, so a decision was made to retain the existing method for the time being.

2.1.4.2 *Non-work travel time*

At its December 1991 meeting, the Transit NZ Authority determined that differences in willingness-to-pay for non-work time savings arising from differences in income should not be used for project economic evaluation. However, this did not preclude introducing differences in VTTS based on transport mode, where this is a reflection of modal and passenger characteristics other than income.

2.1.4.3 *Base VTTS for car drivers*

The base value of non-work travel savings was set for a car driver from an average income household travelling to full-time paid work in free-flowing traffic. The behavioural value adopted, after consideration of the overseas evidence and after correction for indirect taxation, was 40% of the average full-time employed adult hourly income.

The rate of indirect taxation was nominally taken to be 15%, that is GST of 12.5% plus a small margin for other taxation (such as import duty and excise). A better estimate of the average rate of indirect taxation on goods and services was seen to be required, and a task for future work on the topic.

Adding back this 15% implied a behavioural VTTS of 46% of the average wage rate for car drivers. This was similar as a percentage of gross wage rate to the values recommended by Hensher (1989) for use in Australia (36% private car driver, 61% company car driver) and by MVA et al (1987) in the UK (46%), but less than the value of 60% recommended by Miller (1989).

TABLE 2.3 : CURRENT PEM VALUATIONS FOR TIME AND LEVEL OF SERVICE FACTORS (All Values at July 1998)

Traveller/Vehicle Category	VTTS		Notes
	$/person hr	$/veh hr	
In-Work Travel (Persons) – Base Values			
Car, m/c – driver and passenger Bus passenger (seated/standing) Pedestrian, cyclist	21.30		
CV driver/passenger:			
- light	19.25		
- medium/heavy	15.80		
Non-work Travel (Persons) – Base Values			
Drivers (car, m/c, CV)	7.00		
Passengers-seated (car, m/c, CV, bus)	5.25		
Pedestrian, cyclist, standing bus pass	10.55		
Congested Conditions (Persons) – Additions (CRV)			
Drivers (car, m/c, CV) Passengers (car, m/c, CV, bus)	Max 3.50 Max 2.60		• Addition to base In-Work and Non-Work values (above) • Full value applies to stopped/ bottleneck time • Proportion of value applies where V/C ratio exceeds 70% but below 100% (refer PEM A4.5.3).
In-Work Travel (Vehicles/Freight)			
Car		0.45	
CV: - light		1.60	
- medium		5.60	
- heavy I/bus		15.80	
- heavy II		26.00	
Conversion Unsealed to Sealed Road			
All vehicles		$0.16/veh-km	• Represents reduced vehicle occupant discomfort from sealing unsealed roads (refer PEM A7.2.2)

The value of 40% of the average wage rate was calculated to be $6.13 per hour (1991), which was rounded in the 1991 PEM to $6.10, and has since been updated to $7.00 (1998).

The same value was adopted for people driving commercial vehicles in non-work time.

2.1.4.4 *Car passengers*

VTTS for car passengers and passengers on other modes of transport were set relative to car drivers. Miller (1989) had recommended a relativity between car passengers and car drivers of 0.69:1.0, based upon Hensher (1989). The logic for adopting a lower VTTS for passengers than drivers was that the disutility of the trip is greater for the driver. However, the question of whether passengers on average have less time constraints than the driver did not appear to have been researched and was considered to be a possible factor.

The VTTS for car passengers recommended and adopted for the Project Evaluation Manual was a relativity of 0.75:1.0. The alleged reason for this was to maintain a margin between car passengers and bus passengers. While Miller (1989) suggested these be the same, the weight of studies seemed to indicate that VTTS for car passengers would generally be higher than that for urban stage bus passengers, even when income effects were excluded.

2.1.4.5 *Bus passengers*

The recommended VTTS for seated urban stage bus passengers was 25% of the wage rate, that is a relativity of 0.625:1.0 against car drivers. This relativity was slightly greater than recommended by Miller (1989), and about the same as that recommended in the MVA et al (1989) study, but considerably higher than the results of that study which indicated a VTTS for bus passengers about 50% that of car drivers. For express bus services, a higher value would be expected, and an equal value to car passenger might seem reasonable.

In practice, PEM had adopted the same value for seated bus passengers as for car passengers.

2.1.4.6 *Walking, cycling and waiting for transport*

The PEM does not distinguish between walking for public transport access and walking as the main mode, and does not address waiting time for public transport. The background working paper did, however, consider this issue, recommending a single value for walking and waiting time for public transport access equal to the 1.5 times the VTTS for car drivers. This was a similar relativity as given by the values recommended by Miller (1989), and equates to 2.4 times the recommended value for seated bus passengers. This value was also recommended for walking and cycling as main modes, although the empirical research to support this was recognised to be inadequate.

In practice, PEM has adopted a value for walking (either as main mode or for access to public transport) and for cycling approximating to 1.5 times the car driver value and 2.0 times the passenger value.

2.1.4.7 *Modifying factors for standing passengers*

While the evidence on which to suggest modifying factors for levels of in-vehicle comfort was originally found to be limited, a main discriminating factor was suggested to be whether passengers have to sit or stand. The base values for bus passengers assume fully seated passengers. Miller (1989), on the basis of Algers and Widlert (1985), had recommended a VTTS of 250% of the wage rate, or six times his base passenger values, for standing passengers. This very high value was not applied in the PEM; instead a modifying factor for having to stand of approximately 2.0 times the seated in-vehicle time value was recommended and adopted.

2.1.4.8 *Trip purpose*

No compelling evidence was recognised to differentiate VTTS between different non-working trip purposes, although Hensher (1989) was noted as an exception: more investigation of this matter was though to be required, in particular, the grounds for differentiating between recreational travel and other non-work trip purposes.

2.1.4.9 *Modifying factors for person type*

The lower VTTS for students and retired persons allowed in the new UK procedures were recommended for inclusion in New Zealand practice. However, this was another refinement which did not find its way into the 1991 issue of the Project Evaluation Manual.

2.1.4.10 *Modifying factors for congestion and reliability*

There was found to be good evidence that time savings in congested traffic are valued more than in free-flowing conditions, although the degree to which this is contributed to by uncertainty and how much by driver stress and frustration from the road conditions was less clear.

It was seen to be desirable that the benefit of increased reliability of transport service be recognised in project evaluation, so that service enhancements that achieve such improvements be recognised, even though this may not result in overall time saving.

Miller (1989) had recommended a factor of 1.5 between congested and free flowing traffic while the MVA studies suggested a factor of 1.4 from the situations studied and maybe higher under more congested conditions.
Two possibilities for including congestion and reliability effects in evaluation were under active consideration at the time of production of the original Project Evaluation Manual - either to vary the VTTS with traffic level of service (A to E), or

to apply a higher VTTS to stopped vehicle time. Neither was implemented in 1991 because this somewhat radical departure from current practice needed further consideration.

However, subsequently the procedures were modified to incorporate an additional allowance for travel in congested conditions, applied to both in-work and non-work travel time. The maximum allowance for drivers and passengers is set at 50% of the corresponding non-work base values. This maximum applies for bottleneck/stopped time; while it is reduced pro rata for lesser degrees of congestion and becomes zero for a V/C ratio of 70%. [We understand this function is based on very limited evidence.]

2.1.4.11 *Modifying factors for unsealed roads*

A 1992 Transit research project found strong evidence of travellers' willingness-to-pay to travel on sealed rather than unsealed roads, reflecting the greater comfort and lower perceived risks associated with sealed roads (Travers Morgan, 1997). This project used SP-based methods to investigate travellers' trade-offs between different features of unsealed roads, sealed roads and toll charges.

As a result of this research, in the PEM update (1995), an additional comfort benefit of 16¢/vehicle kilometre was introduced for road sealing projects.

2.1.4.12 *Freight time and vehicle fleet savings*

The significance of a value for freight time savings in comparison with the value of time for the heavy vehicle carrying the freight had, in the past, been judged to be very small. However, this was an issue which was questioned from time to time, and was considered in the preparation of the Project Evaluation Manual. Again, the conclusion was reached that this effect was likely to be very small and no allowance was in fact made in the 1991 Manual, although it was suggested that the matter receive some further study.

In subsequent updating of PEM, a set of values was introduced to reflect the value of time savings for freight and for business/commercial vehicle fleets. Details of the derivation of these values are unknown.

2.1.5 Recent New Zealand Research Developments

Three substantial NZ studies relating to VTTS have been undertaken in recent years:

- 'Valuations of Travel Time Savings: Final Report'. (Travers Morgan with Beca, 1997). This study involved a review of all aspects of VTTS and developed a proposed research programme for application in New Zealand.
- 'Travel time Values – Stage 1: Theoretical Framework and Research Outline'. (BAH with Professor David Hensher, 1997). This study included specification of a theoretical framework for the valuation of time savings; development of a corresponding framework for undertaking VTTS market research, based on SP methods; and design of a typical survey based on these methods.

- 'Valuation of Travel Time Savings – Market Research'. (BAH with Professor David Hensher and Colmar Brunton Research, 1999). This study undertook market research in NZ into motorists' valuations of travel time savings, consistent with the research framework and survey methodology defined in the previous report.

The objective of this most recent project was to undertake market research among motorists in New Zealand to establish unit values of travel time savings by:

- trip purpose (particularly commuter *v* other)
- degree of traffic congestion
- uncertainty of travel (arrival) time.

The research covered cars only (not commercial vehicles), drivers only (not passengers), and non-business travel only (not travel related to business purposes).

The research focused on a questionnaire administered to sample individuals relating to a recent (or typical) trip made as a car driver: respondents were then asked to choose between this (reference) trip and two hypothetical alternative trips – with 16 separate sets of alternatives being offered to each respondent.

The reference trip and each alternative were defined by six attributes:

- Travel time – free flow
- Travel time – slowed down
- Travel time – stop/start or crawling
- 'Uncertainty' allowance (ie extra time required to be reasonably certain about arriving at the destination by a particular time)
- Running (fuel) costs
- Toll charges (payable by the driver, relating to road use)

For the alternative trips, the six attributes were allowed to take any of four levels. Except in the case of toll charges, these levels were defined as proportions of the levels associated with the defined reference trip.

The survey was administered through a PC-assisted personal interview approach at the respondent's place of residence.

Key features of the sampling basis were:

- Respondents required to have made a trip as car driver within the last 7 days (local trips) or last 6 months (longer distance trips).
- Four trip categories were covered:
  - Local commuter (150 sample)
  - Local other purposes (150 sample)
  - Medium distance up to 3 hours (75 sample)
  - Long distance, over 3 hours (75 sample).

- Surveys in three main metropolitan areas and four regional centres (with quotas in each).

Full results are provided in the study report. The study could be judged as successful in providing a substantial body of evidence, for the first time in New Zealand, on how motorists' valuations of travel time savings vary with levels of congestion and uncertainty in travel time. Key features of the VTTS findings include:

- Average values for commuters are significantly higher than for other trip purposes.
- Values increase substantially as the degree of congestion increases (reflecting the increased disutility of travel in congested conditions).
- 'Uncertainty' values are significant relative to other time components.

The study thus provides a much-improved basis for modifying non-work VTTS for project evaluation in New Zealand to better reflect variations by trip purpose, degree of congestion and unreliability/uncertainty of travel time. It also may be regarded as a pilot for the use of SP methods in the valuation of time, level of service etc trip attributes.

2.2 Level Of Service Aspects

The previous section (2.1) has primarily dealt with research and practice relating to the opportunity cost of time spent travelling, on the basis that the personal utility (comfort, convenience, etc) of the time spent travelling is similar to that involved in the alternative use of the time. However, in many situations there may be a significant disutility component associated with the time spent travelling, eg if spent in crowded or congested conditions, or other situations of poor level of service.

This 'disutility' issue is of particular interest in the context of the current Transfund Review and hence is addressed separately (at Transfund's request) in this section. This section covers all 'disutility' aspects, including perceptions of travel time reliability, degrees of congestion, comfort and risk perceptions, and other aspects of travel conditions under the general heading of 'level of service' (as perceived by road users).

2.2.1 International practice

Table 2.4 provides a summary, analogous to Table 2.1, of international project evaluation practices relating to level of service' factors. It is evident that, of the four countries, only British Columbia and New Zealand make allowance for 'LoS' or disutility aspects. In these two cases, this allowance is made through adjustment of the 'base' (opportunity cost) time values, to reflect the road user disutility associated with congested traffic conditions.

2.2.2 Recent International Research Developments

There is relatively limited international evidence on the valuations of different 'level of service' factors for car travel. Table 2.5 presents a summary of evidence available: most of this has been derived from research studies primarily concerned with VTTS.

Further brief comments on the evidence on LoS/disutility factors follow, distinguishing between disutility aspects relating to:

- congestion, and associated traveller stress
- reliability of travel time
- comfort
- risk/perceptions of danger.

2.2.2.1 Congestion and reliability factors

While there are two distinct disutility effects here, they are often not separated in practice: the extra stress associated with travelling in congested conditions; and the uncertainty/unreliability of travel times (which is often associated with congestion).

TABLE 2.4 : INTERNATIONAL EVALUATION APPROACHES: 'LEVEL OF SERVICE' FACTORS		
Country	**Approach/Comments**	**Reference**
New Zealand	• Both working and non-working VTTS increased by factors relating to the V/C ratio – refer Table 2.2. • Increases are 0% for V/C = 70%, increasing to 50% of base non-work values when V/C reaches 100% (or stopped conditions). • For sealing of unsealed roads additional allowance of $0.16/veh km, reflecting reduced discomfort of vehicle occupants (based on SP research) – refer Table 2.2.	PEM
Australia	• Not included in current standard valuations • Austroads proposed an on-going R&D program "to address issues relating to the travel time values of...reliability and viability factors; and disutility factors".	Austroads, 1996 (AP 119)
UK	• Not included in current standard valuations • Noted that: - "Reduction of uncertainty in journey times by public transport may have a value in its own right, over and above the extra travel time which people may have to allow for in planning their journeys". - "There were indications that for car drivers the VTTS may be higher where road conditions are more congested, suggesting a 'driver stress' factor" "Separate values for these effects cannot at present be identified and values will depend on further research."	UK DoT, 1987
British Columbia	• Both working and non-work VTTS increased by factors relating to the traffic level of service (D, E, F, stopped) – refer Table 2.1 • These factors stated (for working time) to represent costs of personal annoyance or inactivity of these drivers in highly congested traffic.	

As noted in Table 2.1, British Columbia applies factors to base VTTS for travel in congested conditions, although the research basis for these is somewhat unclear.

A pilot market research survey in British Columbia found that motorists rated travel in slow-moving city traffic as three times more annoying than travel on a regular busy highway; which in turn they rated three times more annoying than travel on non-busy highways (Waters and Evans, 1992). However this is not to say that the VTTS will vary in the same proportions, as the 'annoyance' factor is only one component in the valuation of time savings.

A number of UK studies have investigated the effects of both congestion and reliability/ variability on motorists' valuations. In respect of congestion, various studies indicate VTTS in congested conditions being up to twice values for free-flow conditions. However, these differentials, found from SP surveys, has not been translated into different VTTS values for use in project evaluation.

For reliability/variability of travel time, a SP study of long-distance commuters found that a 1.0 minute reduction in the standard deviation of journey time was valued as equal to a 1.5 minute reduction in expected journey time: the implication was that the valuation of reductions in variability would add around 15% or more to conventional valuations of reductions in expected time.

TABLE 2.5: RECENT INTERNATIONAL STUDIES – EVIDENCE ON 'LEVEL OF SERVICE' FACTORS

Country	**Research Evidence**	**References**
USA	• SP survey of regular car commuters in major US metro areas found that: - uncongested time valued at very low rate (perceived as opportunity to relax between work and home) - congested time valued at average 19% of hourly wage rate	Calfee and Winston, 1996
British Columbia, Canada	• Pilot survey found that motorists rated travel in slow-moving city traffic as three times more annoying than travel on a regular busy highway, which in turn was three times more annoying than travel on non-busy highways. (However, 'annoyance' does not necessarily translate directly into VTTS).	Waters and Evans, 1992
UK	• Congestion level. VTTS sensitive to level of congestion. For business travel, personal VTTS for trip in totally congested conditions approx twice that for trip in free-flow conditions. • Road type. Generally effect of road type insignificant once accounted for effects of congestion and journey length. (If these effects are not separately accounted for, then average VTTS for motorways is greater than for trunk roads, which in turn is greater than for urban roads.) • Road characteristics. For motorways and trunk roads, found that VTTS would reduce by up to 30% if lorries were restricted or banned, by up to 30% with addition of a shoulder, and by up to 20% with an extra (traffic) lane. Effects differed by purpose, with commuters generally most sensitive to these features.	Hague/Accent, 1999
UK	• Congested time valued 30% - 50% higher than free-flow time.	MVA, 1987
UK	• SP survey of long-distance travellers found that a 1 minute reduction in standard deviation of journey time is valued equal to a 1.5 minute reduction in expected journey time. • Based on a typical coefficient of variation in journey time (0.13), this implies that the valuation of reductions in uncertainty should be c.15% additional to the conventional valuations of expected time savings.	Black & Towriss, 1990
UK	• Study to assess benefits of reducing travel time variability for typical UK road schemes adopted unit value for reducing standard deviation of travel time as 77% of value for reducing expected travel time (basis of values not clear).	Dale et al, 1996
Finland	• SP data indicated VTTS on motorways c.20% lower than on local roads; whereas RP models indicated motorway VTTS c.50% lower. • 'Ability to maintain desired travel speed' on inter-urban main roads valued at between half and twice standard VTTS values.	Pursula and Kurri, 1997
Netherlands	• VTTS in less than free-flow conditions for motorway users up to 60% higher than in uncongested conditions: effect depends on trip purpose – highest for commuters, lower for business travel, negligible for other purposes.	Hague, 1990
Brazil	• SP study of commuters found that a one minute reduction in standard deviation of journey time was valued at between 1.6 and 7.9 times a reduction of one minute in expected journey time.	Senna, 1991

The most recent major UK VTTS study also found that road type did not significantly affect motorists' valuations of time savings (once congestion and journey length effects are separated out).

The major Netherlands VTTS project found that unit VTTS figures for motorway travel increased by up to 60% as average speeds fell from above 110km/hour to below 90km/hour. However, contrary to expectations, VTTS in urban conditions were similar to those in uncongested motorway conditions (Bradley and Gunn, 1991).

Miller examined a number of studies and recommended a 60% increase in VTTS for drivers and passengers in congested conditions (Miller 1989).

A Brazilian SP study of commuter preferences also indicated the importance of journey time reliability: a one minute reduction in the standard deviation of journey time was valued at between 1.6 times and 7.9 times (2.4 times to 6.0 times on the central estimates) a reduction of one minute in expected journey time.

2.2.2.2 *Comfort and risk factors*

Again there are two distinct disutility effects here, which are often not separated in practice: the ride quality associated with travel in certain conditions (eg unsealed roads); and the perception of risks associated with particular road conditions.

There is limited evidence available on travellers' willingness-to-pay to improve the physical comfort of their travel (additional to effects related to congestion).

For car travel, the 1993/94 work for Transit New Zealand on willingness-to-pay to avoid travelling on unsealed roads was a pioneer on this topic (Travers Morgan, 1997).

For public transport travel, there has been rather more research. Most studies have indicated that VTTS for standing passengers is around twice that for seated passengers, while VTTS in very crowded conditions may be much higher. There are also differences between public transport modes, associated with ride quality etc: typically VTTS for rail-based services is 10-25% lower than for on-street bus services. Public transport travel is not dealt with in any detail in this report.

2.2.2.3 *Summary*

The international studies reported above have mostly used SP-based research methods to establish values for various aspects of (dis)utility; although there has been some use of RP methods (eg for public transport passengers).

There is clear evidence from the research that the (dis)utility associated with travel varies in different conditions eg due to congestion, or on unsealed roads. However, there have been relatively few studies on this issue and no clear consensus on the extent of adjustments that are appropriate. Few countries yet incorporate such adjustments in their VTTS figures used for project evaluation. Where they do, they are incorporated by way of adjustment to 'standard' (opportunity cost) values of time to reflect (eg) different levels of congestion.

2.2.3 Current New Zealand (PEM) practice

The current PEM practice relating to level of service/(dis)utility effects is set out in Tables 2.1 and 2.4. In summary, PEM allows for these effects in two ways:

- For 'congestion' effects – increase in base non-work VTTS values (for both work and non-work travel) by up to 50% in congested conditions. The research basis for this adjustment is unknown (to us): we believe it is based primarily on the British Columbian practice (for which the research basis is again unknown).
- For 'comfort and risk' factors associated with unsealed roads – a disutility value, expressed per vehicle kilometre, for travel on unsealed (relative to sealed) roads. This value was established through SP-based market research (Travers Morgan, 1993).

It could be said that New Zealand practice is at the forefront of world practice in making these allowances for disutility, the research basis for them is somewhat flimsy.

2.2.4 Recent New Zealand research developments

Recent New Zealand research relevant to level of service/(dis)utility aspects focuses on the 'VTTS – Market Research' project undertaken by BAH/Hensher and described earlier (Section 2.1.5).

This research explicitly considered how drivers' valuation of time savings varied with the degree of traffic congestion, and also how drivers valued reliability. An SP-based research approach was adopted. No attempt was made in this research to examine other aspects of 'level of service'.

In the LoS/(dis)utility context, two general features of the results are particularly notable:

- The relatively low VTTS results for free-flow travel (relative to 'standard' values of non-work travel time in PEM, or internationally); and, by contrast, the substantially higher values in more congested conditions, ie motorists appear to place a relatively high value on the disutility of travel in congested conditions.
- The highly significant values placed on 'uncertainty' of travel time: average values (over all sample) were around $0.60 - $0.70 per trip for local trips, $1.90 for medium-distance trips and $7.20 for long-distance trips.

An earlier SP study, relating to the demand for the Transmission Gully toll road (Steer Davies Gleave, 1992) also examined motorists' valuations of reliability. One minute of expected lateness (ie the chance of being late multiplied by the minutes of lateness) was valued the same as 2.9 minutes of (expected) driving time by car commuters, at 4.7 minutes driving time by other private motorists and at 2.7 minutes driving time by commercial vehicle drivers.

2.3 Vehicle Operating Costs

2.3.1 International practice

Table 2.6 provides a summary of international project evaluation practice relating to unit vehicle operating costs (VOC).

The countries/states surveyed all take account of a number of basic variables – fuel, oil, tyres, maintenance and depreciation – although the detail of how this is done differs. The way these vary with key determinants such as speed and terrain is also allowed for. The form of the functions used (eg, how fuel consumption varies with speed) is generally similar, although it is not clear whether this is simply because one country has drawn on another's work. With the exception of South Africa, resource (not opportunity) costs are used.

Both British Columbia and NSW separately cost fuel consumption when the vehicle is stationery. While this may be a useful level of detail, it presupposes that a suitable traffic model is available to provide the required inputs. NSW also has separate, simplified procedures for rural conditions. As far as can be ascertained, only the UK specifies how fuel prices should be increased in future.

2.3.2 Current New Zealand (PEM) practice

The VOCs presently used in the PEM have been derived from the NZVOP model, which in turn was based on HCM3. Work done initially and periodically since then calibrated and modified this to the New Zealand environment, for example, in terms of the nature of the vehicle fleet. Use has also been made of the ARRB fuel consumption model.

No allowance is presently made for more complex aspects of VOC, for example in congested conditions.

2.3.3 Recent New Zealand research developments

In 1999 Opus Consultants undertook a study of base VOC and the impact of roughness on costs. However the results of this have not yet been included in the PEM. One of the outcomes of this work was that the willingness to pay (WTP) for a reduction on roughness is low – this is inconsistent with earlier results relating to unsealed roads.

2.4 Accident Aspects

2.4.1 International practice

This is summarised in Tables 2.7 and 2.8 for the countries reviewed. The UK moved to a WTP approach in the late 1980s, a little while before New Zealand. The two Australian states and British Columbia all indicated in the early to mid 1990s that a move to WTP was imminent so it is to be expected that this will have taken place. South Africa still appears to rely on the human capital approach.

2.4.2 Recent international research developments

Over the last 10-20 years, a number of countries have changed the basis for ascertaining the VOSL (Value of Statistical Life). Previously the 'human capital' approach was used, which effectively measured the value of lost productivity due to the victim's premature death. This was usually averaged according to the age distribution of accident fatalities. The actual resource cost of the accident (property damage, hospitalisation, etc) continued to be included, however.

There are a number of arguments against the human capital approach: it looks at market wages rather than market values for safety; it undervalues some sections of society such as women and children; and it ignores consideration of pain, grief and suffering.

The theory underlying WTP is that decisions in the public sector which improve safety reduce accident risk and hence can be considered to be avoiding a 'statistical' injury. For a small reduction in risk, the total value which society as a whole is willing to pay to avoid such a statistical injury is equivalent to the marginal rate of substitution of wealth for the probability of being injured. In other words, at the margin, people are prepared to pay a small amount for a small reduction in the risk of injury.

The introduction of the WTP approach has however not been without controversy. For example in the UK, early work on valuing the VOSL using WTP was undertaken in the early 1980s, but the resulting value – which was considerably greater than the previous value – was considered too high by the Department of Transport. While the principle was accepted, the value was not. It was not until 1988, when a much lower 'compromise' value was proposed (based on a review of research, not new surveys) that this was included in the evaluation process. Even so, the new value was almost twice the old one.

2.4.3 Current New Zealand (PEM) practice

2.4.3.1 Historical approach

Until 1991, Transit New Zealand valued accidents essentially using the human capital approach, based on the present value of lost production etc (refer Brown Copeland, 1986). In 1991, using this approach the value adopted for a fatality was $235,000.

At an NZ MoT/NRB workshop in February 1989, consensus was reached that the more appropriate valuation method was willingness-to-pay (WTP). This change followed similar changes made in a number of other countries, including UK and USA. While there were a considerable number of international studies into the value of statistical life (VOSL), it was decided to mount a survey in New Zealand.

TABLE 2.6 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: VEHICLE OPERATING COSTS

Country	Parameter Summary	Valuation Methods
NSW	Urban:	• Market price less tax (ie resource cost) • From ARRB 'Road User Costs for Use In Economic Evaluation of Roading Expenditures', January 1999.
	• Fuel cost per litre • Non-fuel cost per km	• Derived from operating cost model • Comprises depreciation, oil, tyres, maintenance
	• Non-fuel cost per stop	• Represents wear and tear • RTA estimate
	• Fuel used per stop	• Acceleration/deceleration • From ARRB 'Estimating Fuel Consumption of Light to Heavy Vehicles' ARRB TR Paper AIR 454-1
	• Fuel consumption per km	• Cruising at 60km/hour • From ARRB 'Vehicle Fuel Consumption Estimate Program ARF COM-User Guide' TR Paper ATM 28 (1989).
	Rural: • Tabulates cost per km according to speed and roughness • Differential light/heavy vehicle and VCR = 0, 1 • Further increments to allow for curvature.	
Queensland	• Gives values for different vehicle classes • unit values by vehicle type of: - Petrol/litre - Diesel/litre - Oil/litre - Tyres - Vehicles • Combined VOC per km depending on roughness, terrain and speed	• Not clear how these are computed from unit values.
UK	• Comprises six items: fuel, oil, tyres, maintenance, depreciation and size of vehicle fleet • Fixed costs such as insurance are excluded • Fuel cost element changes over time; non-fuel element remains constant in real terms • For vehicles in non-work time, only the fuel costs of VOC are perceived. •	• All costs are resource costs (VAT refunded) • Cost of fuel is a specified function of speed and hilliness • Oil and tyres fixed per km • Maintenance – varies with speed (in a similar way to fuel) but not hilliness • Depreciation is mileage relat

TABLE 2.6 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: VEHICLE OPERATING COSTS (Cont'd)

Country	Parameter Summary	Valuation Methods
UK		• Non-fuel elements are combined in a formula which is similar to fuel consumption but not a function of hilliness • Specifies forecast increase in fuel price for future years.
British Columbia	• Identifies four basic conditions with different VOC: - constant speed - speed change - cornering - idling • Components of cost: - fuel & oil - tyres - maintenance (parts & labour) - depreciation & interest • Road variables affecting VOC: - geometry - surface - traffic control.	• CBA software contains a model for computing VOC as a function of speed and gradient • Acknowledges possible WTP for driver comfort and system reliability.
South Africa	•	• All costs are opportunity costs so use market price and include taxation • Fuel cost a function of vehicle class, speed, gradient and radius • Oil cost related to fuel • Depreciation: fixed amount per km (light vehicles) or value of capital cost/km (heavy vehicles) • Maintenance: function of speed (similar to UK) • Tyre costs: function of speed • VOC varies by roughness, in a different way for light and heavy vehicles.

TABLE 2.7: INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: ACCIDENT COSTS

Country	Parameter Summary	Valuation Methods
NSW	• Casualty cost per person (fatality down to not injured) • Generic cost per accident (fatal down to tow-away) • Cost of accidents by type.	• From ARRB (ARRB 227' Costs for Accident Types and Casualty Classes' 1992, updated to 1999) • Gives casualty cost per person, which includes an incident cost to reflect items such as vehicle repair, insurance, accident investigation and legal costs • Generic cost per accident is based on an analysis of accidents by casualty class
Queensland	• Average number of accidents per million VKT, depending on road type.	• Accident cost based on risk-adjusted changes in the cost of lost income, hospitalisation and medical care, pain and suffering, vehicle repair, etc • Indicates that a move to WTP is planned.
UK	See Table 2.7 following.	• WTP used since 1988 (fatals) and 1994 (non-fatal) • Value of injury related to the value of death • Updated annually according to GDP per capita • Includes allowance for lost output for all accident types • Medical & support costs also included • Accident-related costs; damage to property, insurance administration, police • Having established the total value, the difference between that and the 'tangible' costs (eg medical) is referred to as 'human costs': see Table 2.7 • Average number of casualties per accident taken into account.
British Columbia	• Cost of fatal, non-fatal and damage only accidents	• Reference to US work on 'Comprehensive Accident Cost Method' • Refers to pain and lost quality of life (evaluated using WTP) as well as 'human capital' (property damage, lost earnings, etc). However the former is 'not to be used pending further research' (1992).
South Africa	• Cost of fatal, serious and slight collision.	• Production value only, based on annual GDP per capita • Loss of production depends on age: average loss computed from the distribution of traffic fatalities by age • Serious and slight costs based on sick leave required and % loss of production • Acknowledges that social value should be included but 'no reliable value has been determined to date'.

TABLE 2.8 : UK SUMMARY OF COSTS PER ACCIDENT OCCURRING IN 1994 (JUNE 1994 PRICES IN UK£)							
Type of Accident	**Casualty-Related Costs**			**Accident-Related Costs**			**Total**
	Lost output	**Human costs**	**Medical costs**	**Damage to property**	**Insurance admin**	**Police costs**	
Fatal	305,310	596,660	4,110	5,880	160	1,020	913,140
Serious	13,660	83,280	8,190	2,710	100	140	108,080
Slight	1,570	6,710	670	1,590	60	30	10,630
All injury	7,910	27,940	2,980	1,840	70	60	39,800
Damage only				1,020	30	2	1,050
All Accidents	490	1,740	120	1,070	30	6	3,460

2.4.3.2 *1989/90 VOSL survey*

A New Zealand market research project into VOSL was undertaken in 1989/90 by the MoT Land Transport Division in association with Ted Miller of The Urban Institute. The household survey was administered by Ampt Applied Research. Findings are reported in Miller and Guria: 'The Value of Statistical Life in New Zealand', MoT, May 1991. The following is summarised from that source.

The survey covered 629 adults (age 18+) in a random selection of NZ households: respondents replied on behalf of themselves and their families (related household members).

Five main questions were asked about WTP for safer travel, in terms of measures that would reduce risks of fatalities (or also serious injuries) to household members by half. Table 2.9 summarises these main questions, comments on them and the responses. Additional comments on important survey/analysis issues are as follows:

- Total WTP to reduce risk of death of a family member was derived as own WTP plus WTP by other family members. Own WTP was derived directly only from Q7: therefore the Q7 results had to be used in computing total WTP for questions 11, 14, 22. (In Q20, total household WTP was derived directly and divided by numbers of household members to deduce total WTP per member). This means that results for Q11, 14, 22 are in part dependent on results for Q7: the methods are not fully independent.

- In calculating WTP values per family member, it was assumed that on average the wife in a family valued the husband at the same level as the husband valued the wife; and that any WTP by children is ignored. The impacts of these assumptions are not fully clear.

- Additional questions (Q16, 17) investigated respondent trade-offs between fatalities, 'serious injuries' and 'permanently disabling head injuries'. It was found that, in terms of WTP, about 30 serious injuries are equivalent to one death; but that preventing serious head injuries was regarded as at least as important as preventing deaths. However, LTSA noted that the valuation of serious injuries was subject to potential error: the description given in the question did not represent the average serious injury (refer LTSA comments on BAH May 2000 draft report).

