Value of Time: A Pilot Survey of Road Users

Occasional Paper

This Paper has been prepared as part of an ongoing investigation into the value of travel time savings. It follows on from the work reported in Bureau of Transport Economics Occasional Papers 51 and 57. The results of a pilot survey of non-urban road users using the functional measurement technique are reported. Particular attention is paid to the validity of sampling options and the processing of data.

Value of Time:

A Pilot Survey of Road Users

Bureau of Transport Economics

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FOREWORD

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The results of a pilot survey of non-urban road users using the functional measurement technique are reported. Particular attention is paid to the validity of sampling options and the processing of data.

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September 1984

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SUMMARY

This study follows on from two previous investigations of the value of travel time savings. The first consisted of an extensive literature search to determine what values had been used when evaluating proposed transport projects. A wide range was found, so that little confidence could be attached to any particular value.

The second reviewed methods which could be used to estimate the value of travel time savings. This identified functional measurement as the method least hampered by assumptions.

The pilot survey of non-urban road users described in this paper aimed to test the application of functional measurement together with options for sampling motorists. A number of sampling options were examined and two were tested during the pilot:

- numberplate recording and tracing of owner, followed by home interviews; and
- on-site interviews, at a carefully selected location, of motorists who stopped onroute.

No statistical differences between the road user samples were found other than for maximum journey time and household, rather than personal, income. This suggests that on site interviews at carefully selected locations may provide a simple and low cost representative sample.

The functional measurement approach was used successfully to analyse the data from the pilot survey, but its application revealed problems arising from its disaggregate nature. It is clear that functional measurement requires considerable care in its application and that it may prove impractical to apply it successfully to a large survey.

CHAPTER 1-INTRODUCTION

BACKGROUND

The Bureau of Transport Economics (BTE) has been investigating the value of travel time savings (VTTS), and its estimation. An initial study (BTE 1982) reviewed values that had been estimated and/or used in the past and found considerable variation. A requirement for consistent, reliable estimates of VTTS for use in evaluation work remains.

As a first step towards better estimates, a theoretical investigation of the many potentially useful techniques for estimating VTTS was undertaken (King 1983). The aim was to identify the assumptions and limitations of each technique, and to compare the techniques so that those most likely to be useful could be identified. Functional measurement (FM) was the technique which, in the comparison, appeared to offer the greatest potential for yielding consistent results.

To test FM it was decided to carry out a pilot investigation of road users, since this represented a current area of interest.

Road users can be divided into a number of categories based on journey purpose and region of travel. For example:

- urban journey to/from work;
- urban private (not work associated) journey;
- urban business journey;
- non-urban journey to/from work;
- non-urban private (not work associated) journey; and
- non-urban business journey.

The business journeys can be further sub-divided by the type of vehicle used. For the pilot investigation of FM, non-urban private journeys were chosen because of the small number of factors thought to influence VTTS for this category. The major factors appear to be journey time, uncertainty associated with the journey time, cost and road type.

The more commonly-used revealed preference methods, such as multinomial logit, cannot be generally applied to non-urban road journeys because of a lack of feasible alternative routes available for the journey. This meant that the values obtained with FM could not be compared with those from a more traditionally used technique.

This Paper describes a BTE pilot survey of Australian Capital Territory (ACT) drivers on private journeys between Canberra and Sydney (or vice versa) to investigate:

- the practical application of FM; and
- the representativeness of various sampling options for non-urban road users for future larger surveys.

SAMPLING

The sampling of non-urban car travel is made difficult by a number of factors. This section discusses these factors and a number of sampling options.

Investigations need to be made of a number of particular routes so that the transferability of VTTS may be determined. This requirement applies to any technique, not only FM, because very little attention has been paid to transferability of VTTS between different routes.

This limits the usefulness of in-city surveys because of the low trip incidence on nominated non-urban routes. For example, on the Sydney-Melbourne route the number of passenger trips per month is about 0.6 per cent of the cities' total populations (derived from Hirsch and Russell 1981). Therefore in-city surveys are not appropriate when an investigation is restricted to specific non-urban routes; this is particularly true for long distance routes.

In addition interviews should be conducted as close as possible to the trip date in order to obtain accurate data. BIE (1983) discusses recall problems which occur when respondents are asked to report on all trips from which they had returned home in the past two months. It was found there was a progressive decline in the number of trips reported over time. For short trips (overnight) it was felt that a two-week recall period was not beyond the reach of careful interviewing. This has direct implications for interviews conducted to estimate VTTS as specific trip details are required. Therefore, the interviews should be either during the trip or soon after its completion.