- Q7, 11, 14 relate to fatalities only; Q20 and 22 relate to fatalities and serious injuries. For the latter two questions, serious injuries were converted to equivalent fatalities using the results from Q16 (above), although these are now shown to be somewhat suspect.

In interpreting the results, the report comments that:

- The mean WTP VOSL was $1.91M 'per life saved to buy road safety for their families'. This value is an average across 6 questions and 568 responses (excluding some outliers and inconsistent responses).
- For the three most reliable questions (Q7, Q14, Q20), the average values are all in the range $1.9M - $2.0M and the 95% confidence interval around the combined mean is from $1.7M to $2.2M.
- Average values for single individuals are generally lower than for family members (not unexpectedly, reflecting age/status).
- Values for single individuals would be expected to be, more consistent, as they come direct from the responses to each question on its own. However, these values have a somewhat wider spread ($0.75M - $2.25M for the five questions) than that for the family members.

Two additional points should be noted:

- These values relate to individual WTP components of fatalities. The public cost component needs to be added to derive total public sector valuations.
- Q22 included questions about WTP through taxation to fund safety for the general public (outside the family). 35% of respondents expressed some WTP to protect the general public, with on average payments of 48% of their payment for their own family. Overall, this 'altruistic' payment was about $0.35M per life saved or 17% of WTP for family members. The report notes that this figure is not used (but is replaced by the lower public costs associated with a fatality), and to that extent the $1.9M average figure adopted is conservative.

The study also included a set of questions to establish the relationship between VOSL and VTTS. For an open road they often used, respondents were asked to indicate:

- Relative personal risk of a fatality in open road conditions (daytime, good weather) relative to the New Zealand average.
- Speed in good conditions (daytime, good weather, light traffic).
- Changes in risk if drive at this speed in bad conditions (bad wind and rain storm).
- Expected speed in bad conditions.
- Change in risk at expected speed/bad conditions.

TABLE 2.9: NZ 1989/90 VOSL SURVEY – KEY QUESTIONS

Ref	Question Summary	Cases	Mean VOSL (1990 $000)			Notes
			Individual	Family Member	All	
Q7	Commuter route choice: high risk route (6:10,000 pa chance of death) v low risk toll route (3:10,000 pa chance of death) with nominated max toll per trip	308	2,254	1,970	2,009	• Potential problem of single coin bids.
Q11	Maximum WTP for all households members to attend a road safety course which reduced nominated risk of any household member being killed in road accidents by half.	296	1,121	1,496	1,437	• Unclear whether costs and risk reduction apply for first year only or for life (understand that first year only assumed in analysis). • Weakness of using starting bid.
Q14	Maximum WTP for safety features on car that would reduce nominated risk of household fatality (over car life) by half.	226	1,272	1,920	1,849	• Appears to be sound question. • Considerable spread of values: median $1.25M.
Q20	Maximum additional WTP per year (in terms of annualised house prices) to live in area where nominated chance of any road accident to a household member is halved.	500	1,469	1,910	1,871	• Stated WTP adjusted to fatality WTP by allowing for serious injury costs (but these subject to considerable uncertainty). • VOSL simply derived as fatality WTP divided by number of household members. • Unclear whether additional cost is recurrent (cost of living) or adds to house capital value – potential to significantly influence results. • Considerable spread of values: median $1.3M.
Q22	Maximum WTP through annual taxes for road/pedestrian improvements that would reduce nominated chance of any road accident to a household member by half.	108	755	2,623	2,297	• Unpopular question – at end mentions higher taxes! • Report gives minimal detail of results.
	Overall Average		1,374	1,984	1,893	

There are a number of potential difficulties with this approach in practice:

- Unclear whether stated New Zealand average risks are correct (good conditions, open road, daytime, light traffic).
- Possibility that good conditions speeds are systematically under-stated (as noted in the report).
- Wind/rain conditions are likely to have most effect on speeds at critical points (bends, etc), but may have very little effect on average speeds. It is unclear that respondents will estimate change in average speed realistically.
- Q34b (risk for driving at original speed in bad conditions) may be unrealistic: risk may be seen as very great and not able to be sensibly estimated.
- As speeds reduce in bad conditions, average accident severity and chance of any accident resulting in a fatality will be reduced. This is not taken into account in the analyses.

The analysis of this set of questions first calculated the value of reduced crash risk per hour of added travel time; and then, using the previous question on the trade-off between death and injury, converted this to the value of a fatal risk reduction per added hour of travel. Over 329 responses, it was found that one life was valued at 253,000 hours of travel time saving (mean), or 189,500 hours median. Various assumptions are then made on VTTS to convert this to a monetary value:

- Based on VTTS of 25% of wage rate (the then standard value), VOSL is $0.85M.
- Based on 60% of wage rate for drivers and 45% for passengers (as recommended by Miller), VOSL is $1.85M. This is virtually identical to the average result from the five main questions given in Table 2.9.

The report places emphasis on the VOSL estimate of $1.85M as being consistent with Miller's recommendations re VTTS: it notes that this figure is very consistent with the average of results for the five main questions. However, the current PEM VTTS values imply a significantly lower VOSL: based on the VTTS at 46% of gross wage rate, as currently in PEM, VOSL would be $1.56M.

The report notes that:

> *"The speed choice analysis makes it clear that the values of statistical life and travel time are related. Good policy analysis demands maintaining their proportionality."*

The main conclusions from the market research work were thus:

- On the basis of surveys of WTP of individuals for the road safety of their families, the average VOSL across five separate sets of questions was about $1.9M per life saved (with a 95% CI of $1.7M - $2.1M). This figure excludes the public sector monetary costs associated with fatalities, but these are relatively small.
- In addition, the surveys indicate an average WTP valuation of $0.35M per life saved to protect the general public (ie other than family members). This figure has not been incorporated into subsequently-adopted values.

- A survey to trade-off accident risk against speed indicates that one life is valued at equivalent to about 250,000 hours of travel time saving. On Miller's recommended VTTS figures (as proportion of wage rates), this is very consistent with the above VOSL; but current (lower) PEM VTTS figures would imply a considerably lower VOSL figure.
- WTP for serious injury is estimated at 3.3% of the fatality figure.
- WTP-based accident values should be indexed on the basis of changes in average wage rates (per hour worked).

2.4.3.3 *Subsequent research and developments*

Following completion of the VOSL research, the Minister of Transport decided in April 1991 that:

- The VOSL should be taken as $2.0M at April 1991 prices.
- It should be indexed to the average ordinary wage rate.

Subsequent to the VOSL research, studies were undertaken by MoT (Land Transport Division) into other components of accident costs. The first such study reported in May 1991 (Guria: Estimates of Social Costs of Accidents and Injuries), and this was then updated in August 1993 (Guria: Social Costs of Traffic Accidents). This latter report provides the main basis for the current PEM values, and key aspects are summarised as follows.

Accident costs were analysed in the following categories:

1. Loss of life and quality due to long term impairments.
2. Medical treatment:
   - emergency services
   - hospitalisation or other initial medical treatment
   - follow-on treatment.
3. Property damage.
4. Legal system:
   - court system
   - traffic enforcement.
5. Loss of output due to temporary incapacitation.

Table 2.10 summarises the relevant values from the 1993 report. It is evident that the WTP/life quality component is the dominant cost for all accident categories. It is also noted that the values adopted for serious and minor injuries were estimated from other sources and analyses, rather than making use of the 1989/90 survey results.

The original $2.0M for VOSL (at April 1991 prices) has subsequently been indexed by LTSA, based on changes in ordinary time wage rates: the current LTSA value is $2.485M at June 2000 prices. (The current PEM value differs slightly from this value, as Transfund has adopted a different basis for indexation).

All the above values relate to the value of a single injury or fatality. The PEM values given for costs of different accident types are based on a combination of injury types derived from the LTSA traffic accident database.

TABLE 2.10 : AVERAGE COSTS PER INJURY (Costs in $000, July 1992 Prices)			
Cost Item	**Fatal**	**Serious**	**Minor**
1. Loss of life/permanent disability	2,025.0(1)	162.0(2)	8.1(2)
2. Medical	4.6	10.1	0.6
3. Property damage	2.9	2.4	2.8
4. Legal	3.1	0.4	0.2
5. Loss of output due to temporary incapacitation	-	0.4	0.1
Total	2,035.5	175.3	11.9

Source: Guria, 1993.
Notes: (1) Equivalent to original figure of $2.0M at April 1991 prices.
(2) Based on 8% (serious) and 0.4% (minor) of VOSL. These proportions derived from 'Guria's review (The Expected Loss of Life Quality from Traffic Injuries Requiring Hospitalisation, Accidents Analysis and Prevention, Vol 25 No.6) of the average loss of life quality for serious (hospitalised) and minor injuries relative to that for fatalities. The 8% for serious injuries replaces the 3.3% estimated in the VOSL study, which was not based on a comprehensive appraisal.

2.4.4 Recent New Zealand research developments

2.4.4.1 'Value of Safety' study

The following description focuses on the New Zealand 'Value of Safety' (VOS) survey undertaken in 1997/98, which updated and extended the 1989/90 VOSL survey described in the previous section. To date, the new survey results are only reported in unpublished form (Guria et al 'The Value of Statistical Life and Prevention of Injuries in New Zealand', Draft Report, April 1999), and have not been incorporated into standard evaluation values.

Key features of the 1997/98 survey method included:

- Undertaken by/for LTSA with expert inputs from University of Newcastle-upon-Tyne (Michael Jones-Lee/Graham Loomes) and surveys by Ampt Applied Research.
- Surveys involved one adult (over 17) in random sample (total 1,051) of New Zealand households (sub-sample of national travel survey). Survey undertaken over period October 1997 – September 1998.
- Survey had three purposes (more comprehensive than 1989/90 survey):
  - to update VOSL (WTP basis)
  - to determine corresponding WTA value
  - to determine the relative WTP values for serious and minor injuries.
- Key part of the survey was a computer-based interactive questionnaire which sought to establish:
  - Measure of relative 'badness' between different levels of injury (minor, temporary, permanent, fatal): this used both 'matching' methods and 'standard gamble' methods

- Monetary values people place on changes in their risks in three scenarios:
- reduction in death/injury risk *v* higher cost of living
- increase in death/injury risk *v* lower cost of living
- extra cost paid by household to pay for nationwide programme of safety improvements.

Key features of the survey results were:

(i) VOSL-WTP:

- Median VOSL calculated from WTP questions varied between $2.6M and $4.0M.
- 'Untrimmed' mean values are much higher, but mean values reduce towards median as high-end outliers are trimmed. More conservative VOSL, after trimming top 15% of responses, would be around $5M.
- Still more conservatively, some combination of median and trimmed mean VOSL suggests a value in the range $3M to $5M.

(ii) VOSL-WTA

- WTA values were in range of 3 to 10 times the WTP values.
- Compared with international experience, a ratio of 3:1 is not unusual, but a ratio of 10:1 is unusually high.

(iii) Injuries-WTP

- Balance of evidence (from the survey and other sources) is that WTP to avoid serious injury is about 10% of VOSL, and WTP to avoid minor injury is about 0.4% of VOSL.

Based on these results, the draft report recommended the following:

(1) *"The WTP-based value of statistical life for road risks in New Zealand should be set at between$3M and $5M. If a single figure is to be chosen, $4M would be reasonable.*

(2) *The WTA-based value of statistical life for road risks in New Zealand should be set at between three and five times the WTP-based value. If a single ratio is required, 4:1 would seem acceptable.*

(3) *The value for preventing a serious non-fatal road injury in New Zealand should be set at 10% of the WTP-based value of statistical life, with the corresponding figure for preventing a minor injury being 0.4%. The same WTA/WTP ratio as in VOSL should apply."*

[It is noted that these values represent only the WTP/WTA element of accident values. Other components, covering loss of output and other direct economic costs, need to be added in.]

2.4.4.2 *Comments on VOS study*

While the 1997/98 VOS survey was broader than the 1989/90 VOSL survey, it addressed the same basic issue as the earlier survey, ie the VOSL on a WTP basis. On this issue, its recommendation was for a WTP value of around $4M, which is almost twice the mean value from the earlier survey ($1.9M in original prices). As the recommended WTP values for injuries are expressed as a proportion of the VOSL, adoption of this recommendation would result in all accident benefits calculated through PEM being almost doubled from their present estimates. Clearly the validity of the new estimates, and the reasons why they differ so much from the earlier survey estimates, are of some importance.

Unfortunately the two surveys adopted rather different methods to assess VOSL on a WTP basis. In this regard the more recent survey addressed only:

- WTP (in cost of living) for living in an area where the risk of being killed or injured is reduced by 20% or 50%.
- WTP (by household) for a nationwide programme of road safety measures which reduced all accident rates by 20%.

The first of these questions is similar (but not identical) to Q20 of the earlier survey; the second of these is similar to the earlier Q22. There has been no attempt to repeat the first three questions (Q7, 11, 14) of the earlier survey; nor to repeat the earlier trade-off between accidents/fatalities and time saved. This is unfortunate, as it would have helped in examining the factors behind the apparent increase in VOSL figures.

The recent survey report notes [almost in passing] two possible reasons why its WTP results were substantially higher than those from the earlier survey:

(i) WTP for road safety may have risen faster than real incomes (perhaps related to ability to pay). However, no convincing rationale is given for this, nor evidence from elsewhere. In fact, the recent report estimates a VOSL income elasticity in the range 0.4 to 0.9, which would tend to indicate a less-than–proportionate increase with incomes.

(ii) The improved level of road safety since 1989/90 may have affected people's WTP for further improvements. The report itself gives no evidence to support this suggestion. However, in discussion LTSA suggested that perhaps respondents' stated WTP for a given percentage accident reduction has not changed markedly since the earlier survey; but the absolute accident risks have been reduced significantly; and hence the WTP per accident avoided has significantly increased. This seems a plausible explanation, but does cast doubt on whether respondents are really able to comprehend the absolute risks involved in making their trade-offs.

A third possible reason was mentioned by LTSA in discussion:

(iii) More 'trimming' of high-end outliers was undertaken with the 1989/90 survey than with the more recent survey. If less trimming had taken place, the 1989/90 results would have been higher: however, while this adjustment would probably be significant, its extent is unclear.

Before considering adoption of the new recommended WTP VOSL figures, it would be very helpful to have:

- Evidence on how they compare with other countries in absolute terms (allowing for differences in GDP/head etc)?
- Any evidence on trends over time in values elsewhere?

It would also be more reassuring if the earlier WTP questions had been repeated, so as to shed light on whether the higher values were the result of different question/analysis methods or of genuine increases in values. It would also be helpful to test further how people's responses are affected by the absolute level of risk involved (rather than just a proportionate change in risk).

In regard to the WTA VOSL results, the report notes that the WTA:WTP ratios are at the high end of the range of general experience. Again, if a WTA value is to be adopted for use in appropriate circumstances, it would be more helpful if the New Zealand results could be compared against equivalent international research.

2.5 Environmental Effects

2.5.1 International practice

Table 2.11 provides a summary of international project evaluation practice relating to environmental effects.

With a few exceptions, the countries/states which were reviewed did not specify monetary values such as "1 tonne of CO_2 has a value of $30". British Columbia gives a figure for the impact of noise on property values; NSW does something similar and includes a number of other values, e,g., relating PM_{10} levels to mortality and the value of life.

In the UK a number of non-monetary indicators are used, for example the number of properties experiencing a change in noise greater than 3dB(A). These are part of a wider multi-criteria evaluation framework covering five areas, one of which is environment.

2.5.2 Current New Zealand (PEM) practice

In general, values are given in the PEM to a number of environmental impacts, but many do not have a specific value. There is however a means by which intangible effects can be monetarised and included 'below the line' in the calculation of the BCR. This entails assessing a level of benefits representing an intangible feature of an option such as a reduction in severance. The intangible benefits being claimed are then undiscounted and converted to a meaningful unit such as $ per property.

2.5.2.1 *Air pollution*

There are several prediction methods which allow the concentration of pollutants to be estimated as a function of traffic volume and speed and distance from the road. Specifically, PM_{10} are known to affect mortality and the PEM gives a formula for deriving the cost of an increase/decrease in PM_{10} concentration from the value of life. PM_{10} are largely an urban problem and should be taken into account when a project is forecast to affect the value of traffic in urban areas.

2.5.2.2 *Carbon dioxide*

The effect of CO_2 emissions is global ('the greenhouse effect') while that of other air pollution is largely local. The PEM gives an economic value for CO_2 emissions of

$30 per tonne, a figure which is based on the average results of the Land Transport Pricing Study. Production of CO_2 is related to the Vehicle Operating Costs (excluding roughness effects) for road links and to fuel consumption at intersections.

2.5.2.3 *Noise*

The PEM specifies that traffic noise forecasts, 10 years after project completion, should be calculated using a method devised and used in the UK. The value of a change in noise is computed as:

$$\$190 \text{ per year} \times \text{dB change} \times \text{households affected.}$$

The value of $190 is derived as follows: hedonic pricing work in a number of countries has concluded that the cost of noise as a proportion of affected property value is in the range 0.5% to 0.7% per dB. However, this does not take account of any WTP effects, nor the fact that WTP has been shown to increase as base noise rises.

Effects on other travellers and those in non-residential buildings are also excluded. A figure of 1.2% has therefore been adopted. Taking an average property value of $150,000 gives an NPV cost of $1,800 per dB which can be equated to an annual value of $190.

2.5.2.4 *Vibration*

Methods for estimating vibration are given in the PEM, but no economic evaluation is proposed.

2.5.2.5 *Water quality*

The PEM specifies that effects should be reported and the impacts predicted suing a suitable approach is they are significant.

2.5.2.6 *Special areas, ecological effects ,visual impact*

All these should be identified and described, but no economic value is given.

2.5.2.7 *Severance*

Areas affected should be identified and mapped if appropriate. Where features to reduce severance are incorporated, the benefits of reduced travel times (particularly for pedestrians and cyclists) and accident savings should be quantified and included as tangible benefits in the BCR. Conversely, where severance causes increased travel times for these groups, these should be included in the benefit calculation.

2.5.2.8 *Other impacts*

Overshadowing, isolation and psychological distress are to be reported but do not have an economic value. The benefit from reducing site-specific discomfort (eg crossing a narrow bridge) can be given a value up to 10¢ per vehicle although there is no empirical basis for this figure.

TABLE 2.11 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: ENVIRONMENTAL EFFECTS

Country	Parameter Summary	Valuation Methods
NSW	• No specific values supplied.	• Gives some specific values, eg cost to properties of additional noise, increased mortality from increased PM_{10} • allows scores to be assigned to social and economic impacts (e.g. 'very much better' scores +4)
UK	• No economic evaluation	• Environment is one of 5 areas in the multi-criterion evaluation framework • Sub-headings used are noise, air quality, landscape, bio-diversity, heritage and water • Seven point scale used where quantification not possible • Noise impact measured by number of properties experiencing a change >3dB(A) • Air quality: number of properties experiencing a change in NO_2 and PM_{10}, plus additional tonnes of CO_2 • Landscape, bio-diversity and heritage: based on Environmental Capital • Water quality impact measured by risk of damage.
Queensland	• No specific values supplied.	•
British Columbia	• Quantifies the impact on property values of each increase/decrease of 1dB(A) • Other effects to be treated qualitatively.	•
South Africa	• No specific values supplied.	•

2.5.2.9 *Summary*

Overall, New Zealand appears to have assigned economic values to more environmental impacts than most of the other countries considered. Environmental assessment in the UK is part of the MCE framework. Values for other impacts are being researched but do not yet appear to be sufficiently well established.

2.5.3 Recent New Zealand research developments

From discussions with Transfund, we understand there has been no significant recent research in New Zealand that is relevant to establishing/refining unit benefit values for the environmental effects included in PEM.

3 Key Methodology Issues and Appraisal

3.1 The Basis for Evaluation

Transfund's principal objective is "to allocate resources to achieve a safe and efficient roading system". Its primary objectives, derived from this principal objective, include:

- *"to approve and purchase a national roading programme which prioritises funding consistently on the basis of expected national benefits for a given cost.*
- *To establish the process for evaluation and to fund efficient alternatives to the provision or maintenance of roading."*

The methodology adopted by Transfund for project evaluation and determining priorities between competing claims on funds is Social Cost-Benefit Analysis (SCBA, or CBA). The principal performance indicator used with the CBA methodology for prioritisation of projects is the Benefit:Cost Ratio (BCR), where:

- B is the net benefits (tangible or intangible) of the project to both transport system users and non-users.
- C is the net costs of the project incurred by the roading authority, including both up-front (capital) costs and on-going (operations, maintenance) costs.

The CBA methodology is undertaken from the national perspective, in which all costs and benefits are those to the community as a whole.

Transfund has developed detailed requirements and guidelines for the application of CBA to all projects which are candidates for Transfund funding. These requirements/guidelines are contained in:

- Project Evaluation Manual (1997, with subsequent updates) – for roading projects.
- Evaluation Procedures for Alternatives to Roading (1999) – for 'alternative to roading' proposals.

The theoretical basis for CBA is derived from the field of welfare economics. Key concepts underlying CBA are:

- Individual preferences: valuation should be based on the preferences of the individuals affected by a project or policy. Therefore the willingness-to-pay of affected persons is the relevant measure of benefits.
- Opportunity costs: costs are defined by the value of what must be foregone in order to use resources for a policy or project rather than in the best alternative way.
- Potential compensation: a project or policy should be adopted, if the gainers' benefits are sufficient to compensate the losers, whether compensation is actually paid or not.

The concept of **efficiency** is also crucial to the CBA methodology:

- A project is described as efficient if its expected net social benefit is positive, i.e. its total benefits exceed its total costs.
- In the case of alternative projects, the most efficient one is that which provides the highest net social benefit.
- In a constrained funding situation, the most efficient solution for a given level of funds is obtained by selecting projects in order of their BCR values (highest first), until the budget is exhausted (on the assumption that the constrained budget relates to the 'costs' in the BCR denominator).

In the context of the CBA methodology, it should further be noted that:

- All costs and benefits should be assessed over the life of the investment. Discounting is used to allow for the fact that future costs and benefits are less highly valued than present ones.
- Where possible, cost and benefit items are expressed in a common unit of value, which is in dollar terms. In the case of costs and benefits which are not able to be expressed in monetary terms, a judgement has to be made in comparing their impacts with the benefits and costs that have been monetarised.
- CBA is not concerned with equity issues, i.e. the distribution of costs and benefits.

3.2 Benefit Valuation Principles

As described above, the valuation of inputs to CBA is most appropriately based on the concepts of willingness-to-pay (WTP) of individuals and opportunity costs of resources. In both cases, values should be in 'resource' terms, ie net of any non-resource components (such as taxes and subsidies).

However, practical difficulties are encountered in estimating WTP or opportunity cost for certain goods or services. Therefore a range of pragmatic methods have been developed to provide estimates of or proxies for WTP/opportunity cost. Examples include the following (refer OECD, 1992 and further discussion of valuation methods in Chapter 3):

- market price of consumer goods
- modified market price, allowing for externalities, monopoly rents, taxes, regulations, etc
- damage costs calculated from damage functions (dose-response technique)
- expenses for private complementary goods as minimum benefit of a public good (e.g. travel cost methods)
- price of private goods as substitute of public goods
- mitigation costs (costs of measures to avoid or reduce negative externalities)
- explaining actual prices by implicit components (hedonic pricing methods)

- actual choices showing WTP (revealed preferences)
- surveys asking for WTP (contingent valuation or transfer pricing)
- surveys asking for minimum compensation to accept disadvantages
- surveys about hypothetical choices (stated preference, stated choice or stated ranking).

The opportunity cost of resources refers to the cost to society of consuming resources, and is measured by the marginal production cost for newly-created resources or the market price for existing resources (assuming a situation of perfect competition). In cases where market prices are distorted by any non-resource elements (e.g. indirect taxes), a correction is made to derive a marginal resource cost (or shadow price).

To use a WTP measure in establishing a marginal resource valuation, we have to establish appropriate marginal cost functions, and to identify the equivalence between the marginal WTP and the marginal implicit price, after correction for non-resource components. This results in a resource valuation that is derived from marginal WTP and provides a consistency of approach between WTP and 'shadow price' approaches. There then remains the practical issue of what are the best sources of the various data inputs required for the evaluation.

Current CBA procedures in New Zealand and elsewhere, use both WTP values and shadow price values as most practically appropriate. One example in New Zealand is the valuation of time savings: values for non-working time are based directly on the WTP approach (with non-resource corrections); values for working time are based in part on the resource valuation approach (employer benefits) and in part on the WTP approach (employee benefits).

We see no reason to change the approach to this issue adopted hitherto. Our recommendations developed in this report on future research methods and the derivation of evaluation parameters therefrom thus involve WTP-based estimates and resource/shadow price estimates, derived through a range of research techniques.

3.3 Monetary Valuation Techniques

3.3.1 Introduction

Before reviewing the techniques for monetary valuation, it is important to establish exactly what is meant by economic value. The concept of economic value has been defined by the Australian Department of Environment (1998), as "any net change in the welfare of society". This concept includes environmental values from direct use or consumption of a resource as well as the benefits received from environmental resources, such as national parks, clean air, etc. From an economic perspective, values can be associated equally with the consumption of goods purchased in markets and with the services from environmental amenities for which no actual payments are made.

Pearce and Turner (1990) identify three types of value:

- private preference value;
- public preference value; and
- non-preference value.

Conventional economics examines the private preference values of individuals, i.e. their individual needs and wants. However, in terms of the environment it is argued that individuals also have public preference values that involve beliefs about what ought to be the case rather than reflecting individual wants, e.g. the protection of National Parks or historical buildings. It is also argued that nature has intrinsic value, which exists whether or not humans are present to experience it: this is defined as non-preference value.

The majority of the valuation techniques concentrate on the private preference value. Private preference value can be divided into a number of value groups. Rendel Planning (1992) define the total economic value of an environmental good to be:

$$\text{Economic Value} = \text{Use Value} + \text{Non-use Value}$$

where:

- use value is the value of the benefit gained by using the good;
- non-use value is the benefit individuals obtain from environmental resources without directly using them.

The Australian Department of Environment (1998) describes the non-use value as a combination of the following factors:

- existence value (the welfare gained from knowing a resource exists and/or is protected;
- vicarious value (the welfare gained from indirect consumption via books or other media);
- option value (welfare gained from having the option to use the resource at some future date);
- quasi-option value (welfare gained from the opportunity to get better information by delaying a decision that may result in irreversible environmental loss in the future);
- bequest value (to provide a good environment for future generations, friends and relatives, and sympathy for people and animals in poor environments).

Total non-use value is a sum of all these factors:

$$\text{Non-Use Value} = \text{Existence Value} + \text{Vicarious Value} + \text{Option Value} + \text{Quasi-Option Value} + \text{Bequest Value}$$

Non-use values depend upon the perceptions and feelings of individuals towards future generations, other people and animals, the overall strategic effects of policies and feeling of responsibility for environmental impacts.

3.3.2 What should be valued?

There are some aspects of the environment that seem unlikely to lend themselves to monetary valuation. Firstly, Button (1993) suggests that "evaluation is only conceptually possible if the environmental resource is non-essential. Clearly if the resource is essential then it has infinite value". Secondly, Rendel Planning (1992) and SACTRA (1992) define other aspects that cannot sensibly be valued such as:

- global warming;
- sacrosanct environmental assets; and
- irreversible cumulative impacts felt by future generations, etc.

Figure 3.1 (following) shows the economic approach to the environment in comparison with the social and scientific approaches as described by Turner (1988). Some impacts (e.g. those listed above) reflecting public preference and non-preference value may be better addressed using social and scientific approaches. In the case of road infrastructure appraisal most of the environmental impacts under consideration tend to be local in nature, and hence should lend themselves to monetary valuation.

3.3.3 Economic valuation approaches

Figure 3.1 also shows the breakdown of economic approaches into those of:

- market value approaches;
- non-market value approaches.

In competitive markets, prices are direct measures of benefits and cost, and so can be observed and used as values. However, competitive markets rarely exist for environmental goods, and in their absence valuations must be derived from other kinds of non-direct market data.

3.3.4 Market value approaches

A change in the environment may alter economic activities and so change the monetary revenues and costs of those activities. This change in revenues and costs can sometimes be used to value the change in the environment. The effects of environmental change and the sources of valuation can be summarised as follows:

Effect of Change	Valuation Source
Change in availability, quality or quantity of an output	Change in productivity
Change in availability, quality or quantity of an input	Change in income
Individuals, groups or society replace an entire asset, part of an asset, or quality of an asset	Replacement cost
Individuals, groups or society spend money to defend their environment	Preventative expenditure
Individuals, groups or society relocate an activity	Relocation cost

Source: Australian Department of Environment (1998).

In the case of road infrastructure appraisal such valuation mechanisms are not applicable to most environmental impacts under consideration. Hence, .other non-market techniques have to be used to infer values of the environment.

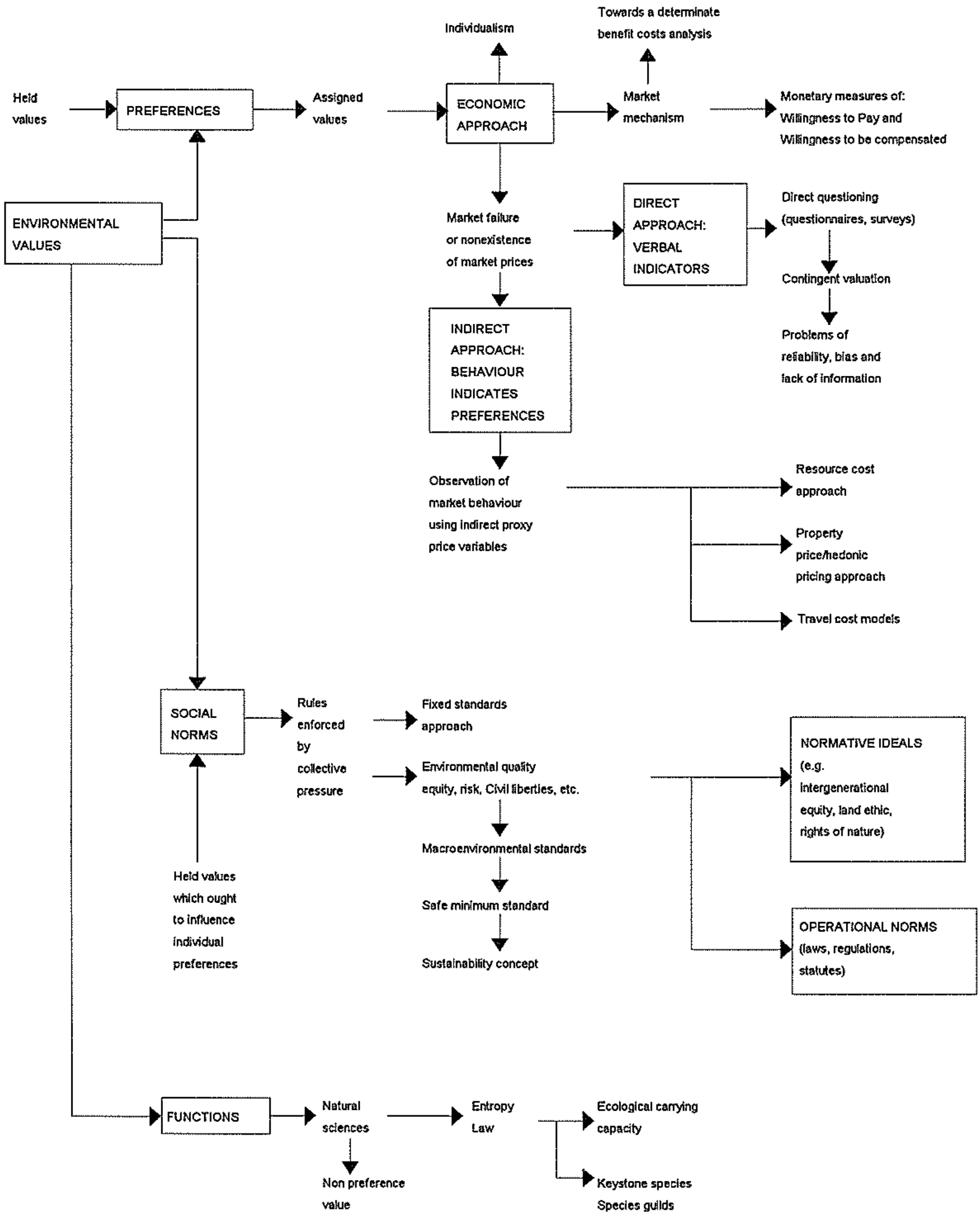

Figure 3.1: Methods of Quantifying Environmental Values (Turner 1988)

3.3.5 Non-market value approaches

There are two main non-market approaches to valuing environmental goods, direct and indirect:

- Direct ('stated preference') approaches use market research survey techniques to gather valuations directly from individuals;
- Indirect ('revealed preference') techniques use either a surrogate market or data from other sources to generate valuations. The indirect methods are shadow pricing, dose/response, expert opinion and surrogate market techniques: travel cost method and hedonic pricing. Most indirect techniques have significant problems in their application.

The following sections describe the present methods of monetary valuation available under these two groupings.

3.3.6 Direct valuation techniques

3.3.6.1 *Overview/terminology*

A wide range of direct valuation techniques are potentially available to estimate the values that transport system users (and non-users) place on different attributes of the system. Most of these techniques were originally developed in conjunction with market research in non-transport sectors over the last 30 years – typically for research designed to test responses to potential new products or services. Over the last 10–20 years, these research techniques have been increasingly adapted and applied in the transport sector – to estimate transport user valuations of system attributes and non-user valuations of transport externalities (environmental effects etc).

Figure 3.2 provides a classification of the major direct valuation techniques of relevance here. It might be noted that:

- The research literature is far from consistent in its use of terminology to describe such techniques. In particular, in the transport sector the term 'stated preference' is often used very loosely and not consistently.
- Numerous variations exist on the basic techniques shown in the diagram, and the dividing lines between techniques are often blurred.

The basic split of valuation techniques is between revealed preference (RP) and stated preference (SP) techniques:

- RP (indirect) methods are based on observation of subjects' actual choices.
- SP (direct) methods are based on stated (or declared) intentions of subjects.

RP (indirect) methods are discussed in the next section.

The term SP refers to a variety of individual techniques such as contingent valuation methods, transfer price analysis, and conjoint analysis. The techniques use the results of direct interviews to model behaviour of individuals. Stated preference techniques refer to a number of different approaches all of which use peoples statements of how they would respond to different situations" (Pearmain et al., 1991). The techniques use controlled experimental designs to construct a series of alternative situations, individuals are then asked how they would respond to these situations if they were faced in reality. "This is a family of survey techniques used to measure respondents' perceived value of something, usually by getting them to compare and choose between alternative scenarios" (JMP, 1996). The researcher has complete control over the factors presented in the situations. This enables a wide range of situations to be investigated, which may not easily be measured when observations of actual behaviour are used.

While SP techniques cover a wide range of methodologies, they usually involve three key features:

- a description of the benefit to be valued;
- questions/choice situations intended to determine the value set by the respondent to one or more benefits;
- questions intended to reveal characteristics of the respondent which may influence the valuation results.

SP techniques are increasingly used in the field of transport research. "Stated preference methods are widely used in travel behaviour research to identify responses to choice situations which are not revealed in the market" (Hensher, 1994). SACTRA (1992) describe some of the applications of SP: "the most well established applications have included offering different combinations of time and money in the context of a hypothetical mode or route choice, and different combinations of comfort, amenity and convenience in the context of station or train design". SP techniques are also used in the existing UK Trunk Road appraisal process to supply monetary values of time to COBA.

The following sub-sections discuss in more detail the contingent valuation method (CVM) and the family of conjoint analysis methods (CA). The transfer price method (TP) is an intermediate method between CVM and CA, and is noted under the conjoint analysis heading rather than separately.

3.3.6.2 *Contingent valuation method*

Much research in the environmental field has concentrated on the Contingent Valuation Method (CVM). CVM has also been used externally in willingness-to-pa studies of the valuation of safety, including in NZ studies (refer Sections 2.4.3, 2.4.4). CVM is an expressed preference survey method. It asks individuals, in a structured way, about their maximum willingness to pay (WTP) for an (environmental) gain or minimum willingness to accept (WTA) compensation for a loss. CVM assumes that respondents would behave in the same way in a real market, as they do in the hypothetical market postulated in a CVM survey. Because CVM asks individuals directly for their full valuation of an environmental asset it is the only technique which theoretically captures the full total economic value rather than just the individual's use value. Button (1993) describes the method as the most widespread approach, that asks through questions of a relevant group of individuals what compensation they would need to keep them at their current level of welfare if some defined transport-induced environmental degradation took place or what amount they would pay to prevent this occurrence.

Figure 3.2: DIRECT VALUATION TECHNIQUES – TERMINOLOGY

* **All User Preference Methods**

  * **Revealed Preference (RP)**
    - based on actual (observed) choices

  * 1.1.2 * Stated Preference (SP)

    * **Contingent Valuation Method (CVM)**
      - Direct approach – asks people directly re WTP for a benefit or WTA for a loss.
      - May use: direct, open-ended question; bidding game; or less direct question (as in referendum). (1)

    * **Transfer Price Method (TP)**
      - Examines choice between current situatio and a hypothetical situation.
      - Lies between CVM and CA in directness and complexity.
      - Methodology closest to CVM – relatively simple form, direct approach. (2)

    * **Conjoint Analysis (CA)** (3) (or Trade-off or Stated Choice Analysis)
      - Indirect approach – asks people to choose between or rank packages involving several factors (at different levels) and then infers factor values from choices.
      - Three main approaches: choice (between 2+ packages), ranking and rating.

      * **Traditional Conjoint Analysis (TCA)**
        - Ranking or rating (not choice) approach
        - Analysis commonly by OLS (ordinary least squares) or Adaptive Conjoint Analysis (ACA) – Sawtooth Software

      * **Choice-based Conjoint Analysis (CBCA)**
        - Extension of CA, with respondent choosing from several competing factor options.
        - Analysis by use of discrete choice models (logit/probit analysis).

Note:

(1) Examples are:

- Direct, open-ended question: 'What is the most you would pay for X...?'
- Bidding game: 'Would you pay $10 for X?' If 'yes', increase amount till respondent says no, etc.
- Less direct question: 'The Government is considering X: it involves a tax increase of $Y. Would you vote for or against X?'. If 'for', then increase $Y until vote is 'against'.

(2) Example: 'The bus journey you described took 20 mins and cost $1. What is the maximum you would be prepared to pay if the journey took only 15 mins?'

(3) In transport sector, 'Conjoint Analysis' is also sometimes referred to as 'Stated Preference' (SP), but this terminology is liable to mislead.

A CVM experiment is based on:

- a detailed description of the goods being valued and hypothetical circumstance that is available to the respondent;
- questions on respondents' characteristics and their use of goods;
- willingness to pay questions for the good to be valued.

The willingness to pay question typically takes a form similar to the following:

> *"What amount would you be willing to pay in taxes and higher prices each year to keep (or improve) the situation (with respect to some environmental amenity)" (Mitchell & Carson, 1989, cited in Nash, 1990).*

CVM can also be undertaken in the form of bidding games, where respondents are asked to accept or reject bids for an environmental gain or loss. Hanley (1988) gives an example of a bidding game in a study of the valuation of straw burning:

> *"Suppose the government decided to ban straw burning due to the nuisance caused to people and damage done to the countryside. The local authority might have to compensate farmers for the extra expenditure incurred by them in baling or ploughing in the straw, or spend extra money policing the ban. Rates would have to be raised to cover this. How much extra rates would you be willing to pay to avoid straw burning?*
>
> - *Would you pay an extra £5 a year?*
> - *Would you pay an extra £10 a year?*
>
> *(Continue raising in £5 increments until a NO bid is reached)"*

Baughan & Savill (1994) carried out a CVM study in the UK on traffic noise nuisance. They found consistency between valuations and traffic nuisance changes, and the ability of people to give separate values for different components of traffic nuisance. Randall (1983) notes that "*valuation bids are not random numbers. Many empirical studies show that individual or household bids are significantly related to income, availability of substitutes and complementary goods, and demographic characteristics*".

CVM has generally gained superiority over the indirect methods of valuation for environmental factors because:

- It asks individuals directly for their full valuation of an environmental factor, and so can take into account 'option' and 'bequest' values.
- It is a very flexible technique and can be adapted to different situations: therefore, it should be applicable to a wide range of environmental impacts.
- The environmental factor can be singled out: this is not possible in revealed preference.
- The method is not limited geographically.

In theory CVM should be applicable to all environmental and other effects. However, in practice its use is more restricted. In particular, CVM scenarios require:

- Information on individual property rights with respect to the environmental asset, income levels and a clear definition of the type of goods being valued (for example with public goods it is important to inform the individual whether or not they are paying through taxes for an environmental attribute); and
- the goods being valued should be clearly defined in an 'understandable' way. The more 'familiar' the environmental good in question, the greater the likelihood of a successful survey.

CVM is prone to bias from various sources, as discussed in a subsequent section (3.4.6).

CVM can be used to elicit both WTP and WTA values. Major disparities between these two values have been revealed, although traditional economic theory suggests that WTA and WTP values should be similar. Johanssen (1993) identifies divergences up to a factor of 10 (cited in Bateman, 1994). Kahneman & Tversky (1984) tried to define this pattern of difference between WTA and WTP via Prospect Theory. The theory suggests that people make judgements on gains or losses from a reference point. Depending whether they see the change as a gain or a loss determines their valuation of that change. Coursey et al. (1988) noted that *"psychologists argue that people are more averse to a loss than attracted to the same gain"*. In general people do not wish to spend money they already have, so WTP values are low, whereas people will accept infinite levels of compensation for a loss, so WTA values for the same effects are higher. Knetsch & Sinden (1984) describe this phenomenon as *"people are willing to spend actual or 'realised' income or wealth less readily than 'opportunity' income or wealth"*.

3.3.6.3 *Conjoint analysis*

The term conjoint analysis (CA) refers to a wide family of techniques which involve an indirect approach to asking people to choose between (or rank) packages involving several factors at different levels, and hence to infer valuations of these factors. CA is sometimes known as trade-off analysis or stated choice analysis. It is also sometimes taken to embrace the Transfer Price method. (In the transport sector, terminology is often confused: 'stated preference' is sometimes used as synonymous with 'conjoint analysis', sometimes taken as embracing all stated choice methods – refer Figure 3.2. The following text attempts to use terminology consistent with Figure 3.2, although this is not always achievable particularly in regard to quotations.)

The implicit nature of the valuation from CA experiments gives it a number of advantages over CVM in some situations. The most important advantage is that strategic bias is unlikely to occur. The complicated designs of CA experiments and the trade-offs offered make it very difficult for the respondent to strategically influence the results of a SP experiment. Magat et al. (1988) recognise this pattern in an evaluation of morbidity risk. The study compares a CA approach with a CVM approach. They argue that the *"contingent valuation approach may create incentives for respondents to state values which are somewhat below their true reservation* *prices for the commodities being valued, while the paired comparison approach eliminates these incentives to understate preferences and thus it seems to provide more accurate measures of willingness to pay"* (Magat et al., 1988).

CA techniques should also be less open to learning bias, for similar reasons, i.e. the complexity of the experimental format. If learning should occur, it is likely that this would be a much slower process than with the CVM method, as it is a more difficult system for respondents to master. It is unlikely that starting point bias will occur. A CA experiment is designed with various levels for each attribute (e.g. environmental factors and cost factors). The levels are designed, piloted and tested to ensure that they are within boundary values, i.e. respondents are facing a situation in which they will trade off one attribute against another. Method of payment bias (i.e. if a tax or cash payment is proposed) and information bias (i.e. the method of representation, description and amount of information) are equally likely to apply to CA as to CVM. The impact of the type, representation, and amount of information supplied to a respondent is vital to the validity of both CA and CVM results.

CA techniques, therefore, have all the advantages of the CVM when compared to the indirect valuation techniques. For some issues (particularly in the environmental field, they also have significant advantages over CVM, especially in terms of eliminating bias in response. Support for the use and further research into CA techniques as a method of valuation of the environmental impacts of road schemes, comes from a number of sources:

> *"The evidence to date has led to the conclusion that neither Contingent Valuation or Stated Preference (CA) techniques are without their problems, although clearly both have been proved to be useful in valuation studies. In attempting to make recommendations as to the most appropriate, the critical questions are; what externality is to be examined and in what context is that externality being examined? There is clearly more valuable work that could be undertaken in this area to contribute to knowledge in this field"* (Sheldon, 1997).

> *"Although the review of previous work did not reveal any instances where conjoint analysis techniques have been used to value environmental goods intuitively it would overcome some of the bias problems inherent in CVM"* (JMP, 1996).

> *"The appealing traits of the choice experiment technique (focused response tasks, an emphasis on trade-offs between factors, consistency with the random utility model) suggest that it may offer a valuable alternative to contingent valuation in the measurement of non-use values. For example, individuals could be presented with alternative community level attributes (e.g. air quality) as well as levels of household taxes paid"* (Adamowicz et. al., 1994).

> *"We do however believe that the results of properly conducted surveys into contingent valuations and stated preferences can in the long run be of value to decision-makers"* (SACTRA, 1992).

"In conclusion we feel that enormous advances have been made in hypothetical survey techniques in the past few years and evidence suggest that people are able to value certain environmental costs and benefits in money terms. We feel that such techniques could be used at the scheme specific level to provide meaningful valuations to a number of local effects which people are familiar. Further research is needed but of all the techniques of environmental valuation, SP (CA) techniques offer the greatest unexploited potential" (Nash, 1990).

The use of CA techniques for the valuation of environmental factors is in its infancy. An extensive literature review reveals very little research into the use of CA techniques to place values on environmental impacts. In the main, such experiments have focused on valuing recreational amenity, such as the study by Louviere et al. (1987) and a study by Adamowicz et al. (1994) into the values of the attributes of recreational sites. A couple of studies have been carried out in the UK into the use of CA/SP techniques for the valuation of the environmental impacts of road schemes. One study was commissioned by the Department of Transport, UK, and carried out by JMP (1996), where the study of CA/SP techniques was part of a larger remit to investigate a number of methods for the monetary valuation of traffic nuisance. The other was a PhD thesis undertaken by Nelson (1998) into the "Monetary Valuation Of The Environmental Impacts Of Road Transport : A Stated Preference Approach". Both of these studies found significant difficulties in the application of CA/SP techniques especially in the range of valuations derived.

3.3.7 Indirect valuation techniques

3.3.7.1 *Dose-response*

The Dose-Response technique values an environmental commodity such as air pollution from the relationship between a specific amount of pollution and the observed damage it causes. Dose-Response estimates the value of a commodity as the economic costs at current market prices associated with the damage caused. The Dose-Response method involves two stages. Firstly, to define the general relationship between the physical damage and the level of pollution. Secondly, the specific level of pollution is used to estimate the actual physical damage. Multiplying by the price per unit of damage gives the cost of the total pollution.

An example of a Dose-Response situation is the relationship between vehicle emissions and mortality levels. If a relationship could be derived between these two factors, the increase in the cost of health care due to the increase in vehicle emissions would act as a value for the cost of an increase in traffic. Unfortunately, Pearce & Markandya (1989) note that in the UK there is a major problem of defining a statistical relationship between air pollution and mortality. Therefore, it is often difficult to define a causal link between environmental impact and its associated economic cost factor. Sheldon (1997) reports that a type of Dose-Response technique, via an averting behaviour approach has also measured the utility loss from noise. This approach assesses how much people are prepared to spend to avert the consequences of an externality such as noise, for example by installing double-glazing to reduce noise levels. The method has problems in that double-glazing provides other benefits other than noise reduction, e.g. savings in heating bills. Also double-glazing does not give protection from noise when the windows are open, or when the resident is outside the property.

3.3.7.2 *Shadow pricing*

Shadow pricing is the cost of providing a hypothetical alternative environmental good elsewhere, i.e. the replacement cost. The costs of replacing assets damaged by a product can be measured, and these costs can be interpreted as an estimate of the benefits presumed to flow from measures taken to prevent that damage from occurring. Dixon et al. (1986) refer to this method as a form of green accounting procedure. The method is based on assumptions that the magnitude of the damage is measurable and that the replacement costs are calculable. An example of a situation where a shadow project technique may be used, is where natural assets are threatened and the creation of a substitute can be considered. This might include attempts to recreate an important habitat or to improve a degraded habitat in compensation for a loss elsewhere. Such methods can be defined as the *"cost of rectifying damage or replacing destroyed resources"* (Nash, 1990). The costs of a shadow project would form the cost component of environmental damage in the assessment procedure.

Dose-response and shadow pricing techniques have been applied to a wide range of studies, some examples are as follows:

- Pollution and health studies - Gerking & Stanley (1986) considered individual's 'defensive' expenditures to protect themselves from the impact of air pollution on health;
- Transportation Impacts - Schulze & Schulz (1989) identified the social costs of traffic (including costs of noise, air pollution and use of land for infrastructure) for the West German Federal Office of the Environment;
- Water Studies - Pearce & Markandya (1989) have reported a number of studies, which estimated the monetary impacts on inland waterways of sea defences and sewerage schemes.

Dose-response and shadow pricing methods can offer the only feasible way to value some environmental effects. This is true where individuals are unaware of the full effect of consequences of changes in environmental effects, either because these changes are difficult to perceive or because the implications of the changes are poorly understood. However, there are a number of difficulties with these methods:

- Data requirements to establish the pollution-damage relationship are high; there are difficulties in measuring pollution impacts; and the interdependence of causal variables can result in statistical difficulties.
- Different individuals respond differently to a pollution dose. For example, some will invest in preventative measures, (e.g. investment in double glazing to combat noise pollution) while others will not. These behavioural differences, and the cost of preventative actions, need to be included in the model.
- Investigation of the change in dose levels cannot necessarily be based on present prices of remedial measures as these may alter in the future as the dosage changes. For example, a valuation based on health care costs, may change in the future with the introduction of new drugs, treatment methods, etc. Similarly, account needs to be taken of any price intervention that occurs in the market. For example, allowances made for agricultural crop subsidies need to be made in estimating the cost of crop damage.

3.3.7.3 *Expert opinion*

Another potential method for valuation is to use the opinions of experts to place values on environmental impacts. This method has not been widely used to date, but some examples are available in the literature. A recent study on behalf of the Department of Transport (UK), (JMP, 1996) used district valuers experience to quantify the reductions in domestic property prices due to traffic using new road schemes. This approach is similar to hedonic pricing, except that the relationships between house prices and the environment are derived from the expertise and knowledge of valuers and using actual compensation cases where awards have been made to householders. A similar methodology is to base valuations on court awards, for instance if such an award was made for injury to health due to air pollution. Nash and Bowers (in Turner, 1988) suggest an example of expert opinion as the required compensation for death or injury being based on court awards.

This approach has drawbacks in that:

- it assumes district valuers have sufficient knowledge of factors which affect house prices to provide surrogate market prices as a function of environmental attributes which are systematically varied;
- it assumes that court awards given in compensation accurately reflect the value the person attaches to that environmental change;
- district valuers have difficulty in estimating the impacts of small changes in the environment.

3.3.7.4 *Surrogate market techniques*

Hedonic Pricing and the Travel Cost Method are methods that use surrogate markets to infer values for environmental change. Surrogate market methods use revealed preferences, dealing with observable trade-offs made by individuals and society. Basically this means *"observing and examining peoples' actual behaviour or their revealed preferences for environmental protection or goods"* (Nash, 1990).

3.3.7.5 Hedonic pricing (HP)

The Hedonic Pricing (HP) method uses information revealed by purchasing decisions to estimate the monetary value of environmental goods which do not have market prices. "The most widely used case is that of house prices" (Rendel Planning, 1992), although land values and wage differentials are also used. House prices vary in accordance with environmental attributes. Johansson (1990) describes a simple example as two houses identical in all respects, except one house is affected by air pollution whereas the other house is not. The difference in market price between the two houses should therefore reflect the willingness to pay for better air quality. Multiple regression analysis is used to find the relationship between house prices and environmental attributes. *"Most HP studies have been carried out in the USA but recently studies have been undertaken in Europe"* (Rendel Planning, 1992). Larsen (1985) derived changes in house prices caused by changes in road traffic flow which were used as a surrogate variable for environmental quality, as a 0.8% decrease in house prices per 1000 vehicles per day on the nearest road. The SACTRA report

(1992) states that *"there is a weight of evidence to suggest discernible relationships between house prices and highly localised environmental factors, for example noise and air pollution"*.

There are a number of theoretical and practical difficulties with HP methods as follows:

- explanatory variables are often inter-dependent. This results in problems of multi-collinearity in the regression analysis. Possible resolutions of such problems are by using only a single environmental variable rather than several or by using a single composite variable which combines all explanatory variables;
- there is a problem in defining all the factors affecting property prices, if a relevant factor is excluded, this may lead to bias in the results;
- there is also the problem of the choice of the functional form of the model, the wrong functional form will significantly influence the valuation;
- the measurement of explanatory variables and house prices for the regression analysis necessitates high data requirements;
- distortions in the housing market can result from inefficiencies due to supply problems or public sector rationing, limited information to vendors about highest bids available, mobility restrictions, or averting behaviour by households (e.g. installation of double glazing to combat noise pollution). These distortions can cause errors in estimating the impact of environmental attributes on house prices;
- the relationship between the willingness to pay curve, as exhibited by sale prices, and social cost/benefits, is not clear. Pearce & Markandya (1989) indicate that individuals may undervalue the benefits of reducing pollution because they are not fully aware of the impact on their health.

3.3.7.6 Travel cost method

The Travel Cost Method (TCM) uses market related prices to estimate the demand curve for a non-market good. TCM assumes that each visitor to a country park, for example, values the park to be at least as great as the costs incurred, including transport costs, entrance fees and the value of time. The costs to all visitors can be summed in a valuation of that amenity to the community. TCM is used to estimate consumer surplus from the demand curve, that is the amount of satisfaction gained from consuming a good/service in excess of payment. To forecast this it is necessary to identify not only incurred costs but also other factors including household income, duration and purpose of visit and available of alternative facilities to the household. To derive the demand curve, which relates to the number of trips, income and travel costs, requires high data inputs. It is then possible to estimate the value of altering the facilities, for example, by the construction of a road. *"TCM studies have been widely applied in the USA and Europe"* (Rendel Planning, 1992). In the UK TCM has been used to value the consumer surplus of visitors to forests of £1.34 – £3.31 per visit (Benson & Willis, 1990) and to bird sanctuaries of £1.99 – £3.49 per visit (Harley & Hanley, 1989).

Apart from the large data requirements there are statistical and practical problems to be overcome with TCM:

- the initial task of deriving the demand relationship is to specify a function relating the number of trips made to travel cost and income of visitors. Statistical expertise is required to avoid the mis-specification of parameter estimates and the resultant demand relationship;
- the method has truncation bias. TCM surveys cannot take into account those who do not visit the resource. This significantly affects the estimate of consumer surplus because of its effect on the specification of the demand relationship. The method therefore deals with use value only, and cannot take account of 'option' or 'existence' value;
- important sites are rarely lost outright by conversion to highway schemes, it is unclear how this method could be applied to partial degradation of the environment;
- TCM in practice is restricted exclusively to the valuation of recreational facilities, and its application to other goods is inappropriate.

Kroes and Sheldon (in Button, 1993) state the limitations of surrogate market or revealed preference methods as follows:

3.3.8 Limitations to monetary valuation

Finally, there are a number of ethical and technical issues in economic environmental valuation, which must be considered when applying monetary values to the environment.

3.3.8.1 *Ethical issues*

It is not always feasible or desirable to convert all environmental benefits and costs into money values. As discussed above some environmental factors, such as global warming, do not lend themselves easily to valuation, due to our lack of knowledge of the global ecosystem and the long term impacts upon it. The impacts of global and irreversible changes in environment are potentially too complex to be captured in a single monetary value.

The main ethical limitations to monetary valuation are:

- Conventions on equity and morality are assumed in an economic analysis. Values given to goods are frequently limited to people's ability to pay for them. In consequence some individual's valuations (i.e. those that can afford to pay) count significantly, whereas others hardly count at all;
- Any valuation judgement implies that natural resource attributes are of relative and not absolute importance. However, for some people no amount of money can compensate for damage to environmental resources;
- Whose values should be assessed? All the methods described above use only human values, few valuations include non-preference or intrinsic values;

- Furthermore, the values of the present generation may be significantly different to those of future generations;
- Individual valuations are not necessarily preferences of society as a whole, i.e. valuations rarely include public preference value;
- Monetary valuation is generally part of an assessment undertaken in a cost-benefit framework. Cost benefit analysis focuses on efficiency in a narrow economic way and does not address issues of social equity or other social concerns. Cost benefit analysis includes such difficulties as what discount rate should be applied to environmental factors.

3.3.8.2 *Technical issues*

Despite advances in both science and economics there are a number of unresolved technical problems with monetary valuation:

- Monetary values are normally required on complex and often poorly understood effects. This is a significant issue as valuations are often derived from a lay person's behaviour or preference, when they may have limited knowledge of the environmental factor or the influence of their valuation upon the future environment;
- The comparison of monetary values for different goods is limited by distortions in the market (due to government or other interventions);
- Monetary values provide no more than an estimate for a single point in time. Shifts in social attitudes, improved information, improved techniques and a declining resource base may all lead to changes in valuations.

3.4 Issues in Stated Preference Survey Design and Analysis

3.4.1 The 'packaging' effect

3.4.1.1 *The issue*

Some SP/CA studies attempt to measure the value of investing in improvements to transport infrastructure such as station improvements, the provision of enhanced rolling stock or improved security. These improvements are often put together as a package and SP/CA trade off exercises are used to estimate values for both the package and the individual attributes of that package. When analysing the results of these trade-offs it is common to find that the package is given an appreciably lower value than is obtained by summing the values attributed to the individual components of that package. This problem is known as the 'packaging' effect.

3.4.1.2 *Discussion*

Five kinds of explanation have been offered for this phenomenon:

1) The attributes of the individual components of the package are not independent of one another, so that when they are combined there is some redundancy. For example, improvements in service reliability may reduce the advantages of real time information for passengers, hence the value of the latter decreases as reliability improves. The presence of a member of staff may also reduce the value placed on information provision, security, etc.

2) Travellers value existing services at more than fare, and so are happy to pay a certain amount for any improvement. This implies that the value respondents attach to an attribute is not only a reflection of the value of that attribute, it is also a measure of the consumer surplus that the consumer already enjoys by using the service. Depending on the design, this value may be attached to each attribute and so is counted several times if the attribute values are summed, whereas it only counts once if the whole package is offered.

3) There is a budget constraint such that an individual can not afford to pay for the summed value of all the individual attributes, regardless of how large the improvement in service, although they would be willing and able to pay for a sub-set of them.

4) Differences are due to the 'halo' effect, whereby improving one attribute can appear to increase the value ascribed to other attributes. For example, a newly refurbished station might also be scored more highly on cleanliness and on security – although in fact neither may have changed in objective terms. In that respect, this is different from point 1), where the interaction effects are 'real'.

5) Problems with the design of the SP/CA exercise. These might arise in several areas, particularly where attribute level and package level exercises have been presented in different ways:
   - Attribute values are often lower in between-mode than within-mode exercises.

- The form of presentation of trade off exercises can affect attribute values significantly (e.g. rating versus ranking or pairwise choices): if methods are mixed results may not be strictly comparable.
- The number of attributes and order of presentation can affect the valuations.

While SP/CA exercises are generally carried out without taking into account the cost of various improvements to the operator (other than to the extent that these are reflected in fares and other charges paid by travellers), decision makers invariably choose between alternative investment options by comparing the benefits and costs of each option. To do this there is a requirement to have an accurate valuation of both the scale and size of the benefits associated with the various options. The implication of the package effect is that SP/CA analysis provides a relatively poor estimation of the valuation of individual components of alternative improvements. When comparing summed attribute values against the direct package valuation, differences may often be a factor of 2 or 3 (i.e. individual attribute values drop to one-half or one-third of their original value when combined in packages).

However, if the cause of the package effect is clear-cut, it is possible to formulate ways in which the impact of the package effect can be reduced or removed. For example:

- SP designs can be tailored to pick up both the main and most likely interaction effects. Using this information the values of the single attributes can be summed taking into account the appropriate interaction terms. This is most appropriate when there is 'redundancy' in the package (point 1 above) – though it rarely accounts in full for the differences in attribute v package level valuations.
- The consumer surplus effect can be removed by estimating the fixed reduction in value per attribute that would sum to the package value minus the same fixed reduction. As a cross check, respondents could be asked a simple 'transfer price' form of question about how much more they would be willing to pay for the existing level of service.
- If the packaging effect can be shown to be due to the budget effect, through an analysis of the impact of income on the decision-making process, this implies that there is a maximum willingness-to-pay for improvements in service quality. In a non-commercial environment there is an argument to say that the full value of the package is determined by adding the individual components. In a commercial environment the value of individual components can be scaled to sum to the package or the budget constraint can simply be treated as a cap on investment.

In practice, however, it is often difficult to determine which of the five factors listed above is having the major impact on the results. To counter this approach an alternative method of analysing service level improvements has been proposed that focus on the valuation of the package rather than the individual attributes of that package. This is likely to provide a better guide for investment decisions.

3.4.1.3 *Conclusions and implications for evaluation*

- While standard SP/CA studies provide reasonably reliable ranking of individual attributes they are not, however, likely to provide accurate estimates of the size of the benefits associated with various attributes once we move away from core variables such as travel time and service frequency into the 'softer' investment areas.
- If SP/CA is being used to evaluate the benefits of various improvements it is essential that the SP/CA experiment be thoroughly tested before it is implemented. Problems with the interaction effect, budget constraints and more general SP/CA design problems can all be identified through testing, and appropriate action taken.
- A more effective means of comparing options may be to design an approach that evaluates the packages rather than the individual attributes of that package.

In terms of this latter point, careful consideration needs to be given to the identification and valuation of the 'optimum' investment package. In the study undertaken for London Transport Buses (Steer Davies Gleave 1995), respondents were asked to identify a package of their most preferred service improvements. A stated preference experiment was then constructed to estimate the willingness to pay for this 'perfect service' relative to their existing service. Estimates of willingness to pay were then averaged across all respondents to produce an average valuation for the 'perfect service'. Where valuations for a bundle of attributes were required, it was recommended that individual values be treated additively, subject to the total valuation for the bundle in question being 'capped' by the average value of the 'perfect service'.

3.4.2 'Numeraire' issue

3.4.2.1 *The issue*

In CA surveys involving some kind of trade-off between the items to be valued (e.g. time) and money, it is sometimes found that different valuations are obtained depending on how the monetary variable is expressed. For example, in the recent New Zealand VTTS CA/SP survey, significantly different VTTS results were obtained relative to $1 spent on fuel than for $1 spent on road tolls. This problem is known as the 'numeraire' issue, or the 'payment vehicle' issue.

3.4.2.2 *Discussion*

This issue is important from a policy perspective because it creates uncertainty regarding which of the derived values is most appropriate for evaluation purposes. For example, is the relatively low value of time associated with tolls more appropriate than the value of time associated with fuels, or vice versa? To address this problem, it is necessary to examine why there could be a differential between the value of time associated with fuel costs and the value of time associated with toll costs. That is, is it likely that the dollar cost associated with fuel or toll charges under or over-estimates the true cost of that payment to the consumer.

Payment of additional fuel costs. A consumer would typically have an established payment system for their fuel costs and typically the marginal cost of any additional fuel payments is simply the value of the fuel consumed. This would suggest that if an individual is presented with a CA/SP exercise that involves the payment of an additional $1 of fuel expenditure they will typically only include this cost in their weighting of the fuel expenditure. However, a significant number of individuals do not personally incur the fuel costs associated with their car travel: in these situations the marginal cost to the individual would effectively be zero. Other individuals may not perceive fuel costs as relating to particular trips. Therefore, in aggregate the value of time relative to fuel costs could be expected to be higher than the true value of time.

Payment of a toll cost. The payment of a toll on the other hand typically involves:

- planning to have the appropriate amount of money before the toll routes is chosen;
- slowing down to pay the toll;
- being presented with a relatively complex driving situation to pay the toll;
- the potential for significant congestion around the toll payment booth.

Each of these costs is likely to be estimated by each respondent and factored into the cost of paying the toll, and are therefore likely to result in low value of time estimates if that value of time is simply based on the dollar value of the toll.

There may be a further 'cost' effect, caused by general public resistance to the concept of road tolling. The UK VTTS studies found widespread resistance to the tolling principle, but this was reduced if some clear benefit resulted from the payments (eg construction of a new motorway). Thus, aside from the 'objective' costs associated with toll payment, subjective resistance may be found, depending very much on the tolling circumstances.

3.4.2.3 *Some evidence*

The recent review study by Wardman (1998) of UK VTTS evidence since 1980 examined their findings relating to this issue in some detail. The findings may be summarised as follows:

- It was hypothesised that:
  - Public transport and parking charges could be expected to have similar coefficients: these costs would be 'correctly' perceived in general
  - Petrol costs could be expected to have a lower coefficient (for the reasons given above)
  - Toll charges could be expected to have higher coefficients, certainly than petrol costs and arguably than public transport fares and parking charges
  - The toll charge coefficient would be expected to be highest for tolls introduced to currently untolled roads, would be lower for tolled new roads, and least for roads currently tolled.