A further restriction is imposed by the form of the FM questionnaire (see Chapter 3) because it requires face-to-face interviews. This restricts the sampling options and can also make the survey more expensive than for other VTTS estimation techniques.

Given the above restrictions the remaining feasible options for sampling were:

A. roadside survey stations;

B. number plate recording and tracing of owner, followed by at-home interviews;

C. obtaining addresses of people who stop at a particular location on the route, followed by a later interview at home; and

D. onsite interviews, at carefully selected locations, of people who stop on route.

Option A is the option most likely to yield a representative sample, but it requires drivers to be stopped during their journey. This could result in biased responses from annoyed drivers. Either police or other authorised persons would be required to direct vehicles into the survey station. Advice was received that, in general, police would be reluctant to participate in such a survey due to doubts concerning legal protection. This is further exacerbated by the need to study a number of routes to obtain Australia-wide values which requires interviews to be carried out over more than one day on each route.

Option B consists of the recording of number plates, tracing the registered owner's name and address through the appropriate motor vehicle registry, obtaining a contact telephone number from the telephone directory, telephone contact for screening and interview arrangement and then the interview. Initial contact by telephone is normally suggested to contain overall survey costs, even though telephone ownership may introduce a small bias. Some State authorities may require that they make the initial contact to determine the willingness of possible respondents before their name and address is made available to the interview team.

The large number of steps in Option B make it complex and costly, with the potential to have a high loss rate from the initial number of recorded number plates to the number of interviews. The losses could be caused by:

- inaccurate recording of number plates by survey team;
- car registered in a business name;
- car not making journey of interest;
- incorrect or out of date details on registration record;
- owner not on telephone;
- owner has telephone but not in telephone directory or entry incorrect or different from registration;
- person unwilling to be interviewed; and
- no contact to arrange interview, particularly if frequent traveller.

This is an expensive way to conduct a survey; not only due to a possible high loss rate but also the possibility of interviews being widely dispersed. In addition the option requires timely access to records of motor vehicle registrations held by State motor registries. The Privacy Legislation enacted in most States prevents this or makes access difficult.

The number of steps in the process make it difficult to complete in a timely manner to limit recall problems. It is unlikely that the interviews could be completed within two weeks and even a four week period could be optimistic for a large number of interviews. Also some drivers may be away from home for an extended period. If the follow up period is too short they could be eliminated from the survey and hence introduce a possible source of bias.

Option C consists of the collection of names and addresses of potential respondents at onroute stopping places such as road houses, places of interest, petrol stations, etc followed by a later interview at home. The selection of stopping places requires a preliminary survey to determine the best location. Drivers would be screened at the stopping places and contacted later at their home to arrange an interview.

This would be less costly than Option B as fewer steps are involved. A much smaller loss rate could be expected due to prior screening and less reliance on registration records and entries in the telephone book.

There are a number of sources of bias associated with Option C. In particular, on short routes, where a refuelling stop is unnecessary, a sizeable proportion of drivers may not stop; leading to biased results if they are not sufficiently similar to drivers who do stop. Major road works using flagmen provide the best opportunity because they will in general stop a greater proportion of the road traffic than any other onroute site and the cars stopped will not be influenced by other attractions. The follow-up at home interviews will need to be well co-ordinated to prevent delays so that recall problems do not occur.

On-site interviewing, Option D, is performed by interviewing people who stop onroute at the locations described in Option C. This has the advantage that all contact takes place at the same time and the respondents are actually undertaking the journey, so no recall bias is introduced. This makes Option D superior to Option C as it minimises cost and biases but the extent, if any, of the non-stopping bias remains unknown.

The above discussion has shown that Option A could be impractical, Option B is possible only if access to registration records could be obtained, and that if only stopping travellers are to be interviewed, then Option D is preferable to Option C provided the survey instrument in suitable. A literature search failed to find any references which described the size of the relevant biases. Therefore, the only way to determine the relative biases, loss rates and time to complete the survey task, was by a pilot study.

The pilot survey chosen was to test Options B and D on ACT drivers travelling between Canberra and Sydney. This choice was made because the BTE had obtained permission to access ACT registration records and the route allowed BTE staff to be used as interviewers. In fact, to minimise costs in this instance, a modified version Option C was used instead of Option D to allow the FM part of the questionnaire to be administered in Canberra and to test recall of the important parameters by observing changes in the responses. This is a result of the need for the parameters, used in the FM part of the questionnaire, to reflect drivers' actual experience, so a prior survey is required. This is described in more detail below.

FUNCTIONAL MEASUREMENT

Functional measurement is a technique for measuring cognitive quantities on interval scales. FM is a disaggregate technique as it estimates a multilinear decision function for each respondent. This means that it avoids the difficulties which can occur if a linear functional form restriction is placed on the decision function or if aggregation is required by the estimation procedure (see King 1983).