- The appraisal of various UK studies largely supported these hypotheses:
  - Toll coefficients were in all cases higher than fare coefficients, which were in turn higher than fuel coefficients. Parking coefficients were also greater than fuel coefficients.
  - Toll coefficients were in all cases higher than fuel coefficients, or combined fuel/parking coefficients. For existing tolled facilities, the toll coefficient was 15-40% higher than the car cost coefficient; for a toll levied on a new route the toll coefficient was 23% higher than the fuel coefficient; while for a toll introduced on an existing un-tolled route, the toll coefficient was 240% higher than the fuel coefficient.

The recent New Zealand VTTS SP survey found that:

- For local trips, the toll coefficients appear to be lower (by in the order of 30%) than the 'running cost' coefficients.
- For medium/long distance trips, the toll coefficients appear to be higher (by up to 60%) than the 'running cost' coefficients.

This latter result is largely consistent with the UK evidence; while the former result is unexpected and the reason for it unclear.

3.4.2.4 *Conclusions and implications*

The 'numeraire' issue is clearly of major importance in the design and interpretation of SP surveys. The payment mechanism hypothesised will affect the valuation of the parameters of interest – in part because the costs perceived by respondents may be greater or less than the nominal $ cost; in part because of respondent bias for or against particular charging mechanisms.

In practice, parking charges (car travel) and fares (public transport travel) may be regarded as the most 'neutral' payment mechanisms, for which the perception best accords with the nominal $ cost and there is least bias. Fuel charges are likely to be under-perceived in practice, and hence have a lower coefficient (resulting in high values of time, etc); while toll charges are likely to be over-perceived in practice. As tolling becomes more common-place, more accepted and more electronic, this over-perception might be expected to reduce.

For SP survey design, it is therefore recommended that:

- Parking charges and/or fares be used as the primary payment vehicle where this is feasible and sensible.
- Where fuel costs are used, there should be particular emphasis on ensuring respondents understand that these will be real costs that they have to meet.
- Where toll charges are used, their circumstances need to be clearly defined and they should be portrayed as being as painless as possible.
- More than one payment vehicle should be tested where feasible.
- In such cases, where the analysis indicates significantly different values (of time, etc) relative to different payment vehicles, it is suggested that a

parameter-weighted estimate be adopted as the 'best' value, which is equivalent to simply combining the two cost dimensions.

3.4.3 Valuation of motorist risk through SP/CA surveys

3.4.3.1 *The issue*

The issue is a follows:

- Motorists perceptions of risk, etc in adverse driving environments probably include two components: the unpleasantness of driving; and the chance of having an accident.
- The latter component is conventionally reflected in the actual costs of accidents (however valued).
- Hence there will be an element of double-counting if conventional accident costs and motorists' perceptions are simply added together.
- The problem is therefore to design a survey which can separate out the 'unpleasantness' component from the 'accident' component.

3.4.3.2 Discussion

The issue is analogous to that in estimating the opportunity cost of time and the marginal disutility of travel in the value of business time. CA methods are very appropriate, in principle, in distinguishing between the two dimensions of 'unpleasantness' and 'accidents'. The CA experimental design would ask respondents to consider alternative routes which are postulated to have defined (identical or different) accident risks and defined pleasantness of driving. In a route choice context this is an attractive approach and very amenable to WTP techniques.

In practice, a number of difficulties are anticipated and much will depend on the details of survey design. The major difficulty will be to design the survey in such a way that respondents really separate the unpleasantness effect from the (objective) accident risk – even when respondents are presented with a 'pleasant' and an 'unpleasant' route with the same accident risk, they are liable to assume that the unpleasant route carries greater risks. (This is an example of the 'halo' effect – refer Section 3.4.1).

We are not aware of any international literature that has addressed this issue. We suggest a cautious approach will be necessary in survey design, including focus groups and piloting different possible questionnaire designs.

3.4.4 Willingness-to-pay and willingness-to-accept: implications for evaluation

There appears to be acceptance in the literature that there is a difference between a person's willingness to pay (WTP) and their willingness to accept (WTA) for a good or service. The differential is particularly marked in instances where there is poor substitutability and a limited market for a good or service, as is the case when valuing the impact of changes in transport safety. Such a marked differential has been found in the NZ 'value of safety' studies (Section 2.4.4.1): refer also discussion in Section 3.3.6.2.

From a policy perspective, the issue is which of the estimated values should be used in analysing alternative investment options. This issue becomes very important in instances where some people are made better off by a decision and some people are made worse off. Should the costs associated with the people who are being made worse off be priced in terms of their willingness to accept or using the more traditional willingness to pay?

Prima facie, WTP is the appropriate measure where improvements in the base situation for the factor under consideration are being contemplated (eg. time savings, accident reductions); but WTA is more appropriate where deteriorations are contemplated (eg. increased accident risk, with or without time savings). The issue is perhaps most important in the case of safety measures:

- The evidence indicates that the difference between WTP and WTA value is greater in this area (see above): values of time do not appear to differ markedly.
- Some road improvement schemes may well increase accident risks, although providing other benefits.
- Some regulatory measures or changes thereto may also increase accident risks.

The WTP measure has a number of weaknesses but of these weaknesses the WTA estimates only strongly addresses the budget constraint problem. Moreover, the differential between WTP and WTA has been shown to exist in the absence of a budget constraint (Hartman, Doane & Woo, 1991).

One argument that has been put forward for the differential between WTP and WTA values is that it is due to the WTA estimates including some element of risk. The acceptance of money (WTA) requires that an individual gives up a defined level of utility in return for a cash payment. The individual then has to bear the risk that they will be able to spend that money and receive an equivalent level of utility to that which they have given up. In cases where there is a poorly developed market for a good or service, or limited substitutability, the risk that this will be the case is quite high and one would expect the individual to price accordingly. The payment for a good or service (WTP) on the other hand, provides certainty to the individual that they will receive the additional utility associated with the good or service that they have purchased. Typically this risk component would be excluded from a cost benefit analysis calculation.

3.4.5 Other survey design and analysis issues

The following provides a brief discussion of additional issues relating to the application of SP techniques in the transport and environmental sector. It is drawn primarily from Fowkes (1991), Pearce and Markandya (1989) and Mitchell and Cameron (1989).

3.4.5.1 *Transfer price studies*

Several of the earlier CV studies reviewed in the literature on non-market valuation have employed what is commonly referred to as the 'bidding game' technique. This attempts to establish precise values at which individuals will reveal their WTP for an environmental gain (or WTA an environmental loss). The process has also been referred to as 'transfer pricing' in the literature on travel choice, the point of indifference at which a change in decision occurs.

Problems found in the use of the transfer pricing technique in hypothetical market studies are firstly that the artificiality of the situation is emphasised, and that the subsequent bidding responses may be led by the response to the starting bid. There is also a good chance that respondents will either refuse to participate to will treat the process as 'a game' divorced from reality. The technique can only be practically applied to situations where there is a trade-off between one clear non-market attribute and the measure of monetary value.

Transfer pricing was used extensively in earlier studies, but less so in more recent work.

3.4.5.2 Dichotomous and multiple choice questionnaire

CVM now commonly employs either a dichotomous (binary) questionnaire or multiple choice survey framework using discrete levels of attributes rather than continuous variables.

The method is to present the subject with a series of discrete choices between either two options at a time, asking for an indication of preference, or ranking or rating a number of options. Data analysis generally uses the multinomial logit model, although other possibilities such as multinomial probit model and multinomial logit derivatives, such as sequentially structured or nested logit models are also available. The technique has a number of advantages:

- It has the ability to incorporate several attributes in various combinations.
- It can deal with qualitative, original and continuous attributes in the same framework.
- It minimises 'leading questions' in the presentation of the survey.
- Compared with HPM, it is easier to control for attributes not required in the survey.
- It is consistent with the micro-economic theory of consumer choice.
- It is relatively straightforward in the statistical methods employed.

3.4.5.3 Choice of attributes

In deciding what attributes are to be included in a CVM survey, one important consideration is that these should not be highly correlated and, if possible, there should be no correlation at all (the attributes then being said to be 'orthogonal'). The higher the degree of correlation between attributes, the more difficult it will be to separate their values in the analysis. For example, it would be futile to include both the noise exposure and the distance of the dwelling from the roadway as explanatory variables as the two are so highly correlated.

The number of attributes which can practically be incorporated into a structured choice survey is limited. The fewer the attributes, the fewer questions have to be asked and the easier it is for interviewees to make the choices. One attribute has to be the monetary value or 'payment vehicle'. It becomes difficult for respondents to deal with any more than five variables simultaneously and, for a new field of enquiry, two to three variables are preferred.

3.4.5.4 *Boundary values*

Another consideration in experimental design is the 'boundary values' at which the survey subjects become indifferent to the choice between two options. In order to design the survey, it is necessary to have some foreknowledge of where these boundary values are likely to lie. Without such knowledge there is a good chance that inappropriate levels of attributes will be chosen and that the experiment will not adequately straddle the various points of indifference between the attributes.

For surveys in which more than two attributes are involved, it is advantageous that, for any given pairwise choice, no more than two attributes are allowed to differ. This ensures that the boundary values anticipated by foreknowledge from prior studies or pilot surveys are designed into the survey and are not some unknown function of a third variable. It also allows irrational responses to be more readily identified.

3.4.5.5 *Dealing with irrational responses*

It is important to be able to identify irrational responses so that these can be excluded from the analysis where it is appropriate to do so. These will include respondents who have 'taken a position' on a particular environmental attribute and claim that no amount would cause then to compromise a standard or their position. There are also those who have misunderstood the questions; and those who are deliberately trying to bias the results. Fowkes (1991) suggested that for the first group of irrational respondents, even though they may value the attribute very highly, in practice they will not be able to afford to pay the indicated high amount and so are effectively refusing either of the alternatives offered. However, Fowkes also emphasised the importance that the number of such refusals be identified, as this may indicate a demand for some form of performance criterion for the environmental quality.

We conclude that exclusion of 'irrational' data from CVM surveys is a source of some debate and must be handled with care.

3.4.6 Survey Bias Issues

Problems and practical considerations in applying SP (CVM and CA) methods have been recognised for many years. The literature discusses the various biases that can infiltrate the design and execution of such a survey, and other problems stemming from the 'unreality' of the choice contexts offered to those participating. These are summarised in the following paragraphs.

3.4.6.1 *Respondent bias*

There are various ways in which interviewees may consciously or unconsciously introduce bias into their responses to CVM questions. These may originate from:

- a desire to influence the result of the survey by giving an answer designed to achieve a certain outcome (strategic bias);

- genuine misunderstanding of the question, or difficulty in relating the question to their everyday experience, or a lack of incentive to fully consider the values before responding (hypothetical bias); or
- a disagreement in principle with the concept of monetary valuation or the survey method (refusal and zero bid response).

These types of bias are now each discussed.

3.4.6.2 *Strategic bias*

Brookshire et al. (1976) argued that individuals have strong incentives to strategically bias the answers to questions designed to reveal their preferences for public goods. Pearce and Markandya (1989) discuss methods for testing for strategic bias and noted that laboratory experiments and CVM studies showed little or no evidence of strategic bias. SACTRA (1992) noted that *"respondents may state sums of money which are much greater than those which would in truth satisfy them in the knowledge that no real charge is being threatened and their answers may influence policy in a desired direction."*

Intuitively, certain lines of questioning seem more likely to induce a strategic response, for example questions which equate WTP with some form of levy or tax imposition, as opposed to questions which imply a more voluntary form of payment. Strategic bias can also be in the form of the respondent wanting to be a 'good respondent' and therefore biasing their response to achieve this objective.

'Learning' bias can also affect strategic bias in that the simpler nature of the CVM bidding games make then relatively more simple to learn. This learning process can allow strategic bidding and can therefore affect the final bid.

3.4.6.3 *Hypothetical bias*

This is a fundamental concern in CVM and is most pointedly described by the maxim *"ask a [hypothetical] silly question and you get a [hypothetical] silly answer"*. Interviewees may find the hypothetical situation particularly hard to grasp. It is therefore important that any choice context put to survey respondents be one with which they are familiar and with which they can identify.

Thayer (1981) put forward the idea of using a site substitution analysis to counter the effect of hypothetical bias. For example, apart from asking the respondents to value the particular environmental attribute, other questions could be asked which would indicate alternative plans that would satisfy their demand for an environmental goal. The response to these alternative plans (such as travel, recreation, etc) could then be valued from market price data and used to check the validity of their bidding game response.

Pearce and Markandya (1989) describe other forms of back-to-back study where CVM and actual payments are compared, or where the choice context is varied between WTP and WTA. In each case, some evidence of hypothetical bias was detected which, in the second case, reduced as the respondents became more familiar with the actual experience involved.

In the case of traffic noise, respondents may have few ideas about the means and costs of reducing noise, may not be fully aware of the real damage they have to suffer, and hence be largely ignorant of what suitable compensation would be. Offering levels of noise exposure in decibels will have little or no meaning to most householders, whereas a qualitative description of the traffic conditions may be more readily associated with the proximity disturbance from noise and other effects.

There have been efforts to engender realism to surveys of personal response to environmental effects of traffic by attempting to physically simulate the environmental changes in a controlled laboratory setting. Use of sketches and photographs to convey information is another option. Baughan and Savil (1994) describe examples of these approaches. In the current context, use of videos to illustrate different road/traffic conditions may be helpful.

This will be one of the most important, practical issues in the design of surveys to elicit realistic responses on 'level of service' and related aspects of travel.

3.4.6.4 *Refusals, excessive and zero bids*

A recognised problem in CVM is how to deal with respondents who choose zero when asked a WTP question, or who refuse to participate or give an extreme response. Zero bids may be genuine or near-zero values, or may be indicative of a lack of understanding of the question.

Zero bids may also be protest bids, in the same category as refusal to participate, either because of an aversion to placing a money value on environmental quality, or a reluctance to reveal any willingness to pay for what they deem a natural 'right' (a form of respondent bias). For example, in the Third London Airport Study, 47% of respondents stated they were not prepared to pay anything to reduce noise and, in a study of the social cost of noise around Paris-Orly Airport, 77% of respondents stated they would not accept any compensation for noise (Alexandre, et al. 1980).

3.4.6.5 *Information bias*

Information bias implies that the nature of the questions and framework within which answers are elicited will influence the responses received. The questions themselves convey information which may be new to the respondent or at variance with his or her past experience. Where a payment card approach is used, the range of answers and form of scaling immediately imposes a frame of value in the mind of the respondent. Johansson (1990) cites evidence to suggest that if further information is given to a respondent, to say that their bid is not sufficient (e.g. to keep vehicle emissions at present levels), many may revise their bid in the light of this new information.

One method suggested by Thayer (1981) to test for this information bias was to supply two sub-groups of the sample with information that was different but intended to elicit the same response. By testing for significance of the difference between the groups, the effect of information bias was able to be gauged. Thayer came to the conclusion that information bias was not a significant determinant of bid behaviour.

Information bias can also occur in the form of scenario mis-specification, where the respondent does not interpret the scenario as the researcher intended. Baughan and Savill (1994) describe one of the major problems in CVM to be the description of not only the physical conditions but also their consequences, for example the volume and traffic and its associated nuisance level.

3.4.6.6 *Starting point bias*

This is a particular type of information bias: responses are influenced by the starting point adopted for the bidding game. A reason for starting point bias is given by Boyle et al. (1985): "We feel the general cause of starting point bias is that the initial bid suggests a reasonable final bid to respondents. This occurs because people are being asked to value items, which they are not used to valuing and they are not familiar with the technique of valuation. Thus the respondent may interpret the initial bid as market information."

This form of bias was later widened in description to 'anchoring bias' and range bias' to describe the wider range of sensitivity of response to the range of choices offered, their scaling and range limits.

It is suggested that the significance of any starting point bias could be tested, and the bias potentially be overcome, by varying the starting point for different individuals drawn from a homogenous group of respondents, and comparing the final bids.

3.4.6.7 *Method of payment bias*

The payment method (or vehicle) used may affect the final bid, or the trade-off between non-monetary factors and the monetary variable. This was discussed earlier (section 3.4.2).

3.4.6.8 *Aggregation bias*

Aggregation bias arises where a combined CVM study of several non-market goods shows a different, normally lower, valuation than the combined WTP from studies of each good individually. It suggests that single issue surveys may not adequately take account of the survey respondents' income constraints, which is another manifestation of stated WTP differing from actual behaviour. A way of minimising aggregation bias is to survey WTP for the combined environmental states and then to explore how the component environmental attributes contribute to the broader valuation. This form of bias was discussed earlier, as the 'packaging effect' (section 3.4.1).

3.5 Review of Recent New Zealand Stated Preference Practice – Transmission Gully

3.5.1 Introduction

What is believed to be the most extensive and most elaborate survey in New Zealand of road user willingness to pay (WTP) for road improvements was recently undertaken in relation to the proposed Transmission Gully road in the Wellington region. This used SP methods to establish the WTP of Wellington region residents for funding of the proposed new route through a combination of user tolls, fuel tax and rate levies. The survey involved extensive questionnaires administered through face-to-face (in home) and through telephone methods.

This survey could potentially provide a model for future surveys of road user WTP for road improvements in New Zealand. Given this and given the focus of this project to develop appropriate market research approaches, it was considered important to undertake a careful appraisal of the TG survey, in order particularly to examine:

- the success of the approach in evaluating user valuations (WTP) for improved road facilities;
- the lessons learned that could be applied in developing the future research programme for assessing PEM benefit parameter valuations.

Our appraisal was not explicitly concerned with assessing the economic (or other) merits of the TG proposal, but rather with the market research methodology used. The following appraisal is based on two principal documents:

- Transmission Gully Community Survey: Report on Household Survey of Regional Residents (McDermott Miller Ltd, May 1999).
- Transmission Gully Community Survey: Stage II – Face to face and Household Telephone Willingness-to-Pay Surveys (McDermott Miller, November 1999).

While these two documents were prepared by McDermott Miller Ltd, many of the inputs to them were provided by the joint clients for the survey (Wellington Regional Council and Transit New Zealand).

In addition, a number of other relevant documents have been examined and are referred to in the following appraisal, including:

- 'Private Sector Funding for Transmission Gully'. Final report by Steer Davies Gleave for Transit NZ, December 1992.
- 'Western Corridor Implementation Plan : Report of the Technical Group'. Wellington Regional Council, April 2000.
- Comments by McDermott Miller (18 January 2000) on an earlier draft of this appraisal.

3.5.2 The Transmission gully (TG) scheme

The TG proposal would involve construction of an inland route (27 km) to bypass the current (coastal) SH1 route north of Wellington, between south of Linden and the McKay's Crossing area. The existing route is very congested at times and is the sole route northwards out of Wellington suitable for heavy traffic. However, the TG proposal is relatively costly ($245 million) because of the hilly terrain. As a result, it is unlikely to be built for at least 15 years under current Transfund evaluation and funding criteria. Meanwhile, improvements to the existing route are envisaged.

The TG proposal is controversial and debate on it has received extensive publicity in the Wellington region over a number of years. Various lobby groups have been formed to campaign in favour of the scheme and it has been given support by most local politicians.

The Stage I report notes the extensive media coverage of the issue during the Stage I information dissemination/interview period. This coverage involved a number of newspaper articles explaining the survey process and the options to be canvassed. It also included newspaper articles expressing a range of views about the scheme, but most of which supported the early construction of the TG scheme. A commonly-held view appeared to be that the scheme should be built as soon as practicable, and that in this case most of the works proposed to upgrade the existing route (which are themselves quite costly) would no longer be necessary. Funding for early construction is envisaged as being through some combination of: Transfund NZ funding (involving varying or making an exception to current evaluation/funding criteria), user tolls, local fuel tax and rate levies.

3.5.3 Survey outline

The Transmission Gully Community Survey was designed to gauge:

- *"support for the early construction of Transmission Gully;*
- *support for the form of regional tax the community would most prefer to pay for Transmission Gully's early construction;*
- *overall support for early construction of Transmission Gully paid for by the Wellington regional community; and,*
- *likely use of Transmission Gully as a free or toll road"* (McDermott Miller, May 1999)

The surveys were undertaken by McDermott Miller Ltd on behalf of Wellington Regional Council and Transit New Zealand. The survey designs, survey methods and results were audited by Dr Jenny Neale (Victoria University) and David Ashley (Sinclair Knight Merz).

The surveys were undertaken in two stages. Stage 1 explored general willingness to pay for bringing forward timing of the construction of the Transmission Gully scheme, through some combination of additional rates, a local petrol tax and a toll for use. In addition, it established market profiles of existing SH1 travellers and their current usage patterns of the route: these were designed to provide a better understanding of the travel market and its likely response to the TG scheme, and to enable the subsequent surveys to be better targeted.

In the light of the general willingness-to-pay established in Stage 1, Stage 2 involved two additional surveys:

- Face-to-face survey, to determine willingness-to-pay tolls for use of the TG route, against a range of specified time savings.
- Telephone survey, to determine willingness-to-pay petrol levies and/or regional taxes (in addition to realistic toll charges) to fund the early construction of the TG route.

The following were the main tasks involved in the two stages:
Stage I:

- Community information programme
- Design of survey questionnaire
- Pilot of household telephone survey and finalisation of questionnaire
- Full telephone survey of 1500 regional households
- Survey analysis and reporting.

Stage II:

- Further analysis of Stage I survey results
- Face-to-face SP survey, to determine level of demand for use of TG under different toll rates
- Calculation of traffic volumes and optimal tolls
- Household telephone survey, to refine previous estimates of WTP for regional rate increases and/or petrol taxes (in addition to tolls)
- Derivation of total revenue from rates/petrol taxes/tolls to determine total WTP of regional households.

Table 3.1 (following) summarises the most relevant features of the Information Pack developed initially and sent to a selection of households throughout the region; and of the three subsequent surveys involving sub-samples of these households.

3.5.4 Commentary and appraisal

The right-hand column of Table 3.1 provides comments and appraisal on key aspects of the Information Pack and the three surveys. The following paragraphs draw together the more controversial aspects and potential weaknesses in the information provided and the survey methodology/questions.

(1) Information Pack – Option Description: Time Savings

Travel time savings are quoted three typical trip movements for Solution 1 and Solution 2 (as defined in the table) for year 2005 relative to [we assume] a 'Do Nothing' case. For trips between Paraparaumu and Wgn CBD, these time savings for Solution 2 (early TG construction) are quoted as "on average, up to" 23 mins AM peak, 29 mins PM peak in year 2005. It is unclear to us how the phrase "on average, up to" is to be interpreted: does it mean on average, at maximum (normal weekday), or what? Since these savings are so crucial to the argument for early construction, this is an important point, which in our view should have been clarified in the Information Pack and throughout the surveys.

[We also note here, that since the TG surveys were completed, WRC has undertaken further traffic analyses and published its Western Corridor Implementation Plan. This states that *"time savings of about 10 to 13 minutes occur in the 2016 morning peak":* as in the Information Pack, these times relate to the implementation of the TG scheme relative to the Do Nothing (or Do Minimum) case. While the Western Corridor Plan does not give time savings for 2005, it is clear they would be significantly less than the 2016 figures quoted in the Information Pack. There is thus a substantial discrepancy between the two sources. This is not a criticism of the TG survey work; but it does suggest that if the survey was to be repeated now, the claimed time savings would be significantly lower, with potential effects on respondent willingness-to-pay.]

(2) Survey Respondent Knowledge and Information Provided.
We note some considerable uncertainty about respondents' degree of knowledge of the TG project in the Stage 1 survey. One interpretation of the questionnaire responses (which is given in the Stage 2 report) is that 68% of respondents knew "a little" or "nothing" about the TG project. Another interpretation is that 72% (ie. 84% of 86%) felt that they "fully understood the issues surrounding TG", and the remainder were provided with additional information. It is unclear where the truth lies between these two extremes: there must be double about the level of knowledge of many respondents.

The Stage II face-to-face survey respondents had all participated in the Stage I survey, and were therefore presumed to be knowledgeable: limited further information was provided.

In the Stage II telephone survey (for which most respondents were new), 44% said they knew a little or nothing about the TG route (they were not asked if they knew about the two options). All respondents were given a brief summary of the options, but with an emphasis on the 'early TG' solution. In terms of travel time, they were told only that "by 2005 TG will save motorists up to 29 minutes travel time during weekday rush hours". This saving is in comparison with the 'Do Nothing' case (as in the Information Pack), although this is not made clear. Arguably the more relevant comparison in this case would be with the upgraded existing route option, relative to which the estimated time saving (as per the Information Pack) is only 9 – 10 minutes: this is the appropriate 'base case' relative to which respondents' willingness-to-pay for early construction of TG should have been assessed. In our view there is a lack of clarity, and potentially misleading information, on this significant aspect.

(3) Willingness-to-pay to Use Transmission Gully
The Stage II face-to-face survey questions about choice of route under different time saving and toll levels allow estimation of respondent values of travel time savings. These values are of the expected order, with a range by trip purpose from around $6/hour (shopping) to $12/hour (business):

- They are generally somewhat lower than the values found in the 1991/92 survey of SH1 users (Steer Davies Gleave).

TABLE 3.1 : TRANSMISSION GULLY COMMUNITY SURVEYS - KEY FEATURES AND COMMENTS

KEY FEATURES	COMMENTS
INFORMATION PACK (MARCH '99) Issued to 5500 households in Wgn region. *Describes two 'solutions': 1: SH1 improvements and TG 'sometime in the future' • SH1 capacity and safety improvements 2000-04 • TG open by 2014 at earliest	
• In 2005, time savings Paraparaumu-Wellington CBD "on average up to" weekday AM peak 13 mins, PM peak 20 mins, Sat midday 45 mins, Sun midday 40 mins.	• Unclear how "on average up to" is to be interpreted: are these average daily savings in 2005, or maximum 2005 savings on a 'normal' day, or what?
2. TG route by 2005 • TG open by 2005 at earliest • SH1 safety improvements 2000-2002	• Noted in text that "under the current designation the earliest date TG could be completed is 2010", but that construction could possible be brought forward.
• In 2005 (assuming TG open), time savings Para-WGN CBD" on average up to" weekday AM peak 23 mins, PM peak 29 mins, Sat midday 50 mins, Sun midday 45 mins.	• "Use of "on average up to" – see above. • This implies time savings for Solution 2 over Solution 1 (2005) of 9-10 mins peaks, 5 mins weekends.
*Describes costs and funding for each solution: - TG toll : $4 peak, $2 off -peak - Solution 2: regional rates $100pa/household or regional petrol tax 5c/litre.	• Stated that regional rate/petrol tax levies would apply from start of TG construction, but not stated how many years they would apply for.
STAGE I HOUSEHOLD TELEPHONE SURVEY *Survey methodology • Computer-aided telephone interviews • Stratified random sample of all households in the Wgn region (excluding Wairarapa): these households had been sent Information Pack. • Random selection of individuals age 18+ in selected households. • Completed sample 1559 people (57% response rate) – 510 Kapiti, 1049 remainder of region. • Interviews March/April 1999.	
*Background information provided: • Most respondents had read the Information Pack and said that they did not require further information. • For others, the further information given was similar to Information Pack 'solutions' 1 and 2 (above). Weekday peak period time savings were given (2005) – up to 20 mins for solution 1, up to 29 mins for solution 2.	• Some doubt on the level of knowledge of respondents about the TG scheme and issues. 86% of respondents said they had read the information pack (Q2), and 84% of these said they did not want (and were not given) further information (Q32). Yet 68% of respondents said they knew 'a little' or 'nothing' about the TG project (Q3). • Time savings appear to be interpreted as maximums, but unclear (see above).
***Key questions:** • WTP extra $2/week (or $1/week) in regional rates to fund early TG construction by 2005 (as well as toll). • WTP extra 5c/litre (2.5c/litre) in petrol tax to fund early TG construction by 2005 (as well as toll). • Preferred method of raising funds – regional rates, petrol tax, mixture, other. • Likely level of use of TG without toll and with toll ($4 peak/ $2 off-peak).	• No statement of what year these levies would start (although this is mentioned in the Information Pack), or how long they would apply for (see above).

KEY FEATURES	COMMENTS
STAGE II FACE-TO-FACE SURVEY	
***Survey methodology:** • Face-to-face computer aided interviews • Random sample from Stage I respondents who indicated willingness to participate, stratified by user segments/geographic locations. • Completed sample 251. • Interviews September 1999. ***Background information provided**: - interviewers had available copies of the Information Pack (to remind respondents) and route maps (all respondents had participated in Stage I survey) ***Key questions:** • Likelihood of using TG (rather than SH1 with safety upgrades) at toll of $0/2/4/6/8 at time saving of 0/15/30/45 mins by trip purpose. ***Key findings:**	
• For zero time savings (all trip purposes), approx 80% of trips would use TG at zero toll, 46% at $2 toll, 28% at $4 toll, approx 14% at $8 toll.	• Perhaps somewhat surprising result, especially 14% at $8 toll for zero time savings. Report notes that respondents were apparently prepared to pay substantial amounts for the increased safety, greater reliability and reduced congestion of the TG route (refer comments in text).
• For 50% use of TG, toll is c$1.90 at zero time savings, c$4.10 at 15 mins saving, c$6.20 at 30 mins saving, c$8.50 at 45 mins savings.	• Indicates median value of time savings of about $9/hour (all purposes); values by purpose in range approx $6/hour (shopping) to $12/hour (business). These are generally plausible results (refer comments in text).
STAGE II HOUSEHOLD TELEPHONE SURVEY	
***Survey methodology:** • Computer aided telephone interviews • Stratified random sample as per Stage I survey; households had previously been sent Information Pack. • Completed sample 762 people (57% response rate). • Interviews November 1999. ***Background information provided:**	
• All respondents had been sent the Information Pack. 56% said they knew a lot, 37% knew a little and 7% knew nothing about the TG route.	• Refer Stage I Survey (above): results indicate apparent significant increase in knowledge from Stage I. (However the Stage II and Stage I questions differ: the Stage I question asked about knowledge of TG issues, the Stage II questions about knowledge of the TG route.)
• All respondents were given a short summary of the Information Pack 'solutions' (see above). Benefits of TG were quoted as "up to 29 minutes travel time savings during weekday rush hours", greater safety, reassurance of an alternative route. ***Key Questions**	• This is potentially misleading, as it compares with the 'Do Nothing' situation, not the alternative Solution 1. The Information Pack figures are for peak (2005) savings of Solution 2 over Solution 1 of 9-10 mins (refer above).
• WTP extra rates of $40/$80pa (Wgn city) or $135/$240 pa (Porirua) per household to pay for early construction of TG. • WTP extra 5.2c/litre regional petrol tax for early construction of TG. • WTP extra rates of $25/$10 pa(Wgn city) or $147/$58 pa (Porirua) together with 2c/4c per litre petrol tax for early construction of TG. ***Key Findings** • Relatively even split between Yes/No for WTP higher rate increases, for high petrol tax increases and for equivalent combinations. • Preferred method of raising funds was combination (rates/petrol tax): also nearly even split between rates alone or petrol tax alone. • Majority in favour of raising money from Wgn region residents to pay for early TG construction (56% Yes, 12% qualified Yes).	• No statement of what year these levies would start, or how many years they would apply for (see above).

- The non-work values are broadly similar to the PEM values (per driver). However, it is somewhat unclear whether the survey values include passenger valuations (where appropriate): unfortunately the survey did not clarify whether or not passengers were being carried in the hypothetical trip.
- The work values appear significantly lower than the corresponding PEM values.

The perhaps more surprising results are the apparent substantial WTP to use the TG route when it provides no time savings. The survey results indicate that around 50% of motorists would be willing to pay a $2 toll in this case, while about 14% would pay $8 or more. Our prior expectations, based on other evidence, were for a more modest WTP for zero time savings:

- The SDG (1992) report notes that with zero time savings, with no toll the traffic would split approximately 50:50 between the two routes.
- The most recent major UK study into the valuation of travel time savings concluded that: "Although an initial analysis indicated large difference in VOTs between road types (motorways, trunk roads, urban roads), these differences disappeared for the most part after variables capturing congestion, journey distance and other factors had been added " (Hague Consulting Group, 1996).

It seems possible that respondents' answers on this issue may be influenced because they are (sub-consciously at least) envisaging the existing route as now, with high traffic volumes and significant congestion; whereas with TG built even a modest transfer of traffic to the new route would improve conditions on the existing route. This is an issue that would have warranted close examination.

(4) Duration of Rate Levies and Petrol Taxes

The Information Pack states that any rate/petrol tax levies would apply from the start of TG construction. This statement is not prominent and is never repeated or referred to subsequently.

It appears that none of the documentation/surveys mentions for how many years the rate/petrol tax levies will apply. This appears to be a significant omission. In the absence of such a statement, it is unclear what respondents might have assumed and therefore how to interpret or adjust their results. One reasonable assumption by respondents would be that the levies would continue indefinitely; another would be that they would continue only until TG would have been built in any event (ie. about 10 years). This lack of clarity makes analysis/interpretation of the results uncertain.

There is a further issue of how the responses might be affected by the way the rates (or petrol) levies are expressed. If respondents had been told that their rates levy would be "$240 pa, or $7,200 over 30 years" they may well have responded very differently to being told it would be "$240 pa, or about $4.60 per week".

3.5.5 Conclusions

As noted at the start of this section, the Transmission Gully Community Survey has been the most extensive and elaborate survey in New Zealand of WTP for road improvements and their funding. It has, prima facie, been successful in achieving all its objectives. The research strategy and survey methodology appear generally sound.

An appropriate balance appears to have been struck between the complexity of a single survey and the separation into several complementary surveys. The Stage I survey strategy to segment the potential market and to investigate travel patterns by market segment provided a good basis for the subsequent Stage II surveys and their analysis and expansion.

However, with the luxury of hindsight, our appraisal has identified a number of aspects of concern. These relate almost entirely to aspects of the information input to the questionnaires rather than to issues of survey design and analysis. They do not invalidate the survey strategy and methodology adopted, but do cast doubt on the validity of the detailed results.

In terms of the survey methods and inputs, our main concerns are in the following areas:

- Content of Information Pack:
  - Lack of clarity re interpretation of stated time savings (interpretation of "on average, up to")
  - Also note that more recent WRC estimates (since the surveys were completed) indicate substantially lower time savings than given in the Information Pack (this is clearly not a criticism of the survey itself)
- Respondent knowledge of options and supplementary information
  - There is doubt about the level of knowledge of Stage I respondents about the TG scheme and issues.
  - Limited further information was provided to Stage II respondents. The information given in the Stage II telephone survey (re travel time savings) was potentially misleading.
- Lack of clarity re duration of rate/petrol tax levies. This problem was present in both the Stage I and Stage II surveys (and the Information Pack): it is potentially significant in terms of interpretation of the results.

Given these survey design and input problems, the validity of the survey results may be open to question in respect of:

- The estimates of motorist route choice (and hence toll revenue) in response to specified tolls and time savings appear to be of broadly the order of magnitude expected based on other (NZ and international) evidence. However, the apparently high value of WTP to use TG with zero time savings (eg. 14% of motorist would pay at least $8) is perhaps surprising and may indicate some mis-perceptions by respondents: it would warrant further examination.
- The stated WTP by regional residents through rates and fuel taxes is open to question, given in particular:
  - the problem with interpretation of the stated time savings (and their stated magnitude)
  - the lack of clarity about the duration of rate/petrol tax levies.

In terms of **lessons to assist in future market** research, the TG surveys reinforce the point that such complex surveys are very difficult to do with complete success: not only does the research strategy need to be sound, but the survey design and inputs need to be 'right' in all significant points:

- There is considerable chance of (unintended) information bias.
- There may be a need to go to great lengths to ensure (and check) adequate and consistent respondent understanding of key relevant issues. (In this regard, face-to-face interviews are generally superior to telephone interviews for complex topics).
- Wherever possible, more than one alternative methodology should be employed to estimate important output values.
- Peer review by independent professional experts at key points in the process (as occurred in this case) is valuable to provide a second opinion on methodology issues.

3.6 Methods for Valuation of Life

Stated preference methods are now widely used internationally and are, in principle, appropriate for assessing the WTP (major) component of the valuation of life and of reducing risks of injury accidents. As described earlier (Section 2.4.3), such methods have been adopted for PEM since 1991.

However, there are particular difficulties in the successful application of SP (CVM/TP or CA) methods in this field, especially relating to the expression and comprehension of the small probability levels involved. This increases the importance of:

- rigorous survey design (including piloting etc) and analysis
- applying several survey approaches to address the same issues, and comparing results
- cross-checking against international market research experience and results.

Many of the issues raised in Section 3.4 relating to SP/CVM methods are relevant in this case, and have been encountered and addressed in the two major NZ studies on the topic (Sections 2.4.3, 2.4.4).
Key issues encountered in this field include (based on Miller and Guria 1991):

- The hypothetical market must be realistic: people should be asked the price they would pay for familiar goods and services.
- Risk, which plays a central role, must be understood. Few people can realistically discriminate between risks of less than 1 in 10,000.
- Risks must be realistic and relate to people's experience; most people will spot that a risk of death of 1 in 1,000 is severe and unlikely to be experienced (notice there is a 'middle ground' between this and the point above).
- Zero bids cannot be trusted, particularly if they are inconsistent with other responses.
- High bids cannot be trusted and may indicate a lack of understanding.

- The method of payment must be chosen carefully (see Section 3.4.2 discussion on 'numeraire' effects): taxes and tolls in particular are likely to lead to protest or inaccurate responses. Also avoid questions leading to discrete responses (e.g. something people tend to think of as being an integer number of dollars).

Other issues that particularly need to be addressed in this field, based on experience from the two New Zealand VOSL studies, include:

- 'Starting point' bias.
- Treatment of 'outliers' in interpretation of results (use of mean, median or trimmed mean).
- The merits of asking for responses relating to a percentage reduction in perceived risk as against an absolute change (e.g. 1 in 10,000).

The apparently wide disparity between WTA and WTP values also raises major issues:

- Are separate WTA and WTP values to be adopted in evaluating safety costs and benefits?
- If so, is it desirable to adopt should such an approach in other evaluation areas (eg. VTTS), and what are the implications of this? (In the valuation of time savings/losses, it is conventionally assumed that WTA and WTP values are equal).

3.7 Treatment of Taxation

3.7.1 The present PEM approach and rationale

The PEM notes (para 2.3) that all costs given in the manual are net of taxes, duties and subsidies and that this is a requirement for social cost-benefit analysis from the national viewpoint. Standard values for vehicle operating costs are provided net of taxes and duties, while for costs of road construction and maintenance the market price net of GST is taken to be a close approximation to resource cost. For the value of time and accidents, PEM gives no further explanation of taxation treatment.

3.7.2 Discussion

3.7.2.1 *Non-working time*

The treatment of taxation for non-working time, which is based upon the willingness to trade time against money, assumes that the traded money would have been spent on goods which carry indirect taxation. The resources associated with the time trade are thus equal to the expenditure less the indirect taxation. Therefore the valuation of non-working time savings should be derived from the behavioural valuation as follows:

$$\text{Economic VTTS} = \text{Behavioural VTTS}/(1+r),$$

where r is the average rate of indirect taxation on goods and services.

This is the approach that has been used in the UK since 1977 (refer DMRB, 1996). It has recently been reviewed and endorsed by Sudgen (Sugden 1998). The appropriate UK value of r was estimated at 20.9% in 1985.

Beca (1992) adopted a nominal value of 15% overall rate of indirect taxation on goods and services in New Zealand as an estimate of r: this figure allows for GST plus a small component for other indirect taxes (eg excise duty). However, it is noted that a mean value of the indirect tax rates on substituting activities needs to be properly established.

3.7.2.2 *Working time*

For in-work travel time savings, the value of output to an employer is its return net of any direct tax, and the cost of labour to the employer is its price before the deduction of income tax. If the resource cost of labour is its price in employment before the removal of income tax, then it is traditionally valued before indirect taxation is added.

When work-related travel time occurs during a period commonly thought of as leisure time, the issue is to what extent the time saved would go into productive work, which should then be valued by the marginal productivity of labour approach; and to what extent it would go into leisure activities, which would then be valued through the willingness-to-pay approach.

3.7.2.3 *Vehicle operating costs*

The resource values of VOC for use in CBA are equal to the nominal prices less GST (all items) less other taxes (fuel). These appear to be treated correctly in the present PEM (Section A5.1.3), and no issues arise.

3.7.2.4 *Accidents*

The accident unit costs incorporated in PEM have been derived essentially on a willingness-to-pay (WTP) basis, involving respondents in making trade-offs against market prices. These values are thus on a gross basis: consistent with the principle adopted in PEM and the approach taken for non-working time (above), they should be adjusted for the average rate of indirect taxation. We understand this adjustment is not incorporated at present, giving rise to an apparent inconsistency in the PEM values.

3.7.3 *Conclusions*

The consistent and correct treatment of taxation is important in the valuation of the various parameter values incorporated in the SCBA. The general principle is that all costs and benefits should be net of any taxes, duties and subsidies.

Particular issues arise in relation to any valuations derived from household or individual willingness-to-pay evidence. In such cases, evaluation (economic) values should be derived from WTP (behavioural) values by dividing by the factor $(1 + r)$, where r is the average rate of indirect taxation in the economy.

This indirect tax correction factor should be applied to valuations of non-working time (as currently in PEM) and to valuations of accidents derived from WTP data (not currently done in PEM).

There appears to have been no New Zealand research into the average rate of indirect taxation on substitute goods and services: some such research appears warranted. Meanwhile a rate of 15% has been suggested as an indicative figure.

3.8 Key Concepts and Issues in Valuation of Travel Time Savings

3.8.1 Theoretical basis

The theoretical basis for a monetary value of travel time savings relies on the micro-economic theory of the consumer and the integration of the time duration of consumption into this theory. Developments in the theoretical base have allowed values to be suggested for time savings under a variety of constraints, which can then be compared with empirically derived results. This theoretical basis also has a role in determining what adjustments are required to 'behavioural' values of time to provide appropriate VTTS for project evaluation.

The basis of the micro-economic theory is that the consumer maximises his/her utility (the satisfaction deriving from consumption activities) subject to various constraints. The basic theory originally ignored the fact that there is a time requirement for consumption, and that for some activities this time requirement will be fixed, while for others there will be a minimum time requirement. Introducing the time duration of consumption into modelling theory provides a mathematical basis for the value of time transfer between activities.

The current consensus on a mathematical specification of the utility maximising behaviour of the consumer, taking account of time duration of consumption and time constraints, appears to lie with models of a form first proposed by DeSerpa (1972), developed by Bruzelius (1979) and later by MVA (1987). In essence, these are concerned with maximising total utility, subject to constraints on income and time available, and recognising the different time constraints on different types of activities (refer TM/Beca 1997, Section 3.2 for details).

3.8.2 Opportunity cost and disutility components

The value of travel time savings has been shown to have two components: an opportunity cost component reflecting the economic value of the resources associated with the 'consumption' of time (referred to as the shadow price of time), and a relative (dis)utility component reflecting the alternative circumstances under which a unit of time is 'consumed'.

For example, 10 minutes spent waiting for a bus engenders greater disutility to a traveller than 10 minutes travelling in a bus or a car. The amount of time resource is the same and hence the opportunity cost is equivalent. This important distinction, linked back to the theoretical model initially developed by DeSerpa, has been translated into an appropriate empirical model of consumer (or traveller) behaviour choice by Truong and Hensher (1985, 1987) and Bates (1987) of the form:

$$V_i = \alpha_i - \lambda C_i - \kappa_i T_i$$

where Vi represents the (indirect) utility expression associated with alternative i, α_i is the mean of the unobserved influences on choice of alternative i, Ci is the monetary cost of using alternative i, and Ti is the travel time associated with alternative i. Importantly the parameter λ associated with money cost is independent of alternative i, in contrast the parameter estimate κ_i associated with travel time is dependent on the particular alternative. The latter reflects the different circumstances under which travel time is consumed in the use of each alternative. The value of travel time savings is given by κ_i/λ. If the shadow price of time (time being a scarce resource) and its actual value in a specific activity are the same, then κ_i/λ equals μ/λ. That is, the relative disutility of travel time is zero.

The important implication of this derivation of an empirical indirect utility expression (6) from economic theory as applied in a mode choice context is that it is not possible to identify the resource value of travel time unless we can assume that the relative disutility associated with spending time on alternative modes of transport is zero. What we can measure is the value of transferring time from activity i to some non-travel activity. To be able to separate out the resource price of time from the value of saving time, we would need to know a priori the resource price of time. Treating the differences in mode-specific values of transferring time (due to different parameter estimates for each mode) as zero (i.e. by constraining the parameters to be identical across the modes) is not a mechanism for obtaining a resource value, without imposing the strong assumption that the marginal (dis)utility of time spent travelling is zero, in contrast to it being constant for all modal alternatives.

The adjustments to these behavioural values, derived from empirical mode choice models, to obtain appropriate values of the cost to society of time resources consumed in travel is controversial in the light of the theoretical argument. In practice we modify the empirical behavioural values to represent an appropriate set of values of travel time savings to represent the cost to society of time resources consumed. Assuming that the opportunity cost associated with the time resource is suitably measured by the (competitive) market price, and that market prices are often distorted true resource (shadow) prices due to the presence of a number of externalities, practice has involved some limited adjustments to allow for distortions created by taxation. Other distortions have not been considered (such as regulations, price capping etc.); with the consequence that our best estimates of the social value of travel time savings derived from utility-maximising discrete choice models approximates the behavioural values of travel time savings.

3.8.3 Behavioural, resource and equity values

The values of travel time savings derived from travel choice models are behavioural values. They tell us how much an individual traveller is willing to pay to save a unit of travel time, ceteris paribus. Such values are appropriate in demand prediction where there is an interest in using a generalised cost or generalised time variable. Combining of travel cost and travel time into one service indicator is promoted where there is high correlation between the component attributes, which is most likely to occur where there is no or limited congestion and/or where levels of service are extracted from a network which tends to reduce the variability in attribute levels substantially.

When the time savings values are applied to a change in the level of economic resources, a willingness to pay (WTP) measure does not always represent the resource implications of the savings or loss of travel time, as demonstrated in the theoretical framework. Resource values are required to convert the predicted change in travel time into monetary units. The presence of direct and indirect taxation has to be considered in the establishment of resource values of travel time savings. Alternative approaches to correcting for the resource effect have been suggested in the literature.

To understand the complication of taxation - direct and indirect - we have to be clear on the meaning of "resources consumed" in the process of "consuming" travel time. The process of consumption entails a transfer of time from one activity to another activity and as such is not time "saved" per se. This is the basis for the phrase the "value of transferring time" originally proposed by Hensher and Truong (1985) and Truong and Hensher (1985), and subsequently adopted by Bates and Glaister (1990) in a review of the literature undertaken for the World Bank.

Economists talk of valuing goods and services at their resource costs on the grounds that they most clearly represent the real cost to the community in terms of resources embodied in their production, and hence indirect taxes and subsidies are excluded. While this may be an unambiguously valid position for estimating changes in national income aggregates, it is arguably an incorrect principle for sectoral cost-benefit evaluations. The cost to the community of a resource to be used in a sectoral project is determined by the value it creates in the use from which it is to be moved (i.e. its opportunity cost). This is the essence of shadow pricing of a resource where we distinguish the marginal production cost of new resources and the market price for existing resources. Thus, if a resource is moved from the production of some good subject to a 100% tax, for example, its cost to the project must be valued as equal to the price, which is twice the resource cost. The distinction between "cost" and "value" is fundamental to an appreciation of this argument.

We tend to assume (implicitly) that our resources already exist in that they are being utilised elsewhere; thus market price is the appropriate basis of identifying the opportunity cost of a resource. The theoretical model driving the pure definition assumes a perfectly competitive market; in reality however there are distortions such as minimum wages and maximum hours worked. Thus the observed market price may indeed be a distorted measure of value, an over- or under-estimate due to the presence of institutional constraints. In a sense this is a form of negative externality in a competitive market, So even though the savings in resources can be observed via market prices, those resources may actually be worth less in a competitive market. That is, institutional constraints have artificially over-priced the real value of a resource.

There is a view that for non-working time the behavioural value of time savings should be the same for all modes/routes and trip purposes. The resulting equity value is consistent with the position that the scarce investment dollar should not be directed towards projects which are more likely to benefit individual travellers with a higher willingness to pay simply because they have a greater ability to pay. This argument rests on the proposition that the value of travel time savings is a function of personal income. Although the empirical evidence on the relationship between VTTS and personal income is ambiguous, despite its theoretical appeal, equity "behavioural" values of travel time savings can be derived from the behavioural values for non-working time. If equity values are used, then the resource value for non-working time should be derived from this equity value.

3.8.4 VTTS for work-related travel

Traditionally, an alternative to the behavioural approach to travel time savings valuation (VTTS) in the work-travel context was the adoption of the marginal productivity of labour (MPL) approach, which states that an employer can be expected to employ labour up to the point at which the total costs of employment equate with the value of production. The value of working travel time savings is then estimated as equal to the gross wage rate (including on-costs) plus a marginal wage increment to allow for any savings in overheads associated with an employee travelling in contrast to spending the equivalent time in the office. This approach makes questionable assumptions about the transfer of travel time to other purposes, it neglects possible productive use of in-travel time (particularly at the marginal rate), and ignores the utility to the employee of time spent at work compared to travelling.

Hensher (1977) suggested an alternative approach to deriving the value of travel time savings for work-related travel. The approach recognises a number of components of opportunity cost and relative disutility. The approach has been applied in the context of business air travel in Australia, and commercial car travel in Sweden, The Netherlands and the United Kingdom. There are four main elements of the formula - a productivity effect, a relative disutility cost, a loss of leisure time and any compensation transfer between employer and employee.

These components are combined into the following formula:

$$VTTS = (1 - r - pq)*MP + \frac{1-r}{1-t}*VW + \frac{r}{1-t}*VL + MPF$$

where

- r = proportion of travel time saved which is used for leisure.
- P = proportion of travel time saved at the expense of work done while travelling
- Q = relative productivity of work done while travelling compared with the equivalent time in the office.
- MP = the marginal product of labour
- VL = the value to the employee of leisure relative to travel time
- VW = the value to the employee of work time while in the office relative to travel time
- MPF = the value of extra output generated due to reduced fatigue

T = employee's personal tax rate, the inflation of rVL and (1-r)VW reflecting compensation. An employer has to compensate an employee for travel, in terms of travel time savings rather than increased income, to allow for the fact that increases in the employee's utility are not subject to tax.

VL is the traditional behavioural value of travel time savings associated with trading travel time with leisure (i.e. non-work) time. The traditional category of business/commercial car travel is usually reserved for 'travel as part of work'. However a significant amount of work-related travel involves activities such as driving to the airport or a client's office. Since a high percentage of the travel time associated with the latter activity occurs outside of normal working hours (i.e. the person would not be travelling at this time during the normal period of work expected by the employer) and is not compensated in any manner by the employer, there is a leisure time trade-off being made.

The value of travel time savings thus can be expected to be lower than the average gross wage rate, reflecting the mix of both employer time and non-work time.

Unpublished studies undertaken by the Hague Consulting Group in 1994 in Holland, the United Kingdom and Sweden, using Hensher's model (Hensher 1977) provide supporting evidence for business values of travel time savings being significantly less than the gross wage rate. Overall, the value to the employer of savings in car travel times in the UK are approximately 50% of the average gross wage rate, 61% in the Netherlands and 32% in Sweden. The lower Swedish value is attributable to greater productivity in the car (especially due to high availability of mobile phones).

3.8.5 VTTS for non-work travel

The valuation of savings in non-working or leisure time (or, more strictly, the valuation of time savings which are then used for non-work purposes) can only be established empirically. The 'traditional' approach (which continues to be largely followed in the current PEM) is to adopt one single value for all non-work travel time savings, which is applied to all modes, person types, times of day and non-work trip purposes.

This rate was originally set in PEM at 25% of the average gross wage rate for full-time employed persons; but has subsequently been adjusted for drivers up to 40% of the average gross wage rate. The rate applied for passengers is 75% of the driver rate.

Aside from the issue of valuation of the (dis)utility of travel time, numerous issues arise in selecting a set of travel time saving values for non-work travel. These include the following:

- Self-selectivity issues
- Non-linearity – including the valuation of small time savings
- Valuation of time savings v losses

- Variations with trip purpose
- Variations with income
- Valuations for passengers v drivers
- 'Equity' issues in selection of values
- Treatment of taxation (refer Section 3.7)
- Future trends in values.

These issues are not discussed in any detail in this report (refer Travers Morgan/Beca 1997 for further discussion.)

3.8.6 VTTS for freight transport

PEM now includes a set of values for time savings relating to commercial vehicles and their goods (as distinct from occupants) – refer Table 2.3. The precise basis of these values is unknown to us: it is unclear to what extent they represent savings in commercial vehicle fleets resulting from travel time savings; and to what extent they represent savings in the costs of the goods themselves.

The value of freight time can be related to the inventory holding value of the goods, which in most cases will be small for the short periods involved, to the perishability of the goods, and to any costs of maintaining the integrity of the goods in transit, such as refrigeration costs. To effectively address this topic requires a study of these costs, which should be a quite straightforward exercise.

Previous literature reviews have shown a paucity of information on the subject of the value of freight time and the conclusions that have been reached show considerable variation. Freight time may be valued because of the costs of deterioration in transit, which in turn are related to perishability, packaging and environmental control, and the roughness of movement. It also may be valued because of just-in-time production and inventory practice in the distribution chain, which puts high value on reliability of transit time. At least for road transport, reliability of freight transit can be traded against additional holding costs: thus there is a reason for undertaking specific research to identify the cost trade-offs between reliability costs, in-transit cost losses, and additional inventory costs. However, against this the evidence tends to suggest that goods transit costs are small in relation to the costs of vehicle and driver.

The present PEM allows for savings in vehicle ownership costs for commercial vehicles and business/commercial cars (including taxis) resulting from time savings. We understand that these cost allowances are based on the annual standing charges divided by average annual hourly utilisation. This effectively assumes that commercial vehicle fleets will be reduced (pro rata) as a result of time savings. It would seem desirable for this assumption to be reviewed.

More extensive discussion and evidence on VTTS for freight transport is given in Travers Morgan/Beca 1997 (Section A7).

3.8.7 Implications for project evaluation

A clear distinction must be made between behavioural values of travel time savings and resource values. The former should be applied in travel demand modelling, to convert time to money or money to time in the input of a generalised cost or generalised time into a travel demand expression. For conversion of predicted time savings into dollars however a resource value is appropriate. For a leisure-travel trade-off the resource value is an adjusted behavioural value; while for a work-related-travel trade-off we promote the production cost approach (Section 3.8.4).

There are strong theoretical grounds for establishing a range of behavioural values to accommodate the variation in the circumstances under which travel time is transferred from one activity to another. This translates into an appropriate resource value for leisure-travel and work-travel trade-off situations derived from a weighted average behavioural value, where the weights reflect the composition of travel time (e.g. walk, wait, transfer, in-vehicle time). This approach would apply to all travel involving a leisure-travel trade-off (eg. commuting, social-recreation trips). Where a travel-work trade-off is applicable, the production cost approach is recommended for the calculation of the resource value. If such work travel involves some trade-off with leisure time instead of work time, then the leisure value of time savings is implemented for that part of time saved which is unrelated to work. For many work-related trips (especially commercial vehicles), the entire time spent travelling is within accepted working hours.

An empirical review of complementary inputs such as vehicle occupancy and the allocation of travel time between time normally earning an income versus leisure time is critical in establishing the final weighted average time savings in dollars. Without this information, it is very difficult to be confident that we have applied the relevant value of travel time savings and expanded the value of the time savings up to from the individual to the vehicle to the population of vehicle and/or person trips.

The theoretical literature makes no judgement about whether values of time savings should be point estimates or distributions. There has been however an almost implicit assumption that economic theory produces a single mean estimate. This assumption of convenience is not a restriction of theory. In Chapter 4 we promote the idea of a valuation function to enable the value of travel time savings to vary by whatever are preferred criteria. These might include the size of the time savings, trip length, income, trip cost, travel time variance (i.e. reliability) and any number of socio-economic and demographic characteristics. The analyst then has the opportunity to replace point estimates in a benefit-cost evaluation with an empirical function which can provide more accurate values according to the trip and individual characteristics. There is always the option however of selecting an average estimate if necessary.

4 Development of Research Approaches

4.1 Overview – Parameters for Consideration

4.1.1 Parameters for consideration

The benefit evaluation parameters that are suggested for inclusion in the revised PEM, and hence need to be covered in the proposed research programme, are listed in Table 4.1 under six categories:

- A: Private travellers - time/level of service
- B: Business/commercial travellers – time/level of service
- C: Vehicle operating costs
- D: Accidents
- E: Environmental effects
- F: Potential additional parameters.

Compared with the existing PEM, the main changes relate to:

- The inclusion of a wide range of 'level of service' variables relating to road/traffic conditions: these variables affect motorists' utility of time spent travelling, for both private travel (Category A1) and business/commercial travel (Category B1).
- The inclusion of some potential additional parameters (Category F) – to be pursued further.

4.1.2 Valuation structure for time and level of service aspects

As described earlier (Section 3.8.2), the value of travel time savings may be considered in two components: an opportunity cost component, reflecting the economic value of the resources associated with the time saved; and a relative (dis)utility component, reflecting the conditions under which the time is consumed (relative to some 'standard' conditions). In this case, where there is special interest in 'level of service' factors, this disaggregation is particularly relevant: for a given traveller, differences in level of service affect the disutility value of time savings, while the opportunity costs depends solely on the amount of time saved.

For private travel, the valuation of improvements in travel time/level of service may be regarded as divided into:

- Level of service benefits (i.e., from enhanced LOS, without any travel time savings) – refer Table 4.1 item A1.
- Travel time savings
  - 'opportunity cost' benefits at a standard LOS
  - plus any utility adjustment for difference between the actual and standard LOS (refer Table 4.1, item A2).

TABLE 4.1 : PARAMETERS FOR INCLUSION IN RESEARCH PROGRAMME

Parameter	Proposed Valuation Basis	Proposed Survey Approach
A. PRIVATE TRAVELLER – TIME & LEVEL OF SERVICE		
A1. Personal Disutility of Travel: • Road hazards • Road quality • Road user amenity • Traffic conditions A2. Personal Opportunity Cost: • Expected travel time • Uncertainty of travel time	• Non-market (WTP), by road traffic conditions, traveller/trip characteristics.	• CA approach. • Range of (over-lapping) surveys to establish full range of valuations in different conditions (refer text). • Will need to be preceded by focus groups, piloting etc to establish best methods in detail. • Refer Sections 4.2 and 4.3.
B. BUSINESS/COMMERCIAL TRAVELLER – TIME & LEVEL OF SERVICE		
B1. Personal Disutility of Travel (as A1). B2. Personal Opportunity Cost (increase in non-work time.	As per (A) above.	• As per (A) above.
B3. Business Opportunity Cost (increase in useful work time)	• Market valuation – MPL/wage rate approach (for business travel, based on Hensher, refer Section 3.8.4)	• For business travel, MR to assess extent to which savings in travel time will translate into increases in output/reductions in employer costs (refer Section 4.4.1). • For commercial vehicle travel, generally base on pay rates + overheads (to extent time savings may be put to productive use).
B4. Freight Time and Condition	• Market valuation	
C. VEHICLE OPERATING COSTS		
C1. Direct Operating Costs: • Fuel • Oil, tyres • R&M	• Market (resource) valuation (net of taxation).	• Determine financial cost structures (as now). • Adjust for fuel duties, taxes, etc.
C2. Capital – depreciation	• Market (resource) valuation	• Assessment of use-related (distance/time) component of depreciation (as now).
C3. Capital - fleet	• Market (resource) valuation (commercial vehicles only).	• Assessment of any fleet savings through time savings (as now).
D. ACCIDENTS		
D1. Human Costs	• Non-market (WTP) – fatalities, injuries	• Comprehensive appraisal of methodology from recent LTSA study (fatalities and injuries), in light of international research methods. • Further research needs defined in this review.
D2. Lost Output	• Market (resource) – fatalities, injuries.	• Resource assessment (as now).

TABLE 4.1 : PARAMETERS FOR INCLUSION IN RESEARCH PROGRAMME

Parameter	Proposed Valuation Basis	Proposed Survey Approach
D3. Medical Costs	• Market (resource) – fatalities, injuries.	• Resource assessment (as now).
D4. Accident-related Costs (property damage, police, insurance costs)	• Market (resource) – all accidents.	• Resource assessment (as now).
E. ENVIRONMENTAL EFFECTS		
E1. Co_2 (Global)	• Non-market • Recent literature suggests that factors such as global warming (and other irreversible aspects felt by future generations) are not amenable to monetary valuations	
E2. Air Pollution (CO_2, NO_X, Lead, PM_{10})	• Non-market • Market (resource) – PM_{10}	• Dose response/shadow pricing
E3. Noise	• Non-market	• HP or CVM/CA
E4. Vibration	• Non-market	• HP or CVM/CA
E5. Water Quality	• Non-market	• Shadow pricing or CVM/CA, depending on how the factor is defined and whether the impact is on the population or ecology.
E6. Special Areas	• Non-market (situation specific)	• CVM/CA • Shadow pricing • Recreational areas - TCM
E7. Ecology	• Non-market	• Shadow pricing or CVM/CA depending on the ecological impact
E8. Visual	• Non-market (situation specific)	• HP or CVM/CA
E9. Community Severance	• Non-market	• HP or CVM/CA
E.10 Isolation	• Non-market (situation specific)	• HP or CVM/CA
E.11 Psychological Distress (Forced Purchase)	• Non-market (situation specific)	• CVM/CA
E.12 Site Specific Discomfort	• Non-market (situation specific)	• HP or CVM/CA
F. POTENTIAL ADDITIONAL PARAMETERS		
F1. Parking Resources		
F2. Health & Fitness		

For **business/commercial travel**, the valuation of improvements in travel time/level of service may have up to four components:

- Personal LOS/disutility benefits (item B1) – equivalent to A1.
- Personal travel time savings (item B2, equivalent to A2), to the extent that time saved can be reallocated to non-work time.
- Business travel time/opportunity cost savings (item B3) – opportunity cost of person time savings to employer.

Freight time and condition (item B4) – opportunity cost of faster delivery of freight (with less damage).

Table 4.2 presents a summary of travel time/level of service benefit components for private travel, business travel and commercial vehicle travel. This summarises how the four benefit components apply to the three classes of traveller.

In terms of developing a research methodology, it is more efficient to focus on the individual benefit components (rather than classes of traveller). Thus the research methodology developed in subsequent sections of this chapter addresses:

- Personal (dis)utility/level of service factors (Section 4.2).
- Personal opportunity cost/time savings (Section 4.3).
- Business opportunity cost (Section 4.4).
- Freight opportunity cost (Section 4.5).

TABLE 4.2: SUMMARY OF TRAVEL TIME/LEVEL OF SERVICE BENEFIT COMPONENTS

	Category of Traveller			
Benefit Component	**Private Motorist**	**Business Traveller**	**Commercial Vehicle Traveller**	**Notes**
Personal (Dis)utility	x	x	x	} Conventionally both covered in VTTS research studies. In this context these need to be broadened to cover LOS factors in more detail (may not be related to time savings).
Personal Opportunity Cost (1)	x	x (1)	x (1)	
Business Opportunity Cost		x	x	Established through business travel time studies (MPL approach etc).
Freight Opportunity Cost (2)			x	'Value of freight' studies.

Notes: (1) Only applicable when business/commercial travel time savings are converted to non-working (personal) time.
(2) Excludes any vehicle-related cost savings (covered under VOC category).

4.1.3 Overview of research approaches

Table 4.1 includes an overview of the recommended research approaches to estimate each parameter or group of parameters, under two headings:

- Proposed valuation basis. In particular, this distinguishes between those parameters for which a market price (or shadow price) assessment is available; and those for which such a market price is not available and hence a non-market (willingness-to-pay) valuation is necessary – refer discussion in Section 3.2.

- Proposed research/survey approach. This provides brief notes on the type of market research/survey approach appropriate for each parameter: these notes are expanded in the following section of this chapter.

As a generalisation, one parameter category (C:VOC) is primarily appropriate for market price (resource) assessment; two categories (A: Private Travel Time/Level of Service, E: Environmental Effects) are appropriate for non-market (WTP) assessment; while categories B: Business & Commercial Time/Level of Service and D: Accidents require a combination of the two approaches.

The main research issues in developing improved parameter values relate to the non-market assessment approach, so this is the primary focus of the remainder of this chapter.

Based on the review of issues and methods presented in Chapter 3, we conclude that the most appropriate non-market survey approach for most parameters is the use of stated preference (SP) techniques – generally involving conjoint analysis (CA) methods. SP/CA methods are most appropriate for categories A, B and D. Category E (Environmental Effects) is best researched through a combination of direct methods (particularly contingent valuation) and indirect methods (primarily hedonic pricing).

In terms of SP/CA techniques, the Chapter 3 review indicates that the following key features should be adopted in their application:

- Experiments should focus on a simple choice between (usually two) alternatives (ie, rather than ranking or rating a larger number of choices).
- These experiments will typically involve 'abstract' choices (differences in travel attributes), but may alternatively involve route, or possibly mode, choices.
- In each SP/CA 'game', at most 3 or 4 variables would differ between the two alternatives offered.
- Wherever possible, the alternatives offered should be related to a 'base' with which the respondent is familiar.

Further, attention will need to be paid to the range of issues relating to SP/CA design discussed in Chapter 3, including the following:

- The 'packaging' effect (Section 3.4.1).
- The selection of payment vehicle (Section 3.4.2).
- The choice of appropriate experimental design, with attribute levels being statistically independent of each other.
- The various potential sources of bias (Section 3.4.6).

A number of important practical issues will need to be addressed in designing the SP/CA survey program to most efficiently derive the required set of parameters on a consistent basis. These issues particularly relate to the 'level of service' aspects, and include the following:

(1) **'Level of service' parameters** – specification and structure. Table 4.1 indicates some suggested LOS categories for inclusion in PEM: these are disaggregated further in Section 4.2. There is a need to define a set of LOS parameters which together efficiently cover user perceptions of all significant road attributes, with minimum overlap. There is also a need to review to what extent each parameter value would vary with trip distance, travel time or other factors.

(2) **Valuation of travel disutility** and opportunity cost components. Traditionally in the transport sector, LOS/disutility effects have been considered as a sub-component in VTTS studies (eg, the recent BAH/Hensher NZ VTTS study). However, for this project this may not be the most cost-effective research approach. Given the central importance of the LOS attributes, it may be more appropriate to mount a set of surveys focussing solely on the LOS variables (with trade-offs against some measure of cost); and with other surveys to then focus on time savings (in some defined LOS conditions) relative to some measure of costs. This has been assumed at this stage (refer Sections 4.2, 4.3).

(3) **Problem of 'double-counting'** and separation of effects. The general issue here is how to design the survey program to establish the separate effects of each attribute, and in particular, to avoid double-counting between attributes which may be determined from separate surveys. A key instance is that 'level of service' surveys may establish a WTP value for subjective 'risk'; while 'value of life' surveys may establish separate values for costs of accidents: the two are arguably not additive, but together involve an element of double-counting.

The SP/CA approach should be able to minimise any such problems, through appropriate survey design. For instance, respondents could be presented with a choice between two routes with identical accidents records, but one may be perceived as more 'risky' (eg, unsealed, poor alignment) than the other. Thus the trade-off should be able to establish the 'objective' risk component separate from the actual accident components. However, careful design will be needed to minimise any 'halo' effects (*see* Sections 3.4.1, 3.4.3).

(4) **The 'packaging' effect**. This ties in with the above issue, and seems likely to be a major concern in valuing the level of service attributes in particular. Respondents are likely to have difficulty in completely isolating each individual attribute in their minds in responding (eg, level of congestion v uncertainty of arrival time; road classification v road roughness); and hence it seems likely that the value of a package of attributes will be less than the sum of the values of the individual attributes.

The most effective way to address this problem will be to evaluate some combined packages as well as the individual attributes in isolation. This will establish the strength of any packaging effects; and if necessary will provide a basis for downward adjustment of the individual attribute valuations to be consistent with the package total values.

(5) **Coverage of all relevant parameters.** The range and number of parameters to be established is such that it is not practical to include them all in a single

SP/CA experimental design: it would be too complex. Therefore, a 'family' of SP/CA surveys is recommended, each containing a sub-set of all parameters of interest, and with some overlap of parameters between the different surveys. One basis for partitioning the problem will be between urban/local travel and long-distance (primarily rural) travel: different attributes and different ranges of value of these attributes will be relevant in each case.

(6) **Selection of payment vehicle**. Previous research in New Zealand and internationally has shown how parameter values may be strongly influenced by the payment 'vehicle' selected (*refer* Section 3.4.2). In investigating motorist level of service attributes, the abstract choice and/or route choice approaches are most appropriate: in this situation the primary payment vehicle is naturally tolls, with fuel costs as a secondary vehicle (plausible changes in fuel costs between routes tend to be small). Both these payment vehicles are not ideal (as discussed earlier). This will need further consideration in the context of each SP/CA survey design.

(7) **Achievement of realism for respondents: use of RP data**. The evidence is that survey responses are more realistic if closely related to the actual travel experience of the respondents. We therefore recommend that the survey program should capture data describing the market context in which individuals actually make choices (i.e. RP data on at least two alternatives including the chosen alternative), as well as an enhanced data source defined by a stated choice experiment in which individuals make choices from an enriched set of attributes, attribute levels and alternatives in the choice set. The SP/CA experiment typically provides greater variability in attribute levels than offered in the market and hence adds a richness necessary for deriving distributions of VTTS, which is often limited in an RP setting. This does not mean that RP data cannot deliver such richness, but that it is our experience that RP data alone is less rich than the combined RP and SP data sources. The SP/CA experiment however must relate to attributes and levels that are meaningful to respondents and where possible are defined as variations around currently experienced levels of service.

Valuation functions or distribution of behavioural values are promoted as a way of delivering adjustments for size of time savings, trip length, congestion, other level of service aspects, and socio-economic segmentation (e.g., income). This provides the analyst with a rich set of information to aggregate and average as they see fit.

(8) **Respondent comprehension**. We anticipate it will be difficult to convey to respondents adequately in words all 'level of service' (and environmental) attributes. Pictures, videos etc are likely to assist respondents in achieving a good understanding of each attribute level or package (this was also the experience in the earlier NZ research into the benefits of road sealing).

We thus anticipate that each survey will require detailed piloting; and that a series of focus groups is likely to be appropriate prior to starting on design of the main surveys.

4.2 Level of Service Factors

4.2.1 Definition of road/traffic factors

As part of developing a research methodology, it is necessary to define relevant LOS factors relating to the road and traffic system, for which value functions are to be derived. Required criteria for factors include:

- clearly defined and (where possible) measurable
- generally relate to physical features of the road/traffic system (rather than to system outputs)
- not over-lapping
- together cover all aspects that significantly affect motorists' perceptions/valuations.

At this stage, we have developed a draft set of factors, based on review of previous practice/experience in Australia/NZ on this aspect. This review is presented in Appendix A, and covers the following key sources:

- Austroads User Satisfaction Index
- Austroads Surveys of Community Perceptions
- Tasmanian Road User Satisfaction System
- New Zealand State Highway Satisfaction Survey.

Of these four sources, we consider that the Tasmanian RUSS system provides the best basis for our purposes: it is the most detailed and best structured in terms of the treatment of road factors/attributes (the Austroads User Satisfaction Index also covers other aspects of motorists' perceptions). The Tasmanian system also appears to adequately cover the range of road factors raised in the recent Transfund consultations.

We note, however, that the Tasmanian system could probably be improved for our purposes:

- It involves an element of repetition/double-counting.
- It does not address the 'travel time reliability' aspect.
- It does not adequately address the 'no surprises'/consistency of standards issue.

At this stage we adopt the Tasmanian system categories as a reasonable starting point for developing research methods, but subject to refinement in the research programme itself. Thus we define eight road performance areas:

- Road hazards — - road delineation
- roadside issues
- Road quality — - road surface condition
- road alignment
- Road user amenity — - road verge quality
- driver information
- Traffic conditions — - road formation
- traffic queuing/delays.

4.2.2 Survey methodology

In our view, the only method that is amenable to producing a complete suite of monetary valuations for each of the eight road performance areas is the SP/CA technique.

A particular challenge associated with this application is the requirement to design a survey instrument that provides survey respondents with sufficient information to complete 'trade-offs' between different packages of road level of service attributes. In theory, three approaches to presentation of information might be used:

- People could be driven along a length of road that demonstrates the various service level features.
- A driving simulator or computer software might be used to demonstrate the various level of service attributes. The use of a simulator would also permit 'pair wise' experiments to be completed by simulating alternative scenarios and asking respondents to express a preference for one of the scenarios.
- Pictorial representations of alternative scenarios that demonstrate the various level of service attributes might be designed.

The technical requirements associated with the design and execution of the proposed research is similar to that commissioned by public transport agencies over the past five years, notably London Transport, to establish customer service quality valuations. Most notably, a study commissioned by London Transport Buses to establish customer 'willingness to pay' for a range of service and infrastructure improvements employed a pictorial experimental design (Steer Davies Gleave 1995).

This research provided a number of useful insights regarding the content and format of the pictorial designs incorporated in the survey instrument (Swanson 1997):

- The context in which information is presented is important (e.g. a bus shelter with or without the street background); and
- Respondents were found to relate better to sketches, rather than photographs or clip-art pictures.

In terms of this latter point, weather, lighting and background figures can all influence the way in which photographs are interpreted. Similarly, the use of colour on sketches or clip-art can also impact on respondent perceptions. It is understood that colour sketches were piloted by the consultant but were ultimately discarded in favour of black and white sketches.

In practice, the survey design and successful execution looks likely to be challenging: it appears more ambitious than any other research in this field of which we are aware. It will certainly be necessary to start with focus groups and/or some qualitative surveys; and then proceed to develop and pilot probably several different survey methodologies prior to selection of the preferred method.

Methodology issues that are likely to be of particular importance in this case include:

- Issues of independence, overlap and double-counting between attributes.
- Grouping of factors into a number of surveys, with some overlapping between them.
- How valuation of attributes varies with distance, time or other parameters.

- Need to cover both drivers and passengers (separately).
- 'Packaging' effect (refer Sections 3.4.1, 4.1.3).
- Numeraire/payment vehicle (refer Section 3.4.2, 4.1.3).
- Form of presentation (refer above).

4.3 Opportunity Cost of Personal Time

4.3.1 Overview

For current purposes of survey specification, we have assumed that separate surveys will be undertaken for personal disutility/level of service factors (as just described), and for opportunity cost of personal time (as now described). However, in practice, it seems quite likely that these may be merged together, or at minimum that there would be some overlap between them.

The case for using CA data for deriving behavioural values of travel time savings for personal (non-work) travel and the opportunity cost component of a work travel model now has considerable empirical support. This approach has become the norm for VTTS studies in Europe over the last decade, and was also used in the recent New Zealand VTTS market research project. It is particularly appropriate in the current context, in which the effects of level of service attributes on travel time values are of major interest.

As noted earlier, it is important that the CA experiment relates to attributes and levels that are meaningful to the respondents, and where possible are defined as variations around the currently experienced levels of such attributes. It is thus desirable for a revealed preference data set to be collected as part of the experimental design: it can then be used to jointly estimate a RP-CA model, with appropriate re-scaling as a check on the values derived from the stand-alone CA results.

The approach to CA survey design for non-working time/level of service attributes outlined previously will result in a distribution of behavioural values relating to different level of service situations and a range of respondent (socio-economic) characteristics. For application purposes, this distribution may be aggregated and averaged as is appropriate for particular analyses.

The following provides an outline project specification for undertaking the required research relating to personal time/level of service parameters.

4.3.2 Valuations of personal time savings

4.3.2.1 *Background*

The present PEM procedures for valuation of savings in non-work travel time and improvement in levels of service were described earlier (Section 2.1.4). Essentially there are three components:

- 'Base' value of non-work VTTS – by three groups of travellers (drivers, passengers, pedestrians/cyclists).

- Adjustment for congested conditions (by drivers/passengers, depending on the degree of congestion).
- Additional benefit term relating to sealing of unsealed roads (expressed per vehicle kilometre).

These values are subject to a number of uncertainties and deficiencies, including:

- They do not distinguish different (non-work) trip purpose, trip lengths, etc.
- Apart from the adjustment for degrees of congestion (which is not well founded on research evidence), they do not allow for other 'level of service' variables.

4.3.2.2 *Objective*

The objective of this research project would be, through market research in New Zealand, to establish appropriate valuations for motorists' savings in personal (non-work) travel time in a range of 'level of service' road and traffic conditions.

4.3.2.3 *Research description*

To address the above objective, the project would involve market research with a sample of New Zealand motorists to derive valuations for travel time savings in a range of 'level of service' conditions. The survey method/scope needs to be designed in conjunction with (and maybe as part of) that for level of service factors (Section 4.2).

It is expected that

- SP/CA methods will be adopted (as described earlier in this chapter).
- The work would build on the recent experience and evidence from the New Zealand VTTS Market Research project (BAH/Hensher).
- The research methodology should have regard to the issues outlined earlier in this chapter.
- Car drivers and passengers should be covered.
- A series of focus groups, followed by detailed survey piloting, are likely to be required (in conjunction with the level of service methods).

4.4 Opportunity Cost of Business/Commercial Time

4.4.1 Overview

This heading covers the valuations of the opportunity costs of the savings for people travelling for work-related purposes: this includes business travel and commercial vehicle travel (Table 4.1 item B3).

For business travel, the benefits of any time savings may be sub-divided into;

- Benefits to the employer – in terms of increased output and/or lower costs.
- Benefits to the employee – in terms of increases in non-work time and/or utility of work time.

It is proposed that these valuations be derived based on the Hensher formula (*refer* Section 3.8.4), which has also been used in the recent Scandinavian studies.

The estimation of benefits to the employee are essentially covered in the previous section (4.3), in the same way as for travellers on non-work purposes. Thus it is proposed that the Section 4.3 methodology be extended to cover a sample of business travellers.

The benefits to the employer would be established through separate research, as set out below (Section 4.4.2).

Time savings for commercial drivers could, in principle, be assessed in much the same way as for business travellers. However, in practice, a simpler approach is normally taken, assuming that:

- Benefits to the employer are based directly on the employee wage rate (plus direct on-costs) applied to the time savings.
- Benefits to the employee are assumed to be zero.

This approach appears reasonable and any further research on this aspect would appear to be of lower priority: no research tasks have therefore been defined at this stage.

4.4.2 Valuation of business (working) travel time savings

4.4.2.1 *Background*

The present PEM procedures for valuation of savings in work travel time are based on the marginal productivity of labour approach, using information generally from the late 1970s. The approaches and assumptions now used have a number of deficiencies including:

- Variable labour on-cost components may be significantly in error
- Employee hours of work are not well defined
- No allowance is made for flexibility of working hours involved in many employment contracts
- No allowances are made for time savings being used for leisure rather than work; or for useful work that may take place during travel.

4.4.2.2 *Objectives*

The objectives of this research would be:

- To establish more appropriate values for savings in travel time for business travellers, relative to their employment costs.

- To obtain improved estimates of the gross (variable) costs of employment for the range of groups involved in business travel, stratified by the nature of their employment conditions.

4.4.2.3 *Research description*

The research would involve two sub-projects, corresponding to the two objectives above.

Part (A) would involve market research on the extent to which savings in business travel time will result in increased work production and/or reduced employer costs, and on the extent to which the savings will result in increased leisure time.

This research would need to address at least the following three aspects:

- The extent to which any travel time savings would be spent in working or in leisure.
- The extent to which productive work is undertaken during travel, in terms of the percentage of travel time spent working and the relative productive efficiency of this time.
- Whether it is reasonable to value any saved time used for working at the average cost of labour (including any variable overhead components), or at a lesser rate than this.

The extent of these various effects can be expected to differ by business sector/employee type, transport mode and time of day, partly because of self-selectivity effects among travellers. The project will need to draw distinctions between travellers by form of remuneration (salaried/wage earners, incentive payments, etc.), flexibility of working hours (fixed hours and times, flexitime, nominal hours that vary with work demands). The research would require in-depth interviews with business travellers sampled across various business sectors/employee types.

Part (B) would involve three main aspects:

- Review the present classification of groups involved in business travel for suitability for analysis purposes.
- Obtain data on gross wage costs and hours of work of business travellers in each group.
- Obtain information on appropriate labour on-costs for the travellers in each group.

The research would involve interviews with selected companies in a range of business sectors. It would also involve deriving gross wage cost data from a range of standard statistical sources.

4.5 Opportunity Cost of Freight

This section is concerned with research methods for the valuation of any savings in freight-related costs associated with reduced travel times, more reliable travel times and/or improved travel conditions (eg, less damage to goods) for commercial vehicle travel. We address here only costs associated with the freight itself: any vehicle savings are covered under Vehicle Operating Costs (in the next section).

As noted earlier (Section 3.8.6), this is an under-researched area generally: while PEM now includes a set of values for freight savings, the basis of these is unclear to us. Although it is generally assumed that any freight-related costs are small relative to driver time and vehicle costs, they may be of some significance. Research may be warranted in three areas:

- The effects of time savings on inventory holding costs: an improved roading system may result in reduced inventories and facilitate just-in-time road deliveries.
- The effects of improved travel time reliability on inventory holding costs.
- The valuation of time savings for courier etc operations in terms of improved levels of service.

The first two of these areas could be addressed through market research interviews with a sample of NZ commercial vehicle operators and users of freight services. This would need to start with a set of exploratory discussions/pilot interviews, leading to a semi-structured questionnaire to be completed by a larger example of freight operators/users.

It is unclear that such research would take high priority within Transfund's current PEM research programme. Therefore the research methodology has not been developed in more detail at this stage.

4.6 Vehicle Operating Costs

Based on Transfund advice, no further work has been undertaken on the development of research approaches on this topic.

4.7 Accidents

There is now widespread acceptance that SP methods are appropriate for estimating the major (WTP) component of accident costs. Such methods have been adopted in New Zealand for the last ten years and in many other countries internationally.

As described earlier (Section 2.4.3), in New Zealand a major WTP survey of the VOSL was undertaken in 1989/90, and this forms the basis of the current PEM accident cost rates. A second major survey to update and extend the earlier work was undertaken through LTSA in 1997/98: its findings and recommendations indicate nearly a doubling of current VOSL figures (along with injury WTP figures), are therefore very controversial and have not yet been adopted.

The research approach and methodologies used in both these previous surveys appear generally sound (and have been subject to significant expert peer review); but there may be scope for improvement in some aspects of the detailed survey design and analyses.

Any further research relating to accident valuations therefore does not require a radical change in direction, but needs primarily to review and build on the previous work. We suggest that it should focus on the following issues:

(i) Reasons for the apparent substantial difference in terms of VOSL WTP results between the 1989/90 and the 1997/98 surveys. Particular points include:

- Potential reasons for differences and implications.
- International evidence on trends over time in VOSL WTP.
- Robustness of methodology (eg refer Section 3.6 re important methodology issues).
- Approach to expressing risk reduction – absolute or proportionate terms (see below).
- Review of possible sources of bias.
- Treatment of financial aspects (see below).

This appraisal may result in a decision to undertake some supplementary survey work.

(ii) Alternative approaches to expressing risk reduction in surveys, and the implications of these on valuations. In our view this could well be a significant factor influencing valuation estimates, and may largely account for the different valuations arising from the 1989/90 and 1997/98 surveys.

(iii) Consistency (or otherwise) of VTTS and VOSL results, and implications for investment programme.

(iv) Use of WTA values in accident evaluation and implications for other evaluation aspects (e.g. VTTS).

(v) Treatment of financial costs re loss of output, personal income etc. In the recent survey, respondents were asked to ignore any financial costs, but it is unclear whether they would be able to separate these (they affect future lifestyle etc). They appear not to be incorporated separately in the PEM values for fatalities (refer Table 2.10), but should be covered somewhere (although they are small in magnitude relative to the WTP component).

(vi) Basis of indexation. Currently LTSA indexes accident cost rates according to movements in average ordinary time wage rates (refer Section 2.4.3.3). However the recent VOSL survey suggests this may be inappropriate, as WTP may be significantly affected by factors other than real wages. PEM indexes cost rates simply according to CPI changes. This issue needs to be revisited (although it is of lesser importance than establishing the 'correct' base values).

(vii) Treatment of taxation. There is a need for review of the treatment of taxation in converting WTP accident values to values suitable for the PEM (resource-based) evaluation. In particular, there is a need for consistency with VTTS values and other evaluation inputs (refer Section 3.7).

The above review work needs to have regard to 'best practice' relating to SP (CVM/CA) methods, including the particular points outlined earlier (Section 3.6).

4.8 Environmental Effects

In most instances, it is possible to identify at least two potential valuation techniques that might be applied to the evaluation of specific environmental factors. Table 4.3 below considers the applicability of the range of techniques discussed in this paper to the issues of particular interest to the project.

It is important to note that the environmental effects identified in the table essentially fall into two classes from a valuation perspective:

- Those environmental effects where generic estimates can be derived and applied across most, if not all, evaluations with equal validity; and
- Those environmental effects where estimates are essentially unique to the specific circumstances of the evaluation.

Environmental effects falling into this latter category include special areas, visual pollution, isolation and psychological distress. We would recommend that available resources are first directed at estimating values for those effects where generic estimates can be derived, given their broad applicability to a range of evaluations.

Note that none of these techniques are considered suitable for the purpose of establishing a monetary valuation associated with Carbon Dioxide (CO2) emissions. Recent literature suggests that where environmental impacts are both cumulative and irreversible, such as the case with CO2 emissions and their impact on global warming, none of the techniques identified in the table are appropriate.

Table 4.3 shows, that in a number of cases, a choice exists between the application of a surrogate market technique (typically hedonic pricing) and the application of a stated preference technique.

Table 4.4 summarises the key strengths and weaknesses of the principal valuation techniques. The table suggests that the key trade-off associated with making a choice between a surrogate market valuation technique and stated preference research is data availability (i.e. surrogate market approaches) vis-a-vis potential bias problems associated with application of stated preference techniques. The capacity of stated preference techniques to generate estimates of both use and non-use values must also be recognised.

Given that a choice between two techniques often needs to be made, another key issue is the perceived validity of estimates for the same environmental effects derived using different methods. Several studies have been undertaken to compare the results of different methodologies, e.g. Bishop et al. (1983), Levesque (1994), Magat et al. (1988), Rowe et al. (1980), Schulze et al. (1981). The different valuation methods would be expected to derive similar results; *however "studies in which different methods are used and compared do not provide any simple conclusions regarding the appropriateness of the different methods"* (Johansson 1990). No definite conclusions can be gained about the applicability of any of the methods as in some studies comparable results are obtained and in others results are dissimilar.

TABLE 4.3: CANDIDATE RESEARCH TECHNIQUES – ENVIRONMENTAL FACTORS

	Indirect Techniques				Direct Techniques
			Surrogate Market		
Environmental Factor	**Dose-response/ Shadow pricing**	**Expert Opinion**	**Hedonic Pricing (HP)**	**Travel Cost Method (TCM)**	**Stated (1) Preference**
Air Pollution (CO, NO_x, Lead, PM_{10})	✓				
Noise			✓		✓
Vibration			✓		✓
Water Quality(2)	✓				✓
Special Areas(3)	✓			✓	✓
Ecology	✓				✓
Visual			✓		✓
Community Severance			✓		✓
Isolation			✓		✓
Psychological Distress					✓

Notes: (1) In each case, estimates can be generated using either the Contingent Valuation Method (CVM) or Conjoint Analysis.
(2) Key issues are how the factor is defined and whether the impact is on the population or ecology.
(3) The Travel Cost Method is only appropriate for recreation areas.

The Australian Department of Environment 'Handbook of Environmental Evaluation' (1998) provides a pragmatic approach to selecting an appropriate valuation technique. In particular, it suggests that a choice should be made on the basis of:

- Theoretical validity – the extent to which the potential techniques accommodate the economic concept of 'value';
- Market validity – requires that the technique interpret observable behaviour;
- Data requirements – scope of data requirements, survey requirements etc (and, presumably, associated costs).
- Skill requirements – need for specialist statistical expertise to analyse and interpret the results etc.

The Handbook suggests that *"where several valuation techniques appear suitable to value a given effect, the preferred method would normally be that with higher (theoretical and market) validity and lower data and skill requirements."*

In general, it would be expected that when consideration is given to data, skill and cost issues, this would tend to favour the use of indirect market rather than stated preference techniques. This is largely a reflection of cost issues. The application of stated preference techniques tends to be 'resource hungry', particularly given the typical requirement to complete a significant body of original market research. However, this choice will not always be available, specifically where the data required to utilise a indirect market approach is not available or not of the required quality.

TABLE 4.4: ASSESSMENT OF VALUATION TECHNIQUES					
	Technique				
	Indirect				Direct
			Surrogate Market		
Aspect	**Dose-response/ Shadow pricing**	**Expert Opinion**	**Hedonic Pricing (HP)**	**Travel Cost Method (TCM)**	**Stated Preference**
'Physical' Data Problems	Yes	Yes	Yes	Yes	No
Benefit Function?	Assumed	Assumed	Yes	Yes	Yes
Sophistication	High	Low	High	High	High
Relation to Behavioural Theory	No	No	Yes	Yes	Yes
Problems	Sensitivity to model specification.	Based on individual opinion. Difficulty of isolating individual impacts.	Sensitivity to model specification. Free markets important.	Sensitivity to model specification. Travel time cost measurement. Influence of site substitutes.	Bias(1) - strategic; - method of payment; - information. WTP/WTA disparity
Special Features	Only method for many issues. Requires separate valuation technique.	-	Can be cross-checked with CVM.	Use limited to recreation. Can be cross-checked with CVM.	Can cover existence values. Direct methods only solution for many issues.

Source: Adapted from Pearce & Markandya (1989)
Notes: (1) Starting point and learning bias are additional issues with the Contingent Valuation Method.

4.9 National Strategic Factors

PEM defines **National Strategic Factors (NSF)** *as "national benefits that are valued by road users or communities, but are not captured elsewhere in the evaluation process."* It notes that for separate inclusion in project evaluation, NSFs have to meet four criteria which (in summary) are:

- be material to the project's ranking
- comprise national economic benefits (not transfers between areas)
- are not counted elsewhere in the procedures
- would be valued in a normal market.

PEM notes that two specific categories of NSFs that meet these criteria have been identified:

- provision for security of access
- provision for investment option values (e.g., provision of extra capacity or flexibility – for future expansion)

It also notes that other NSF categories may be accepted provided they meet the four criteria.

In regard to the valuation of NSFs, PEM states that:

- *"NSFs are to be valued by undertaking a rigorous willingness – to-pay survey or other non-market valuation technique.*
- *There may be a number of different valuation techniques that are appropriate. It is recommended that expert advice be sought before embarking on any significant exercise to value NSFs using non-market valuation techniques."*

Taking the security of access NSF as an example, the WTP of road users (and non-users) for security of access can, in principle, be assessed through the SP/CA approach. Contingent valuation or transfer price methods may be applied, essentially to determine respondents' maximum WTP [probably per year] to have a guaranteed route as against one with a small but finite risk of closure. A slightly different but related approach is that used in determining the value of statistical life (Section 3.6): this would assess user WTP for changes in a [small] probability of disruption, e.g., from 2 days per year to 1 day per year (due to floods, say), and then would extrapolate from this result. The former approach appears more appropriate in this example, as the **guarantee** of access is of primary importance rather than changes in the finite chance of disruption. The former approach would need to be applied to all members [a random sample] of the affected communities, not just road users. However, care would be needed to avoid double-counting of any additional road user costs in the event of disruption.

The recent Transmission Gully WTP surveys (Section 3.5) provide an example of the broad type of approach appropriate to establishing the WTP for NSF, inasmuch as they involved:

- A random survey of the communities of interest (although maybe not broad enough to establish total WTP values).
- An attempt to establish the maximum WTP of these communities for a new facility (additional to conventional road user benefits).

Clearly the double-counting issue is of major concern in the successful design and implementation of such WTP surveys.

GLOSSARY

G.1 Evaluation Frameworks

Social Cost Benefit Analysis (SCBAs). Relates the benefits and costs of government investment to the goal of maximising social welfare, with inputs and effects stated in monetary terms. Even difficult-to-quantify effects are monetarised and thereby reduced to a common measure. Intangible effects which defy expression in monetary terms are treated qualitatively.

Planning Balance Sheet (PBS). A derivative of the SCBA framework, which uses public surveys to determine the value of difficult-to-quantify effects.

Modified Social Cost Benefit Analysis. A modified SCBA framework in which benefits to a target group or region are distinguished from benefits to the remainder of society.

Economic Impact Analysis (EIA). Describes the eventual effects of a transportation investment on the local economy. Net changes to profits, wages, taxes, business income, and employment are determined for relevant sectors of the local economy.

Multiple Criteria analysis (MCA). Characterised by selected objectives and a weighting system which reflects the priorities of the decision maker or the public. A mixture of monetary and non-monetary benefits and costs is possible.

Cost Effectiveness Analysis (CEA). A framework in which one objective is quantified (other than monetarily) and alternatives are ranked either by minimising the cost to achieve a specific objective, or by maximising the objective for a fixed investment.

G.2. Cost Benefit Analysis Concepts

G.2.1 Social cost benefit analysis (SCBA or CBA)

CBA is a tool for determining whether proposed changes in patterns of resource use will be of benefit to the community as a whole. In broad terms, the measure of benefit is determined by the degree to which any proposed pattern of resource use will satisfy the demands of individuals in the community. Cost are represented by the valuation the community places on the resources required to satisfy those demands.

CBA is the most comprehensive of the economic evaluation techniques. It assigns monetary values to all the major costs and benefits associated with a project. The key strength of CBA is that it considers the costs and benefits of alternatives on a consistent basis. Thus the outcomes for a range of alternatives and translated into comparable money values which facilitates evaluation and decision making.

CBA is an analytical too, of the branch of economics as being economics called 'welfare economics'. Welfare economics addresses the economic problems, which is to satisfy the demands of individuals in the community for goods, services and amenities within the community's available resources.

G.2.2 Economic efficiency

Any given allocation of resources is defined as being economically efficient if, by altering the allocation, no individual could be made better off without another individual being made worse off at the same time. A change in resource allocation would increase economic efficiency if those individuals who benefited from the change were able to compensate those who lost, such that the gainers would be better off and the losers no worse off as a result of the change. The test for economic efficiency has two components:

- Firstly, the change in resource use must be 'technically efficient' – it should not be possible to produce a greater output by any reorganisation of inputs.
- Secondly, the change in resource use must be 'allocatively efficient'. That is, it must be consistent with the preferences of individuals in the community. A given pattern of resource use would be allocatively inefficient if a different use of resources could enhance the net economic welfare of the community, by making some individuals better off without anyone being made worse off.

A project is seen as economically efficient is its benefits exceed its costs, where:

- The benefits represent the amount of money that the community would be prepared to pay to experience the satisfactions arising from the improvement.
- The costs represent the community's valuations of the resources required to implement an improvement.

G.2.3 The Pareto concept

The decision in CBA derives from the Pareto improvement test, which has two elements:

- Individuals who gain by a change in resource use would be able, if required, to compensate individuals who lose, such that the gainers would remain better off after paying compensation and the losers would be no worse off after receiving compensation. That is, the change in resource use would produce positive net benefits.
- No change in resource use could be made without making the losses to those who lose by the change greater than the gains to those who are made better off. In other words, no further change in resource use would produce positive net benefits.

In practical terms (i) means that an individual resource change such as a road improvement should produce a surplus of benefits over costs. The concept is extended in (ii): all changes in resource use should be ranked one against the other in terms of their net benefits or net benefit ratio. If (ii) did not hold, greater benefits could be achieved by further reallocation of the available resources.

G.2.4 Willingness to pay

Willingness to pay is central to the concept of economic efficiency. It provides the link between individual preferences, benefits and resources.

Willingness to pay represents the amount of income individuals would be prepared to sacrifice in order to consume the resources required to satisfy their demands. Willingness to pay is the mechanism by which the market rations scarce resources among competing demands. Resources are allocated to individuals who are prepared to pay the most for them. The benefit individuals derive from the use of resources in satisfying their demands for goods, services and amenities is measured by their willingness to pay for the resources required to satisfy those demands.

Market price are a reflection of individuals' combined willingness to pay for the satisfactions arising from the consumption of goods and services. Benefits represent willingness to pay. It is not necessary in welfare economics for payment to be actually made before a benefit accrues. Nevertheless, benefits represent the amounts individuals would pay, if required, for the satisfactions they derive from the consumption of goods and services. In the roads context the good being consumed in access. The benefits of a road improvement represents the satisfactions individuals experience from an improvement in access. If the community's willingness to pay for a given improvement in access at least equals the opportunity costs of supplying it, then provision of that level of road access would be economically efficient. Within the available road authority budget, that improvement would be implemented on economic grounds provided there was no other project promising a greater surplus of benefits over costs.

In road projects, savings in user travel time and vehicle operating costs resulting from road improvements are considered as proxy or surrogate measures of users' willingness to pay for the satisfactions arising from the improvements. The analysis assumes that the amount users would be willing to pay for an improvement would at least equal the value of these savings.

Accident cost savings differ from user cost and maintenance cost savings in that the resource saving does not necessarily accrue either to the road use or the agency. Others may be advantaged by improvements that enhance safety. The range of beneficiaries could include the relatives of potential accident victims, their employers, and property owners adjacent to the road infrastructure, insurers and the public health system.

While these individuals or organisations might not always perceive (or wish to perceive) the benefits of road safety works, the potential benefits are real. Recognising this, the inclusion of accident benefits in CBAs reflect the acceptance by society as a whole of the need to reduce accident benefits, and accordingly a willingness to pay the costs associated with accident reduction.

Willingness to pay is therefore an important element of the economic efficiency concept. It is, in effect, the link between consumer preferences and allocative efficiency. Resources are allocated efficiently when they satisfy those individual preferences for which there is the highest willingness to pay.

Economic welfare refers to the economic welfare of individuals. In economic theory, the community's welfare is the sum total of the welfare of individuals. Therefore, regardless of the priorities or objectives that determine public expenditure programs, the economic welfare implications of those programs are measured by reference to their impact on the economic welfare of individuals. This underlying assumption of welfare economics theory sometimes leads to the application of 'weights' to some categories of benefits and costs in order to achieve outcomes consistent with wider sets of community objectives. In cost benefit analysis, the derivation and application of weights is a political rather than an economic consideration.

G.2.5 Resources and costs

Costs in a freely functioning market represent opportunity costs, that is, the market's valuation of resources in their highest alternate use. The concept of opportunity cost reflects the reality that the community's demands for resources typically exceed the resources available.

Most, if not all the resources consumed in road making could be used to satisfy other demands in the community, and their price reflects their opportunity cost, or the value they could fetch in those alternative uses. For each road improvement, CBA seeks to establish whether the benefits to be obtained from using these resources for road making would be at least as great as in the next highest valued alternative use.

The general approach adopted should be to identify and include in the analysis at resource cost all the resources required to implement the road improvement under investigation.

G.2.6 Shadow pricing

In many instances the market prices for goods and services do not equate with their economic cost (also termed national resource costs). This difference may occur as the result of transfer payments such as taxes, duties and subsidies, or of market imperfections such as monopolistic pricing or other factors.

When performing a CBA it is necessary to substitute the market price of items with a cost that takes account of these differences., This technique is termed shadow pricing.

G.2.7 Externalities

Externalities are costs and benefits which stem from projects but which do not reside with the roading authority or road users. Because cost-benefit analysis takes the national viewpoint, these other costs and benefits shall also be considered.

Examples of externalities are inconvenience caused to pedestrians by traffic, effects of noise and air pollution on nearby properties, and productive gains which result from eliminating dust by sealing roads.

Externalities shall not be included when these merely represent a transfer of advantage from one person or area to another (for example, a change of traffic flow may benefit one service station at the expense of another).

G.2.8 Intangibles

Intangible effects are effects of projects which are not readily converted to monetary terms.

Intangible effects are those for which there is currently no market, and so there is no established price to act as a guide to their value, although in some cases approximate unit prices have been developed. Common examples of intangible effects in roading projects are noise, air pollution, and the barrier or severance effects of roads and traffic streams.

Some intangible effects are capable of quantitative measurement in natural units while others need to be described in more qualitative terms.

G.3 Methods of Valuation

G.3.1 Valuation methods – general

Impacts to be valued may be categorised into four groups:

(A) Impacts for which prices exist in the market. Market-based prices are a key indicators of values of impacts – subject to adjustment where necessary for market failure problems, taxation, etc.

(B) Impacts for which prices can be imputed from quasi-market observations. These methods are described in more detail below.

(C) Impacts that are best assessed using weighting techniques. These techniques are usually used when prices cannot be inferred. There are a number of such multi-criteria techniques. They seek to describe diverse impacts in similar terms so that trade-offs and comparisons can be made. They reduce the impact information to a set of score numbers, and involve pair-wise comparisons to derive the best solution or a partial ranking of alternatives.

(D) Impacts that are best indicated by qualitative descriptions. Such impacts may be divided into two groups; those that cannot be valued because no adequate study of the effects exist; and those where valuation might be wrong in principle because they are irreplaceable or their effects irreversible. The first group may be addressed by expert opinion; the second group by highlighting trade-offs required.

G.3.2 Direct valuation (stated preference) methods

Direct procedures seeks directly to measure the money value of any impacts. This may be done by looking for a surrogate market or by experimental techniques.

The surrogate market approach looks for a market in which goods or factors of production (especially labour services) are bought and sold, and observes that environmental benefits or costs are frequently attributes of those goods or factors. Thus a fine view or the level of the air quality is an attribute or feature of a house, risky environments may be a feature of certain jobs and so on.

The experimental approach simulates a market by placing hypothetical valuations of real improvements in specific environments. The aim is to make the hypothetical valuation as real as possible.

G.3.2.1. *Contingent valuation method (CVM)*

Contingent valuation method uses a direct approach, ie, basically asking people what they are willing to pay for a benefit and/or what they are willing to receive by way if compensation to tolerate a cost or loss. The process of asking may either be through a direct questionnaire/survey, or by experimental techniques in which subjects respond to various stimuli in 'laboratory' conditions. The technique is so named because the value it estimates are contingent upon the hypothetical situation described to the respondent.

One of the main advantages of this approach is that it permits estimation of both use and non-use benefits. CVM design issues are discussed in more detail elsewhere.

G.3.2.2. *Conjoint analysis (or trade-off or stated choice analysis)*

As with contingent valuation, conjoint analysis seeks willingness to pay values by asking people directly, rather than inferring values from observations of people's behaviour. Conjoint analysis reveals how people make complex judgements. The technique assumes that complex decisions, including route choice decisions, are based not on a single factor or criterion, but on several factors 'considered jointly'.

Conjoint studies pose a series of choice decisions about products or services. This method reveals people's preferences in a realistic manner, and enables an assessment of the weight or value people give to various factors that underlie their decisions.

CA methods have the following characteristics:

- They involve the presentation to individuals ('respondents') of hypothetical options.
- These options represent 'packages' of different items (often known as 'attributes') which usually represent a particular 'product' or service.
- The values of the attributes in each option are specified by the researcher and usually presented in the context of respondents' present situations.
- The options are usually constructed in the basis of an experimental design, which ensures that variations in the attributes are statistically independent from one another (some recent developments, however, depart from the use of strict experimental designs); (conjoint measurement).
- The respondents state their preference toward each option by either ranking them in order of importance, rating them on a scale indicating strength of preference (functional measurement); or simply choosing the most preferred option from a pair or group of options (choice – based experiments).

The advantage of conjoint analysis over contingent valuation is that it provides an emphasis on trade-offs between different factors and provides a comparison between tangible costs and intangible costs. However, this may mean that people require more information than is usually available in order to make valuations about goods they do not usually think about.

G.3.3 Indirect valuation (revealed preference) methods

Indirect procedures for benefit estimation do not seek to measure direct preferences for the good in question. Instead, they calculate a 'dose-response' relationship between direct impact (say pollution) and some effect, and only then is some measure of preference for that effect applied. Examples of 'dose-response' relationship include the effect of pollution on health, and the effect of pollution on aquatic ecosystem.

Indirect procedures do not constitute a method of finding the willingness to pay (WTP) for the environment benefit or willingness to accept (WTA) compensation for environmental damage suffered. They estimate the relationship between the 'dose' (eg pollution) and the non-monetary effect (e.g. health impairment). Only then the WTP measures are applied taken from direct valuation approaches.

G.3.3.1 *Travel cost method (TCM)*

This valuation method is appropriate for valuing the loss or modification of outdoor recreational areas pot areas of special significance. The basic approach is to conduct a survey of visitors to the recreational asset (or area of special significance), and to obtain data on how visitation rates from different centres vary with the associated travel from those centres to the site. This enables estimation of consumer surplus (net benefits) for those visiting the site. The method is particularly useful for recreational facilities, but does not take into account the value placed on the site by those who do not visit it.

G.3.3.2. *Dose/response relationship*

This indirect means of quantifying an intangible effect attempts to relate cause and effect, and to put a monetary value on the effect and hence a cost on the cause. As an example, estimates of health costs of certain environmental effects (eg motor vehicle air pollution) are sought. This value is then applied across the roading network and a cost per vehicle kilometre (or some other emission based parameter) derived.

There are difficulties in collecting accurate estimates of the dose and of the relationship between dose and response. There are wide variations in the interpretation of 'health' and estimates of the degree to which land transport contributes to illness and disease (including stress-related illness). While this method of valuation does not readily lend itself to application for specific roading projects, it may provide indicative national values where health costs can be adequately determined, (provided that the health cost for non-traffic-related factors is excluded). Health costs may be particularly important in assessing relative costs and benefit of alternative urban transport systems.

G.3.3.3. *Hedonic price method (HPM)*

The hedonic price technique is built upon the notion that it is often possible to choose the level of consumption of environmental goods, such as noise and air pollution, through the choice of residential location or selection of market goods. The technique uses statistical analysis to isolate the environmental values that contribute to differences in product price, typically price differences observed in real estate markets.

Property values are determined by various factors such as output derived from property shelter usefulness, access to workplace, to commercial amenities and to environmental facilities such as parks, and the environmental quality of the neighbourhood in which the property is located. Given that different locations have varied environmental attributes, such variations will result in differences in property values. These valuations might be used as an input to benefit cost analysis or considered in isolation where the valuation of the environmental attribute is of primary interest.

The 'hedonic' approach attempts to:

- Identify how much of any property price differential is due to a particular environmental difference between properties;
- Infer how much people are willing to pay for an improvement in the environmental quality that they face and what the social value of improvement is.

HPM is not suited to the assessment of non-user or 'conservation' values. Hedonic prices may also reflect short term ignorance of the true effects (which would be reflected in such things as faster turnover of houses in areas with high noise). (Comparisons of 'willingness-to-pay' with changes in property values suggests that true total costs of noise and vibration are four to six times as great as hedonic values suggest.)

A simplified HPM approach may involve commissioning a registered valuer to appraise the effects of a road project on house prices. If traffic is diverted onto or away from a particular route there will potentially be changes in house prices, both on the route that receives more traffic and on the route that has reduced traffic. These potential changes in house prices will be the result of increased/decreased traffic intimidation, etc. Any actual house price movements will occur only after a project has been committed, whereas for evaluation purposes it is necessary to judge the magnitude of any potential changes prior to the event. Hence the use of a registered valuer who is knowledgeable about the influence of such factors, to determine likely house price changes.

G.3.3.4 *Mitigating measure costing*

In this method, the cost of mitigating a particular intangible effect is calculated. If this method entirely mitigates the effect, the cost of mitigation provides an effective upper bound to the environmental cost. Since on the one hand complete mitigation is most unlikely, and on the other hand the cost of mitigation may exceed the damage caused, this method is not recommended. It should only be used if no other method is available, and a caveat about the likely direction and possible size of error should be attached to the results.

G.3.4 Use and Non-Use Benefits

Use benefits are those that accrue from the physical use of resources – such as the benefits to productive activities (eg agriculture, forestry, fishery) of preserving or improving the environmental amenities and the benefits derived from activities such as visiting a park, recreational fishing or appreciating a view at a look-out.

Non-use benefits are generally classified into five types:

- **Existence value** – value obtained from the knowledge that an environmental amenity exists.
- **Vicarious value** – value obtained from indirect consumption of an environmental amenity through print or media.
- **Option value** – value obtained by retaining the opportunity to use an environmental amenity at some future date.'
- **Quasi-option value** – the value of the opportunity of obtaining better information by delaying a decision that may result in irreversible environmental loss.
- **Bequest value** – value the current generation obtains from preserving the environment for future generations.

G.3.5 Willingness-to-Pay/Willingness-to-Accept

In the application of CVM, respondents are asked questions designed to elicit their willingness to pay (WTP) for a gain or their willingness to accept (WTA) compensation for a loss. The survey technique may be to ask direct questions on WTP/WTA or this is deduced from responses to questions in which respondents are asked to rate or rank two or more options in a structured questionnaire. When asked directly about willingness to pay for or to accept a financial incentive for environmental gain or loss, the technique is often referred to as a 'bidding game'; or as 'transfer pricing' where the aim is to bid the price u[p or down to a level at which a distinct switch between choice options is triggered.

WTP and WTA values may differ significantly. For example, in the context of traffic noise, Barde and Alexandre (1987) suggested that questions about WTP and WTA will result in different valuations since the sum of money requested in compensation for noise nuisance is likely to be greater than the willingness to pay for noise reduction, even if willingness to pay does not imply an actual payment. It is argued that people consider quiet to be a 'natural right' for which they should not have to pay, but for which they should be compensated if they suffered any loss of this 'right'.

Practical use of CVM has therefore shown that quite different results can be anticipated if questions concerning an environmental asset are framed as a WTP for an improvement or as WTA an environmental loss. It has been suggested elsewhere (RTA NSW, 1999) that if a WTA compensation method is used, then the resulting value should be divided by 3 to get an acceptable value for use in project evaluation.

REFERENCES

A. Valuation Methods

Adamowicz, W., Louviere, J. and Williams, M. (1994). 'Combining Rescaled and Stated Preference Methods for Valuing Environmental Amenities'. *Journal of Environmental Economics and Management,* 26, pp 271-292.

Bateman, I. (1994). 'Contingent Valuation and Hedonic Pricing: Problems and Possibilities'. *Landscape Research,* 19(1), 1994.

Bateman, I., Turner, R. K. and Bateman, S. (1993). 'Extending Cost Benefit Analysis of UK Highway proposals: Environmental Evaluation and Equity'. *Project Appraisal,* Vol. 8, No. 4, December 1993.

Baughan, C. J. and Savill, T. A. (1994). Contingent Valuation Questions for Placing Monetary Values on Traffic Nuisance'. Transport Research Laboratory Project Report 90 (unpublished).

Benson, J. F and Willis, K. G. (1990). 'The Aggregate Value of the Non-priced Recreation Benefits of the Forestry Commission Estate' Report to the Forestry Commission, University of Newcastle Upon Tyne.

Bishop, R., Heberlein, T. and Kealey, M. J. (1983). 'Contingent Valuation of Environmental Assets: Comparison with a Simulated Market'. *Natural Resources Journal,* Vol. 23.

Boyle, K. (1985). 'Starting Point Bias in Contingent Valuation Bidding Games'. *Land Economics,* 61(2).

Brookshire, D. S., Ives, B. C. and Schulze, W. D. (1976). 'The Valuation of Aesthetic Preferences'. *Journal of Environmental Economics and Management, Vol. 3.*

Button, K. (1993). Transport the Environment and Economic Policy, Elgar.

Coker, A. & Richards, C. (1992). Valuing the Environment: Economic Approaches to Environmental Evaluation. Bellhaven Press, London and Florida.

Coursey, D. L., Hovis, J. J. and Schulze, W. D. (August 1988). 'The Disparity between Willingness to Accept and Willingness to Pay Measures of Value'. *Quarterly Journal of Economics* 102, pp 679-90.

Dale, H. M et al. (1996). 'Are There Quantifiable benefits From Reducing the Variability of Travel Time?'. PTRC SAM D/E Part 2, 1996.

Department of the Environment, Australia (1998). 'A Handbook of Environmental Evaluation'. Australia, (http://www.environment.gov.au/epcg/eeu/publications)

Dixon, J. A. and Hufschmidt, M. (1986*) Economic Valuation Techniques for the Environment.* John Hopkins University Press.

Fowkes A. S (1991), Recent Developments in Stated Preference Techniques in Transport Research, 19th PTRC Summer Annual Meeting.

Gerking, S. and Stanley, L. (1986). 'An Economic Analysis of Air Pollution and Health: The Case of St. Louis, *Review of Economics and Statistics*. Vol. 68, pp 115-121.

Hague Consulting Group (1990). 'The Netherlands' Value of Time Study: Final Report'. February 1990.

Hanley, N. (1988). 'Using Contingent Valuation to Value Environmental Improvements'. *Applied Economics*, 20, pp 541-549.

Harley and Hanley, (1998), cited in Rendal Planning (1992) 'Environmental Appraisal: A Review of Monetary Evaluation and Other Techniques'. TRRL CR290.

Hartman, R.S., Doane, M.J., Woo, Chi-Keung, (1991). Consumer Rationality and the Status Quo, *The Quarterly Journal of Economics*, February 1991.

Hensher, D. A. (1994). 'Stated Preference Analysis of Travel Choices: The State of Practice', *Transportation*, 21, 1994.

Johansson, P-O. (Spring 1990). 'Valuing Environmental Damage'. *Oxford Review of Economic Policy*, Vol. 6, No. 1.

JMP Consultants Ltd. (1996). 'Monetary Valuation of Traffic Nuisance'. Department of Transport, UK, (unpublished).

Kahneman, D. and Tversky, A. (1984). 'Prospect Theory: An Analysis of Decision-Making Under Risk'. *Econometrica*, 47, pp 263-291.

Knetsch, J. and Sinden, J. (1984). 'Willingness to Pay and Compensation Demanded: Experimental Evidence of an Unexpected Disparity in Measures of Value'. *Quarterly Journal of Economics*. Vol. 99 pp 507-521.

Larsen, O. I. (1985). 'Road Traffic and the Value of Housing Properties'. Project Report, Institute of Transport Economics, July 1985.

Levesque, T. J. (1994). 'Modelling the Effects of Airport Noise on Residential Housing Markets'. *Journal of Transport Economics and Policy*, May 1994.

Louviere, J. J., Schroeder, H., Louviere, C. and Woodworth, G. C. (1987). 'Do the Parameters of Choice Models Depend on Differences in Stimulus Presentation: Visual v Verbal Presentation'. *Advances in Consumer Research*, Vol. 14.

Magat, W. A., Viscusi, W. K. And Huber, J. (1988). 'Paired Comparison and Contingent Valuation Approaches to Morbidity Risk Valuation'. *Journal of Environmental Economics and Management*, 15, pp 395-411.

Mitchell, R. C. & Carson R. T. (1989). 'Using Surveys to Value Public Goods'. Resources for the future.

Nash (ed.) (1990). 'Appraising the Environmental Effects of Road Schemes: A Response to the SACTRA Committee'. Institute for Transport Studies, The University of Leeds, Working Paper 293, April 1990.

Nelson, P. S. (1998), 'The Monetary Valuation Of The Environmental Impacts Of Road Transport : A Stated Preference Approach' PhD Thesis, Cranfield School of Management, Cranfield University, UK.

Pearce, D. W. and Markandya, A. (1989). 'Environmental Policy Benefits: Monetary Valuation'. OECD.

Pearce, D. W. and Turner, R. K. (1990). *Economics of Natural Resources and the Environment*. Wheatsheaf, Brighton.

Pearmain, D., Swanson, J., Kroes, E. and Bradley, M. (1991). 'Stated Preference Techniques: A Guide to Practice'. 2nd edn, Steer Davies and Gleave and Hague Consulting Group.

Randall, A. (1983). 'The Problem of Market Failure'. *Natural Resource Journal*, 23(1).

Rendel Planning and Environmental Appraisal Group, University of East Anglia (1992). 'Environmental Appraisal: A Review of Monetary Evaluation and Other Techniques'. Transport Research Laboratory Contractor Report 290.

Rowe, R., d'Arge, R. and Brookshire, D. (1980). 'An Experiment of the Economic Value of Visibility'. *Journal of Economics and Management*, 7, pp 1-19.

SACTRA (March 1992). 'Assessing the Environmental Impact of Road Schemes'. SACTRA, HMSO, UK.

Schulze, W. D., d'Arge, R. C. and Brookshire, D. S. (1981). 'Valuing Environmental Commodities: Some Recent Experiments'. *Land Economics*, Vol. 57 pp 151-172.

Schulze, W and Schulz, E. (1989). 'The Use of Benefits Estimates in Environmental Decision-Making: A Case Study on Germany'. OECD

Sheldon, R. (1997). 'Developing Methodologies and Obtaining Values: An Introduction to the Key Issues. Determining Monetary Values of Environmental Impacts – Enhancing the Quality of Transport Decision-Making'. University of Westminster.

Steer Davies Gleave (1995). Bus Passenger Preferences. Report to London Transport Buses.

Sugden R (1998). 'The Treatment of Taxation in the Cost-Benefit Appraisal of Transport Investment'. Report for DETR, UK, April 1998.

Swanson, J.(1997). The Consultants Experience, PTRC Stated Preference Course, November 1997.

Turner, R. K. (ed) (1988). 'Sustainable Environmental Management: Principles and Practice'. ESRC, Belhaven Press.

B: Travel Time And Level Of Service

Algers and Widlert (1985). Application and Stability of Logit Models in Sweden – Some Recent Findings with Policy Implications. Office of the Public Transit Board, Stockholm County Council.

Algers S, Dillen J. L. and Widlert S. (1996). 'The National Swedish Value of Time Study. PTRC Value of Time Course and Seminar, October 1996.

Austroads (1996). Value of Travel Time Savings. AP 119.

Bates J. and Glaister, S. (1990). The Valuation of Time Savings for Urban Transport Appraisal for Developing Countries: A Review. Report prepared for the World Bank, Washington D.C.

Bates, J. J. (1987). Measuring Travel Time Values with a Discrete Choice Model: A Note, *Economic Journal*, 97, 493-498.

Beca Carter Hollings & Ferner (1992). Working Paper on the Value of Travel Time Savings. Report to Transit New Zealand. May 1992.

Black I. G. and Towriss J. G. (1990). Quantifying the Value of Uncertainty in Travel Time. Paper to PTRC Summer Annual Meeting, Senior H.

Booz·Allen & Hamilton and Hensher D. A. (1997). 'Travel Time Values – Stage 1: Theoretical Framework and Research Outline'. Report to Transfund New Zealand.

Booz·Allen & Hamilton and Hensher D. A. (2000). 'Valuation of Travel Time Savings – Market Research'. Report to Transfund New Zealand.

Bradley, M. A and Gunn, H. F. (1991). Further Application and Validation of the Netherlands Value of Travel Time Study. 6th International Conference on Travel Behaviour, Quebec, May 1991.

Bruzelius, N. (1979). *The Value of Travel Time: Theory and Measurement.* Croom Helm, London, 1979.

Calfee J and Winston C, (1996). 'The Value of Automobile Travel Time: Implications for Congestion Policy'. October 1996.

Cox, B. E. (1979). 'The State-of-the-Art of the Methodology for the Establishment of Values of Travel Time'. Report to NZ National Roads Board. March 1979.

Department of Transport UK (1987). 'Values for Journey Time Savings and Accident Prevention.

DeSerpa, A. J. (1972). A Theory of the Economics of Time. *Economic Journal* 81: pp 828-845.

Gunn H. et al. (1998). Value of Dutch Travel Time Savings in 1997. PTRC SAM Seminar E.

Hague Consulting Group (February 1990). The Netherlands 'Value of Time' Study: Final Report, February 1990.

Hague Consulting Group et al (1999). 'The Value of Travel Time on UK Roads – 1994. Final Report prepared for UK Department of Transport.

Hensher D. A. (1975). The Value of Commuter Travel Time Savings: Empirical Estimation Using an Alternative Valuation Model, *Journal of Transport Economics and Policy,* X, (2), May 1976, pp. 167-176.

Hensher D. A. (1977). *Valuation of Business Travel Time*, Oxford, Pergannon Press.

Hensher D. A. (1989). Behavioural and Resource Values of Travel Time Savings: A Bicentennial Update, *Australian Road Research,* 19 (3), 223-229.

Hensher, D. A. and Truong T. P. (1985). "Valuation of Travel Time Savings – A Direct Experimental Approach", *Journal of Transport Economics and Policy,* 19(3), 1985, pp 237-261.

Miller, T. R. (1989). The Value of Time and the Benefit of Time Saving. Report to the NZ National Roads Board, March 1989.

MVA Consultancy et al. (1987). The Value of Travel Time Savings, Policy Journals, Newbury, Berkshire.

Pursula M and Kurri J, (1997). 'Value of Time Research in Finland'.

Ramjerdi F., Rand L., and, Saelensminde K (1997). 'The Norwegian Value of Time Study – Some Preliminary Results. Institute of Transport Economics, Oslo, Norway.

Senna LADS, (1991). Risk of Delays, Uncertainty and Travellers' Valuation of Travel Time Variability. Paper to PTRC Summer Annual Meeting.

Travers Morgan (1997). Tourism Benefits from Sealing Unsealed Roads: Perceptions of Discomfort and Risk. Transit New Zealand Research Report 81.

Travers Morgan and Beca Carter Hollings & Ferner, (1997). 'Valuation of Travel Time Savings' Final Report to Transfund New Zealand.

Truong, T. P. and Hensher, D. A. (1985). Measurement of Travel Time Values and Opportunity Cost from a Discrete-Choice Model. *Economic Journal*, Vol. 95, No. 378, pp 438-451.

Wardman, M. (1998). The Value of Travel Time: A Review of British Evidence, *Journal of Transport Economics and Policy*, 32 (3), September pp 285-316.

Waters and Evans (1992). The Value of Time Savings for the Economic Valuation of Highway Investments in British Columbia. Centre for Transportation Studies, University of British Columbia.

C. Accidents

Brown Copeland & Company (1986). 'Synthesis of Accident Cost', Research. Road Research Unit, National Roads Board, Bulletin 75 Wellington, NZ.

Guria J. C. (1991). 'Estimates of Social Costs of Accidents and Injuries', NZ Ministry of Transport, May 1991.

Guria J. C. (1993). 'Social Costs of Traffic Accidents', NZ Ministry of Transport, August 1993.

Guria J. C. et al (1999). 'The Value of Statistical Life and Prevention of Injuries in New Zealand'. Draft Report,NZ Land Transport Safety Authority, April 1999.

Miller T. R. and Guria J. C. (1991). 'The Value of Statistical Life in New Zealand'. NZ Ministry of Transport, May 1991

D. Evaluation Manuals

ARRB Transport Research (1999). Road User Costs for Use in the Economic Evaluation of Road Expenditures: Unit Values as at 30 June 1997 and 1998, January 1999.

Austroads (1996). Benefit Cost Analysis Manual

British Colombia Ministry of Transportation and Highways, (1992). The Economic Appraisal of Highway Investment: A Guidebook.

Queensland Department of Main Roads (1999). Cost Benefit Analysis Manual – For Road Infrastructure Investment.

Roads and Traffic Authority NSW (1999). Economic Analysis Manual.

South African Roads Board (1994). 'Cost-Benefit Analysis of Rural Road Projects:' Program CB-Roads Users Manual', August 1994.

Transfund New Zealand (1997). Project Evaluation Manual. Manual No. PFM2. First Revision, May 1997.

Transfund New Zealand (1999). 'Evaluation Procedures for Alternatives to Roading'. Manual No. PFM5, February 1999.

UK Department of Environment (1996). Design Manual for Roads and Bridges.

E. Road User Views

AGB McNair (1995). A Survey of Users' Satisfaction with Australian Roads. Final Draft Report. Prepared for AUSTROADS USI Working Party.

ARRB Transport Research (1998). A Framework for Demonstrating that Road Performance Meets Community Expectations. March 1998.

Austroads (1999). Community Expectations of Levels of Service on Roads, February 1999.

Department of Infrastructure, Energy and Resources, Tasmania (1999). Lyell Highway (Granton to New Norfolk) Road User Satisfaction Score, December 1999.

Nielsen A. C (1998). 'State Highway Satisfaction Survey'. Research Report prepared for Transit New Zealand, September 1998.

F. Other New Zealand References

McDermott Miller Ltd (1999a). Transmission Gully Community Survey: Report on Household Survey of Regional Residents, May 1999.

McDermott Miller Ltd (1999b). Transmission Gully Community Survey: Stage II – Face to Face and Household Telephone Willingness-to-Pay Surveys, November 1999.

Steer Davies Gleave (1992). 'Private Sector Funding for Transmission Gully'. Final Report for Transit NZ, December 1992..

Wellington Regional Council (2000). 'Western Corridor Implementation Plan : Report of the Technical Group', April 2000.

APPENDIX
CATEGORISATION OF ROAD FACTORS CONTRIBUTING TO ROAD USER 'LEVEL OF SERVICE' PERCEPTIONS

A1. Austroads user satisfaction index

The Austroads User Satisfaction Index (USI) has been developed as an overall indicator of user satisfaction with the road system and agency performance. This index is a complex construct of several factors of user valuations representing expected road performance outcomes. All four Austroads outcome dimensions – economic, social, safety and environmental - are represented in these factors.

AGB McNair (1995) was commissioned by Austroads to develop a benchmark USI. Forty-three attributes were developed that related to aspects of the road system and is management, such as road characteristics, social issues and safety. The performance of each of these attributes was ranked on a scale of 1 to 10, where 1 denotes extremely poor and 10 denotes excellent performance.

A factor analysis was employed to group the forty-three attributes used into fourteen factors. Each of these factors was then assigned an 'importance score' to reflect the level of importance that the community placed on each factor. To determine the relative contribution of each factor towards overall satisfaction (ie, importance) a regression analysis was used. The average mean performance score of each factor was then weighted according to its level of importance. The sum of all the factors' scores was calculated to determine the overall User Satisfaction Index.

Although the fourteen factors were deemed statistically meaningful for the USI's calculation, the Working Party simplified the factor categories into ten factor groups (no criteria for this selection has been specified). This indicator aimed to make the factor groupings more appropriate to agency functions and operations. Table A.1 outlines the components of each factor group (AGB McNair 1995).

Some of the 10 factor groups are not related to the features of the road itself. For a given road type, the most important factor group is 'Road Characteristics', which comprises five sub-factors as shown.

The review report includes the following interesting comments:

> *"An important finding of the study was the inverse correlation between the importance of the contributing factor group and the perceived performance of the road system."*
>
> [Comment: there may be a systematic reason for this, i.e., people classify factors as important because performance against these factors is perceived as poor.]
>
> *"A study of community expectations against levels of service should be confined to a single contributing factor group (and probably only one feature in that group) if further complications to the relationships are to be avoided. This assumes that fairly robust and defensible relationships between community expectations against levels of service are being sought."*

A.2 Austroads surveys of community perceptions

Table A2 presents the results of a Victorian community survey of factors that would influence motorists' perceptions of general road conditions. Panel members were asked to rate factors as high/medium/low in terms of their influence on their perception of general road conditions. Each factor was then scored by taking high = 3, medium = 2, low = 1 and summing the scores. The factors were then ranked (separately for urban and rural panels) according to their scores.

A3. Tasmanian road user satisfaction system

Table A3 shows the categorisation of road features used by DIER Tasmania in compiling its Road User Satisfaction Score (RUSS). This has been used in surveys of road user performance by deriving scores (performance relative to expectation) for each of the eight Detailed Performance Areas.

A4. New Zealand state highway satisfaction survey

Research undertaken by AC Nielsen for Transit NZ in 1998 categorised road features as experienced by users and assessed the relative importance of these features. Table A4 provides a summary of results.

It is perhaps notable that four main features (containing 16 sub-features) accounted for about 98% of the relative importance score:

- Traffic flow
- Road surface
- Safety aspects
- Appearance.

TABLE A.1: AUSTROADS USER SATISFACTION ROAD TRAFFIC COMPONENTS

Factor Group	Ave Contribution to User Satisfaction (Aust, National)	Factor	Attributes	Notes
1. Road Types	13.4%	Major Roads	Freeways Tollways	
		Country Roads	Major country roads other than freeways or tollways	
2. Road Characteristics	12.8%	Road Characteristics	Road shoulders and edges Road width Lane width Smoothness of road surface Absence of dangerous curves	
3. Road Features	10.0%	Signage	Regulatory signs Directional signs	
		Rest Stops	Rest stops on country roads	
		Street Lighting	Street lighting	
4. Traffic Management	10.2%	Traffic Management	Making travel times predictable from day to day Minimising delays due to unforeseen events Minimising delays due to road works	
5. Social	10.2%	Social	Low income families Country people 'Your own' social and leisure needs 'Your own' needs for other private business	Not directly relevant here
6. Communication	9.8%	Communication	Information about traffic delays Information about road rules and changes Road safety education for schools Community consultation about new roads and road planning Information about temporary road closures	Not directly relevant here
7. Environment	?	Environment	Control of vehicle air pollution Control of vehicle noise Protecting areas of significant flora and fauna Sensitivity towards cultural and heritage sites Care for the environment during road construction Roadside landscaping	Largely not relevant here
8. Customer Service	8.1%	Customer Service	Telephone service Ease of making payments of fees or fines Response to inquiries or complaints Counter service	Not directly relevant here
9. Safety	8.0%	Safety	Roadworthiness of trucks and buses Roadworthiness of private vehicles Driver competence	Not directly relevant here
10. Non-Motorised Users	7.0%	Non-Motorised Users	Safety for bicyclists Safety for pedestrians Needs of pedestrians Needs of bicyclists	

Source: AGB McNair, quoted in ARRB Transport Research (1998) and Austroads (1999).

TABLE A.2: RESULTS SUMMARY OF COMMUNITY QUESTIONNAIRE SURVEY		
Factors Influencing Perception of Service	**Rank – descending order**	
	Urban Vic	**Rural Vic**
Type of road surface	1	3
Quality of ride (roughness)	2	1
Potholes	2	1
Road signs	3	4
Safety	4	2
Edge wear	5	7
Road width	5	2
Drainage of surface	6	4
Road geometry (sharp curves, steep roads)	7	6
Other: line marking and road humps	8	9
Roadside vegetation	9	8
Rutting	10	5

Source: Austroads, 1999

TABLE A.3: TASMANIAN ROAD USER SATISFACTION SYSTEM

Primary Theme	Detailed Performance Areas	Individual Features
Road Hazards	Road Delineation	• Lighting • Cat's eyes • Curve/corner warning signs • Safety barriers • Median strip • Centre line and edge lines (visual/audible) • Reflective pavement markers • Guideposts, with reflectors for night-time delineation
	Roadside Issues	• Safety pull-over areas • Minor road intersections • Vegetation obstructing sight lines • Minor junctions • Fixed objects, eg, power poles, rock walls, safety barrier, bridge railings
Road Quality	Road Surface Condition	• Road roughness • Slipperiness • Edge drop off from seal to shoulder • Seal age • Surface texture (including patches/defects) • Road rutting (long channels along the road where the wheels go) • Cracking of the seal • Edge breaks – broken seal along the edge
	Road Alignment	• Slope (%) • Crossfall • Curves • Tight consecutive corners • Blind crests • Blind dips
Road User Amenity	Road Verge Quality	• Road verge width • Extent of native vegetation • Safe crossings for pedestrians • Extent of weeds • Extent of rejuvenation • Shoulders & verge wide enough for cyclists • Rehabilitation/erosion problems • Drainage problems • Visual amenity • Shoulder is smooth & clean for cyclists
	Driver Information	• Route/safety signage • Tourist information signage • Signage for services • Signage for roadside pull off areas • Signs easy to read and understand • Signs are well maintained • Authorised or legal signage
Traffic Conditions	Road Formation	• Traffic lane width • Shoulders (sealed/unsealed) • Shoulders – smooth for cyclists • Clear zone from edge of seal to hazards (eg, poles, drains) • Drainage and crossfall
	Traffic Queuing	• Bunching of cars, ie, cars queued behind slower vehicles • Traffic controls (eg, lights) • Roundabouts • Degree of saturation (how much waiting behind vehicles occur) • Speed limit • Overtaking opportunities

Source: DIER Tas, 1999

TABLE A4: IMPORTANCE OF NZ STATE HIGHWAY FEATURES			
Main Feature		Sub-Features	
Feature	**Relative Importance (1)**	**Feature**	**Relative Importance (1)**
Traffic Flow	30%	Number of passing lanes	43%
		Number/location of turning lanes	32%
		Road works that minimise disruption.	25%
Road Surface	28%	Smoothness	38%
		Surface grip	26%
		Consistency of surface	24%
		Efficiency of road maintenance work.	12%
Safety Aspects	23%	Width of road shoulders	28%
		Bend visibility	22%
		Number of guard rails	16%
		Number of median barriers	15%
		Unexpectedly having to slow for bends	14%
		Width of two lane bridges.	5%
Appearance	17%	Blend in with natural landscape	41%
		Appearance of grass areas	36%
		Amount of rubbish.	23%
Road Markings	2%	Speed of repair of reflective marker posts	38%
		Assistance by cats eyes	36%
		Visibility of paint markings in wet.	26%
Road Signs	1%	Number of direction and distance signs	19%
		Visibility of direction and distance signs	19%
		Understanding of direction signs at intersections	18%
		Visibility of road works signs	17%
		Accuracy of bend speed signs	16%
		Understanding of one-way bridge signs	9%
		Appropriateness of roadwork speed signs	2%
		Distraction of advertising billboards.	1%
Rest Area Facilities	0%	Toilets	76%
		Picnic areas	66%
		Rubbish bins	44%
		Drinking water	20%
		Shade	12%
		Barbecue	8%
		Grassed areas	6%
		Children's play area	6%

Source: A C Neilsen (1988) 'State Highway Satisfaction Survey'. Report to Transit New Zealand

Notes: (1) Relative importance scores were estimated from regression analysis; relating overall satisfaction to satisfaction with individual features. For main features, relative importance scores sum to 100%. For sub-features, (except Rest Area Facilities), relative importance scores sum to 100% for each main feature.

TABLE 2.1 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: TIME, COMFORT AND RISK ASPECTS

Country	Parameter Summary	Valuation Methods
NSW	• In RTA (1999), values based on ARRB (1999) • Base values are for: Car – working time Car – non-working time CV (occupants) CV (freight time). • Derives value per vehicle hour for differing traffic situations. • Notes that value for all other forms of non-work travel (including cycle, pedestrian, PT) and including waiting time is equal to that for car non-work travel.	• Refer ARRB (1999) and Austroads (1996). Austroads recommendations based on review of international practice (especially UK) without primary MR. • Unpaid private travel time: value at 40% of average hourly earnings of employed population. Applied to all modes (including waiting time). • Paid private travel time: value at average hourly earnings of employed population (including overheads, excluding PRT) – all modes. • Paid commercial travel time (commercial drivers): value at relevant award rate plus overheads (excluding PRT). • Freight (payload) travel time: value at 25% of hourly VOC. This recommendation subsequently amended by ARRB TR (1999).
Queensland	• In Qld Department of Main Roads (1999), values based on ARRB (1997/1999) • Base values similar to NSW (above) • Values per vehicle hour derived for differing traffic situations.	• As for NSW.
United Kingdom	• In UK DMRB – COBA/HEN2 (1996). Refer also UKDoT (1987). • Working time: values for vehicle occupants by mode (based on average incomes of mode users). Same values for walking, waiting etc time • Non-work time: single standard value for all in-vehicle time, equal to 43% of average hourly earnings of FT adult employees, which is equivalent to 40% of mileage-weighted hourly earnings of commuters. Also provides disaggregated values by people of working age, retired people and children, for use where traveller composition differs from national average. Walking/cycling values and PT waiting/transfer values are double in-vehicle time values • Notes issues of driver stress and travel time uncertainty, but that further research on this is required. • Future (real) values assumed to increase in line with growth in real GDP/capita. Notes that values are for use in evaluation only, not appropriate for forecasting.	• Developed from extensive MR program by UKDoT (MVA et al, 1987). Derivation of values from research findings is explained in UKDoT (1987) • Research programme involved 6 surveys relating to non-work time: - Car drivers with choice tolled/untolled route (RP/SP) - London commuters with choice coach/train (RP/SP) - W. Yorks commuters with choice car/bus/train (RP) - Long distance car drivers - choice between actual route and hypothetical free-flow routes with tolls (SP) - Long distance rail/coach passengers – choice between actual journey and hypothetical changes to fares, journey times, frequency, reliability (SP) - Local bus passengers – choice between actual journey and hypothetical changes in fares, journey time and waiting times/frequencies (SP) • Did not cover car passengers, cyclists, pedestrians (except for PT access) or children. • Key survey findings: - All surveys found higher IVT values than the previous DoT value (based on 25% of wage rate) - Values increased with household income - Values lower (c.25%) for retired people - Some evidence of higher values in congested conditions

TABLE 2.1 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: TIME, COMFORT AND RISK ASPECTS

Country	Parameter Summary	Valuation Methods
		- Other disaggregations mostly insignificant - Walking, waiting and unscheduled time for PT all valued more highly than IVT. • In deriving appraisal values from the survey findings, it was determined that: - A single standard value should continue to be used for appraisal purposes, based on the survey model results and the proportion of total travel time spent on each mode - Car passengers were treated as travellers generally - Average values for children were taken as 25% and for retirees as 67% of values for working age adults - Public transport access values (walking/waiting) taken as twice rate for IVT. • Empirically derived values were reduced by 17.3%, representing the proportion of indirect taxes (net of subsidies) in consumer expenditure in 1985.
British Columbia	• In BC Ministry of Transportation & Highways (1992) • Working time: base values for vehicle drivers/passengers by vehicle type (car/light truck, bus, medium truck/heavy truck) • Driver working time increased by factors for poor levels of service (D, E, F, stopped): maximum factor is 1.33 • Non-work time: separate base values for adults, retired, under 16. • Non-work time increased by factors for poor levels of service (D, E, F, stopped): maximum factor is 2.00.	• Values said to be based on a 1991 literature review (University of British Columbia). Noted that "surveys are being conducted in the province to validate these estimates". • Working time-base values: based on wage rate plus fringe benefits and some overheads. (Working time savings which translate into additional leisure are valued at the non-work rate.) • Working time factors (drivers) represent cost of personal annoyance or inactivity of these drivers in highly congested traffic. • Non-work time - base values: taken as 40% of the wage rate.
South Africa	• In SA Roads Board (1994) • Single value for all situations.	• Value said to be GDP per capita divided by 8760 hours per year(!).

TABLE 2.2 : RECENT INTERNATIONAL VTTS STUDIES – SUMMARY OF RESEARCH METHODS

Country	Methodology Summary	References
USA	• SP survey of auto commuters in major US metro areas who regularly drive to work and face some degree of congestion. • Conducted with survey respondents who are members of a well-known nation-wide mail panel • 67% response rate (mail back), 1,170 responses. • Abstract choice survey (not mode or route choice). • Asked to rank 13 cards. Each defined a scenario in terms of congested travel time, uncongested travel time, toll charge, whether trucks use the road. Also distinguished whether toll route was public or private, and use of toll revenue. • Findings: - Uncongested time – valued at very low rate (perceived as opportunity for commuters to relax between home and work) - Congested time – average value 19% of hourly wage rate, not sensitive to use of tolls - Congested time values increase slowly with income (income elasticity c.0.1) • Low VTTS results have major implications for urban road pricing and investment policies.	Calfee and Winston, 1996
Finland	• 1995 research to investigate car driver perceptions of attractiveness of different routes. • Stage 1: MOMB questionnaire to sample of Helsinki car owners. Respondents asked to show on map their normal commuter route and an alternative route. Used as basis of RP analysis. • Stage 2A: MOMB SP questionnaire on general factors influencing route choice, relating to home-work trip. Attributes were travel time, cost, frequency/duration of unexpected delays, type of roads. Respondents required to make 10 sets of choices between two alternative routes. • Stage 2B: Similar MOMB questionnaire but including toll charge. Attributes were travel time, fuel costs, toll, level of congestion, type of roads. Half the questionnaires referred to 'toll', the other half had the toll embedded in the travel cost. Again 10 sets of choices were offered per respondent. • All choices were between 2 alternatives, in each case with 3 or 4 attributes differing between the alternatives. • C. 450 responses, used to estimate logit route choice models. • Relevant findings: - SP VTTS results similar to RP results (Stage 1) - Time savings and time losses of similar value - Unit value for small savings/losses same as for larger savings/losses - Disbenefit from driving 1 minute on local road is equal to 2 minutes on a motorway - Mention of the 'toll' word corresponds to a disutility of 4 minutes in time (relative to equivalent in travel costs). • Main lessons learned relative to VTTS SP research - Desirable to combine RP and SP data - Tailor SP questionnaire to respondents by using RP data - Carefully designed MOMB questionnaires are satisfactory - Sample sizes need to be sufficient to allow segmentation by trip purpose and socio-economic factors - Special attention needed to the definition of the car cost variables.	Pursula and Kurri ,1997
Norway	• Major national Norwegian VTTS study, 1994-97. • Similar approach to British (1987) and Netherlands (1990) studies. • Used SP approach, with logit model applied to generalised cost of travel. • Also transfer price (TP) approach, with regression models used to estimate VTTS distribution.	Ramjerdi et al, 1997

	• Covered all modes: car travel through home interview (recruited by telephone), with 900 interviews and 79% response rate. • For SP, each respondent offered 9 paired choices, each involving alternative modes. Car mode specified in terms of cost, in-vehicle time and frequency of speed cameras (3 attributes in all games). • For TP (same sample), respondents were asked their WTP or WTA for specific improvements or deteriorations in travel time. Some of respondents were reminded of their budget constraint (other transport improvements; or improvements in other goods and services). • SP results - private travel (car travel): - VTTS lower for local trips, higher for non-local trips – but decreases for longest trips (>300 kms) - VTTS generally increases with income - VTTS higher for those who travel frequently (may be related to income effect) - VTTS lower for small time savings. • TP results: - Substantial proportion of respondents stated zero WTP/WTA for small time savings (greater percentage for WTP than WTA) - Values from SP and TP studies are comparable: SP values generally between WTP and WTA values from TP study.	
Sweden	• Major national Swedish VTTS study 1994. • Similar theoretical base and survey approach to the UK (1987) and Netherlands (1990) studies. • Used SP approach, with logit model applied to generalised cost of travel. • Covered all modes (car, air, long distance/regional train, long distance/regional coach). • For car travellers, recorded licence plates at selected locations, then contacted car owners, identified drivers and arranged telephone interview. • Samples of car travellers were 1,000 for private values (private/business trips), 200 for behavioural values (business trips) and 200 self-employed people. Response rates were 65% for private cars, 50% for company cars, 30-40% for self-employed. • Survey collected socio-economic information (respondent/household), trip information and responses to SP scenarios. For car users, SP scenarios simply involved in-vehicle time and cost factors. Each game involved choice between base alternative and a change from this. Careful attention paid to randomising factors to avoid bias. • Main results – private trips: - For local trips, value for commuting c.25% higher than for other purposes. Value for longer trips (> 50km) over double that for local trips. - Generally values increased with income, with this more pronounced if using individual incomes. • Main results – business trips: - Used Hensher formulation. - Found high proportion of travel time was used productively (even for car travel).	Algers et al, 1996
UK	• Major national UK VTTS study, 1993-94 following and updating the earlier (1985) UK study. • Involved following surveys: (i) Car drivers/passengers: 12 different questionnaires covering 5 SP games: - VTTS (journey time v cost) - Road characteristics (travel time, lorry access, number of lanes, hard shoulder). - Departure time (departure time, travel time). - Chance of delay (travel time, chance of unexpected delay, delay information). - Road tolling choice (journey time, travel cost).	Hague/Accent, 1999

	(ii) Freight and bus/coach operator survey, involving 2 SP games: - Within route options (total time, total costs, chance of unexpected delay, real time information). - Road tolling/route choice options (total time, total costs, real time information). (iii) Newcastle SP/RP survey; initial recruitment questionnaire to Tyne Bridge/Tunnel users, followed by 5 questionnaires using a joint RP/SP approach. Variables were petrol cost, toll charge, travel time (moving freely v delayed). • Results were summarised for this study, earlier UK study and Netherlands study, and VTTS variations and their causal factors examined by: - Journey context (purpose; mode; distance, road type and congestion level; car occupancy; whether travel costs reimbursed). - Person/household characteristics (income, occupation, age/gender, household composition, free time). - Travel time change (time savings v losses; large v small changes).	
Netherlands	• Major national Netherlands VTTS study, 1986-90, updated using identical methodology in 1997. • Started with 1 page recruitment survey, covering car drivers (at petrol stations and car parks) and train travellers (at stations). This established willingness to participate in main survey, and recorded details of current trip. • Main survey was through postal questionnaire. Involved 3 parts: - Questions regarding the reference (recruitment) trip. - SP survey, with respondents asked to make 12 pair-wise choices between alternatives of changes in travel time and cost (choices varied to suit the reference trip). - Questions regarding the respondent and the household. • Survey covered car drivers, train users and bus/tram users. • 12 questionnaire variants based on 3 travel modes and 4 total travel time classes – as determined at the recruitment stage. • 1997 survey target was 5000 usable interviews (commuter 2500, business 1000, other 1500): target set so as to be able to detect a 10% change in group average VTTS estimates (at the 95% level). • Valid SP returns from 1997 survey were used to estimate four choice models of time v cost trade-offs: - Logit model on 1997 data, with full segmentation variables. - Logit model on pooled 1988 and 1997 data (with/without time trend term). - Logit model with less segmentation, estimated on both 1997 and 1988 data. - Same model on pooled data (with/without time trend term). • Summary results 1997 v 1988: results generally very similar, but with 1997 travellers somewhat less time sensitive than in 1988. • Summary results – personal VTTS values: - business > commuter > other - values increase with income, but less than proportionately. Summary results – employer VTTS values (Hensher formula): found that employer values for all modes substantially decreased 1988 – 1997. This is result of smaller proportion of time savings that would be converted into work, and an increased proportion of travel time spent working (mobile phones etc).	Hague Consulting Group 1990, Gunn et al, 1998

TABLE 2.3 : CURRENT PEM VALUATIONS FOR TIME AND LEVEL OF SERVICE FACTORS (All Values at July 1998)

Traveller/Vehicle Category	VTTS		Notes
	$/person hr	$/veh hr	
In-Work Travel (Persons) – Base Values			
Car, m/c – driver and passenger Bus passenger (seated/standing) Pedestrian, cyclist	21.30		
CV driver/passenger:			
- light	19.25		
- medium/heavy	15.80		
Non-work Travel (Persons) – Base Values			
Drivers (car, m/c, CV)	7.00		
Passengers-seated (car, m/c, CV, bus)	5.25		
Pedestrian, cyclist, standing bus pass	10.55		
Congested Conditions (Persons) – Additions (CRV)			
Drivers (car, m/c, CV)	Max 3.50		• Addition to base In-Work and Non-Work values (above) • Full value applies to stopped/ bottleneck time • Proportion of value applies where V/C ratio exceeds 70% but below 100% (refer PEM A4.5.3).
Passengers (car, m/c, CV, bus)	Max 2.60		
In-Work Travel (Vehicles/Freight)			
Car		0.45	
CV: - light		1.60	
- medium		5.60	
- heavy I/bus		15.80	
- heavy II		26.00	
Conversion Unsealed to Sealed Road			
All vehicles		$0.16/veh-km	• Represents reduced vehicle occupant discomfort from sealing unsealed roads (refer PEM A7.2.2)

TABLE 2.6 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: VEHICLE OPERATING COSTS

Country	Parameter Summary	Valuation Methods
NSW	Urban:	• Market price less tax (ie resource cost) • From ARRB 'Road User Costs for Use In Economic Evaluation of Roading Expenditures', January 1999.
	• Fuel cost per litre • Non-fuel cost per km	• Derived from operating cost model • Comprises depreciation, oil, tyres, maintenance
	• Non-fuel cost per stop	• Represents wear and tear • RTA estimate
	• Fuel used per stop	• Acceleration/deceleration • From ARRB 'Estimating Fuel Consumption of Light to Heavy Vehicles' ARRB TR Paper AIR 454-1
	• Fuel consumption per km	• Cruising at 60km/hour • From ARRB 'Vehicle Fuel Consumption Estimate Program ARF COM-User Guide' TR Paper ATM 28 (1989).
	Rural: • Tabulates cost per km according to speed and roughness • Differential light/heavy vehicle and VCR = 0, 1 • Further increments to allow for curvature.	
Queensland	• Gives values for different vehicle classes • unit values by vehicle type of: - Petrol/litre - Diesel/litre - Oil/litre - Tyres - Vehicles • Combined VOC per km depending on roughness, terrain and speed	• Not clear how these are computed from unit values.
UK	• Comprises six items: fuel, oil, tyres, maintenance, depreciation and size of vehicle fleet • Fixed costs such as insurance are excluded • Fuel cost element changes over time; non-fuel element remains constant in real terms • For vehicles in non-work time, only the fuel costs of VOC are perceived. •	• All costs are resource costs (VAT refunded) • Cost of fuel is a specified function of speed and hilliness • Oil and tyres fixed per km • Maintenance – varies with speed (in a similar way to fuel) but not hilliness • Depreciation is mileage relat

TABLE 2.6 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: VEHICLE OPERATING COSTS (Cont'd)

Country	Parameter Summary	Valuation Methods
UK		• Non-fuel elements are combined in a formula which is similar to fuel consumption but not a function of hilliness • Specifies forecast increase in fuel price for future years.
British Columbia	• Identifies four basic conditions with different VOC: - constant speed - speed change - cornering - idling • Components of cost: - fuel & oil - tyres - maintenance (parts & labour) - depreciation & interest • Road variables affecting VOC: - geometry - surface - traffic control.	• CBA software contains a model for computing VOC as a function of speed and gradient • Acknowledges possible WTP for driver comfort and system reliability.
South Africa	•	• All costs are opportunity costs so use market price and include taxation • Fuel cost a function of vehicle class, speed, gradient and radius • Oil cost related to fuel • Depreciation: fixed amount per km (light vehicles) or value of capital cost/km (heavy vehicles) • Maintenance: function of speed (similar to UK) • Tyre costs: function of speed • VOC varies by roughness, in a different way for light and heavy vehicles.

TABLE 2.7: INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: ACCIDENT COSTS

Country	Parameter Summary	Valuation Methods
NSW	• Casualty cost per person (fatality down to not injured) • Generic cost per accident (fatal down to tow-away) • Cost of accidents by type.	• From ARRB (ARRB 227' Costs for Accident Types and Casualty Classes' 1992, updated to 1999) • Gives casualty cost per person, which includes an incident cost to reflect items such as vehicle repair, insurance, accident investigation and legal costs • Generic cost per accident is based on an analysis of accidents by casualty class
Queensland	• Average number of accidents per million VKT, depending on road type.	• Accident cost based on risk-adjusted changes in the cost of lost income, hospitalisation and medical care, pain and suffering, vehicle repair, etc • Indicates that a move to WTP is planned.
UK	See Table 2.7 following.	• WTP used since 1988 (fatals) and 1994 (non-fatal) • Value of injury related to the value of death • Updated annually according to GDP per capita • Includes allowance for lost output for all accident types • Medical & support costs also included • Accident-related costs; damage to property, insurance administration, police • Having established the total value, the difference between that and the 'tangible' costs (eg medical) is referred to as 'human costs': see Table 2.7 • Average number of casualties per accident taken into account.
British Columbia	• Cost of fatal, non-fatal and damage only accidents	• Reference to US work on 'Comprehensive Accident Cost Method' • Refers to pain and lost quality of life (evaluated using WTP) as well as 'human capital' (property damage, lost earnings, etc). However the former is 'not to be used pending further research' (1992).
South Africa	• Cost of fatal, serious and slight collision.	• Production value only, based on annual GDP per capita • Loss of production depends on age: average loss computed from the distribution of traffic fatalities by age • Serious and slight costs based on sick leave required and % loss of production • Acknowledges that social value should be included but 'no reliable value has been determined to date'.

TABLE 2.9: NZ 1989/90 VOSL SURVEY – KEY QUESTIONS

Ref	Question Summary	Cases	Mean VOSL (1990 $000)			Notes
			Individual	Family Member	All	
Q7	Commuter route choice: high risk route (6:10,000 pa chance of death) v low risk toll route (3:10,000 pa chance of death) with nominated max toll per trip	308	2,254	1,970	2,009	• Potential problem of single coin bids.
Q11	Maximum WTP for all households members to attend a road safety course which reduced nominated risk of any household member being killed in road accidents by half.	296	1,121	1,496	1,437	• Unclear whether costs and risk reduction apply for first year only or for life (understand that first year only assumed in analysis). • Weakness of using starting bid.
Q14	Maximum WTP for safety features on car that would reduce nominated risk of household fatality (over car life) by half.	226	1,272	1,920	1,849	• Appears to be sound question. • Considerable spread of values: median $1.25M.
Q20	Maximum additional WTP per year (in terms of annualised house prices) to live in area where nominated chance of any road accident to a household member is halved.	500	1,469	1,910	1,871	• Stated WTP adjusted to fatality WTP by allowing for serious injury costs (but these subject to considerable uncertainty). • VOSL simply derived as fatality WTP divided by number of household members. • Unclear whether additional cost is recurrent (cost of living) or adds to house capital value – potential to significantly influence results. • Considerable spread of values: median $1.3M.
Q22	Maximum WTP through annual taxes for road/pedestrian improvements that would reduce nominated chance of any road accident to a household member by half.	108	755	2,623	2,297	• Unpopular question – at end mentions higher taxes! • Report gives minimal detail of results.
	Overall Average		1,374	1,984	1,893	

TABLE 2.11 : INTERNATIONAL EVALUATION PARAMETERS AND VALUATION METHODS: ENVIRONMENTAL EFFECTS

Country	Parameter Summary	Valuation Methods
NSW	• No specific values supplied.	• Gives some specific values, eg cost to properties of additional noise, increased mortality from increased PM_{10} • allows scores to be assigned to social and economic impacts (e.g. 'very much better' scores +4)
UK	• No economic evaluation	• Environment is one of 5 areas in the multi-criterion evaluation framework • Sub-headings used are noise, air quality, landscape, bio-diversity, heritage and water • Seven point scale used where quantification not possible • Noise impact measured by number of properties experiencing a change >3dB(A) • Air quality: number of properties experiencing a change in NO_2 and PM_{10}, plus additional tonnes of CO_2 • Landscape, bio-diversity and heritage: based on Environmental Capital • Water quality impact measured by risk of damage.
Queensland	• No specific values supplied.	•
British Columbia	• Quantifies the impact on property values of each increase/decrease of 1dB(A) • Other effects to be treated qualitatively.	•
South Africa	• No specific values supplied.	•

Figure 3.2: DIRECT VALUATION TECHNIQUES – TERMINOLOGY

* **All User Preference Methods**
  * **Revealed Preference (RP)** - based on actual (observed) choices
  * **1.1.2** * Stated Preference (SP)
    * **Contingent Valuation Method (CVM)**
      - Direct approach – asks people directly re WTP for a benefit or WTA for a loss.
      - May use: direct, open-ended question; bidding game; or less direct question (as in referendum). [1]
    * **Transfer Price Method (TP)**
      - Examines choice between current situatio and a hypothetical situation.
      - Lies between CVM and CA in directness and complexity.
      - Methodology closest to CVM – relatively simple form, direct approach. [2]
    * **Conjoint Analysis (CA)** [3] (or Trade-off or Stated Choice Analysis)
      - Indirect approach – asks people to choose between or rank packages involving several factors (at different levels) and then infers factor values from choices.
      - Three main approaches: choice (between 2+ packages), ranking and rating.
      * **Traditional Conjoint Analysis (TCA)**
        - Ranking or rating (not choice) approach
        - Analysis commonly by OLS (ordinary least squares) or Adaptive Conjoint Analysis (ACA) – Sawtooth Software
      * **Choice-based Conjoint Analysis (CBCA)**
        - Extension of CA, with respondent choosing from several competing factor options.
        - Analysis by use of discrete choice models (logit/probit analysis).

Note:

(1) Examples are:

- Direct, open-ended question: 'What is the most you would pay for X...?'
- Bidding game: 'Would you pay $10 for X?' If 'yes', increase amount till respondent says no, etc.
- Less direct question: 'The Government is considering X: it involves a tax increase of $Y. Would you vote for or against X?'. If 'for', then increase $Y until vote is 'against'.

(2) Example: 'The bus journey you described took 20 mins and cost $1. What is the maximum you would be prepared to pay if the journey took only 15 mins?'

(3) In transport sector, 'Conjoint Analysis' is also sometimes referred to as 'Stated Preference' (SP), but this terminology is liable to mislead.

KEY FEATURES	COMMENTS
STAGE II FACE-TO-FACE SURVEY ***Survey methodology:** • Face-to-face computer aided interviews • Random sample from Stage I respondents who indicated willingness to participate, stratified by user segments/geographic locations. • Completed sample 251. • Interviews September 1999. ***Background information provided**: - interviewers had available copies of the Information Pack (to remind respondents) and route maps (all respondents had participated in Stage I survey) ***Key questions:** • Likelihood of using TG (rather than SH1 with safety upgrades) at toll of $0/2/4/6/8 at time saving of 0/15/30/45 mins by trip purpose. ***Key findings:**	
• For zero time savings (all trip purposes), approx 80% of trips would use TG at zero toll, 46% at $2 toll, 28% at $4 toll, approx 14% at $8 toll.	• Perhaps somewhat surprising result, especially 14% at $8 toll for zero time savings. Report notes that respondents were apparently prepared to pay substantial amounts for the increased safety, greater reliability and reduced congestion of the TG route (refer comments in text).
• For 50% use of TG, toll is c$1.90 at zero time savings, c$4.10 at 15 mins saving, c$6.20 at 30 mins saving, c$8.50 at 45 mins savings.	• Indicates median value of time savings of about $9/hour (all purposes); values by purpose in range approx $6/hour (shopping) to $12/hour (business). These are generally plausible results (refer comments in text).
STAGE II HOUSEHOLD TELEPHONE SURVEY ***Survey methodology:** • Computer aided telephone interviews • Stratified random sample as per Stage I survey; households had previously been sent Information Pack. • Completed sample 762 people (57% response rate). • Interviews November 1999. ***Background information provided:**	
• All respondents had been sent the Information Pack. 56% said they knew a lot, 37% knew a little and 7% knew nothing about the TG route.	• Refer Stage I Survey (above): results indicate apparent significant increase in knowledge from Stage I. (However the Stage II and Stage I questions differ: the Stage I question asked about knowledge of TG issues, the Stage II questions about knowledge of the TG route.)
• All respondents were given a short summary of the Information Pack 'solutions' (see above). Benefits of TG were quoted as "up to 29 minutes travel time savings during weekday rush hours", greater safety, reassurance of an alternative route. ***Key Questions**	• This is potentially misleading, as it compares with the 'Do Nothing' situation, not the alternative Solution 1. The Information Pack figures are for peak (2005) savings of Solution 2 over Solution 1 of 9-10 mins (refer above).
• WTP extra rates of $40/$80pa (Wgn city) or $135/$240 pa (Porirua) per household to pay for early construction of TG.	• No statement of what year these levies would start, or how many years they would apply for (see above).
• WTP extra 5.2c/litre regional petrol tax for early construction of TG. • WTP extra rates of $25/$10 pa(Wgn city) or $147/$58 pa (Porirua) together with 2c/4c per litre petrol tax for early construction of TG. ***Key Findings** • Relatively even split between Yes/No for WTP higher rate increases, for high petrol tax increases and for equivalent combinations. • Preferred method of raising funds was combination (rates/petrol tax): also nearly even split between rates alone or petrol tax alone. • Majority in favour of raising money from Wgn region residents to pay for early TG construction (56% Yes, 12% qualified Yes).	

TABLE 4.1 : PARAMETERS FOR INCLUSION IN RESEARCH PROGRAMME

Parameter	Proposed Valuation Basis	Proposed Survey Approach
A. PRIVATE TRAVELLER – TIME & LEVEL OF SERVICE		
A1. Personal Disutility of Travel: • Road hazards • Road quality • Road user amenity • Traffic conditions A2. Personal Opportunity Cost: • Expected travel time • Uncertainty of travel time	• Non-market (WTP), by road traffic conditions, traveller/trip characteristics.	• CA approach. • Range of (over-lapping) surveys to establish full range of valuations in different conditions (refer text). • Will need to be preceded by focus groups, piloting etc to establish best methods in detail. • Refer Sections 4.2 and 4.3.
B. BUSINESS/COMMERCIAL TRAVELLER – TIME & LEVEL OF SERVICE		
B1. Personal Disutility of Travel (as A1). B2. Personal Opportunity Cost (increase in non-work time.	As per (A) above.	• As per (A) above.
B3. Business Opportunity Cost (increase in useful work time)	• Market valuation – MPL/wage rate approach (for business travel, based on Hensher, refer Section 3.8.4)	• For business travel, MR to assess extent to which savings in travel time will translate into increases in output/reductions in employer costs (refer Section 4.4.1). • For commercial vehicle travel, generally base on pay rates + overheads (to extent time savings may be put to productive use).
B4. Freight Time and Condition	• Market valuation	
C. VEHICLE OPERATING COSTS		
C1. Direct Operating Costs: • Fuel • Oil, tyres • R&M	• Market (resource) valuation (net of taxation).	• Determine financial cost structures (as now). • Adjust for fuel duties, taxes, etc.
C2. Capital – depreciation	• Market (resource) valuation	• Assessment of use-related (distance/time) component of depreciation (as now).
C3. Capital - fleet	• Market (resource) valuation (commercial vehicles only).	• Assessment of any fleet savings through time savings (as now).
D. ACCIDENTS		
D1. Human Costs	• Non-market (WTP) – fatalities, injuries	• Comprehensive appraisal of methodology from recent LTSA study (fatalities and injuries), in light of international research methods. • Further research needs defined in this review.
D2. Lost Output	• Market (resource) – fatalities, injuries.	• Resource assessment (as now).

TABLE 4.1 : PARAMETERS FOR INCLUSION IN RESEARCH PROGRAMME

Parameter	Proposed Valuation Basis	Proposed Survey Approach
D3. Medical Costs	• Market (resource) – fatalities, injuries.	• Resource assessment (as now).
D4. Accident-related Costs (property damage, police, insurance costs)	• Market (resource) – all accidents.	• Resource assessment (as now).
E. ENVIRONMENTAL EFFECTS		
E1. Co_2 (Global)	• Non-market • Recent literature suggests that factors such as global warming (and other irreversible aspects felt by future generations) are not amenable to monetary valuations	
E2. Air Pollution (CO_2, NO_X, Lead, PM_{10})	• Non-market • Market (resource) – PM_{10}	• Dose response/shadow pricing
E3. Noise	• Non-market	• HP or CVM/CA
E4. Vibration	• Non-market	• HP or CVM/CA
E5. Water Quality	• Non-market	• Shadow pricing or CVM/CA, depending on how the factor is defined and whether the impact is on the population or ecology.
E6. Special Areas	• Non-market (situation specific)	• CVM/CA • Shadow pricing • Recreational areas - TCM
E7. Ecology	• Non-market	• Shadow pricing or CVM/CA depending on the ecological impact
E8. Visual	• Non-market (situation specific)	• HP or CVM/CA
E9. Community Severance	• Non-market	• HP or CVM/CA
E.10 Isolation	• Non-market (situation specific)	• HP or CVM/CA
E.11 Psychological Distress (Forced Purchase)	• Non-market (situation specific)	• CVM/CA
E.12 Site Specific Discomfort	• Non-market (situation specific)	• HP or CVM/CA
F. POTENTIAL ADDITIONAL PARAMETERS		
F1. Parking Resources		
F2. Health & Fitness		