The two parts of FM are a rating method, which allows individuals to respond to scenarios in such a way that their responses form an interval scale, and the empirical knowledge that individuals combine (integrate) information by a simple multilinear rule. The scenarios consist of a description of the values taken by the factors which may be involved in the decision.

The rating method (Anderson 1981) consists of a scale, the ends of which are described by scenarios (end anchors) outside the range it is wished the individuals to respond to. The scale is usually placed on a piece of board sufficiently long to contain all scenarios, and marked with a number scale from at least 1 to 10 and possibly 1 to 20. The individuals are given the scenarios in a random order and asked to place them on the scale so that the position of the scenarios shows their reaction to it relative to the ends and the other scenarios already on the scale. An alternative to end anchors is to use a scenario to define the middle of the scale and to tell respondents that none of the scenarios are as good or as bad as the ends of the scale. The knowledge that information is combined by a simple multilinear rule allows experimental designs to be used to efficiently gather responses. The multilinear models related to the designs can be fitted by ordinary least squares regression due to the cardinal nature of the responses. If the responses were only considered to have a rank value then regression could not be used.

To limit the number of scenarios presented for rating, fractional factorial designs are usually used. Hahn and Shapiro (1966) and Webb (1971) contain tables of designs which are useful for minimising the number of scenarios.

Appendix I contains an example of the scale, cards describing the scenarios and instructions given to respondents.

To use FM to assess the VTTS of non-urban car private car journeys the following characteristics of a journey were used in the scenarios:

- time
- cost
- time uncertainty
- road type.

Time uncertainty is the variation in the time the respondents expect to complete the journey. For example a trip of 4 hours with a time uncertainty of 15 minutes could be described as taking between 3 hours 45 minutes and 4 hours 15 minutes.

Road type is a description of the road and possibly its condition. It needs to be brief, and easily and consistently interpreted by respondents.

The experimental design used had time and cost each taking three levels, and time uncertainty and road type each taking two levels. The multilinear model fitted in the pilot included squared terms for time and cost and all linear by linear interaction terms. (This is discussed in more detail in Chapter 3.) Webb (1971) provided a design which allows the estimation of all terms for such a model with 14 scenarios. The restriction this places is that, because there are the coefficients of 12 terms to be estimated, there is initially only one degree of freedom available to test the significance of the regression.

For the responses by individuals to be meaningful, the journey characteristics described by the scenarios must relate to the conditions experienced by drivers. Therefore, it is necessary to use a survey to determine drivers' perceptions of the journey characteristics. This led to the use of Option C where drivers were interviewed on-site to determine how they perceived journey characteristics and later reinterviewed when they had returned home. This still allowed the 'non-stopping' bias to be investigated but it limited the on-route interviewing in that the full questionnaire was not required, the FM part being omitted (see Appendix I).

The pilot also allowed the examination of the difficulties respondents had in completing the FM exercise and the computational problems in calculating the VTTS for particular situations. In particular, the possibility of obtaining negative VTTS and the reasons for this needed to be investigated before a major survey was considered.

CHAPTER 2-THE SAMPLES

Having decided on the sampling methods to be tested, a site survey was undertaken. The Golden Fleece petrol station at Mittagong (see Figure 2.1) was chosen because of all the potential sites examined, it was the only one observed to have a significant proportion (about 10 per cent) of the passing ACT cars stop. ACT cars were readily identified by their number plates. The on-route interviewing was carried out by BTE staff from 8.00 am to 4.15 pm on Friday 29 April 1983. It had been planned to continue until sunset, but cold inclement weather had set in by about 4.00 pm discouraging drivers from being interviewed.

At the same time as the interviewing, the number plates of passing ACT cars were recorded together with a brief description of the vehicle (Make/model and colour). The description proved valuable when tracing the cars through the ACT Motor Registry, because, even though two people were used to record the number plates, some appeared to have been misread. This allowed letter combinations, which may have been confused, to be checked and alternatives with suitable descriptions searched for.

The details of the samples are summarised in Table 2.1. The three samples referred to are:

Sample I on-site interviews at Mittagong

Sample II re-interview of Sample I in Canberra

Sample III number plate traced interviews.

A total of 371 ACT registered cars and light commercial passenger vehicles were observed during the survey period.

Sample I was drawn from 36 cars that stopped at the petrol station but, due to the number of cars present at peak times, only 32 of these were approached. These yielded 29 interviews, 23 of whom expressed a willingness to be re-interviewed at home and would have returned home before the in-Canberra interview period. Of these only 10 could be contacted at home and seven were willing to undertake the interview. The very low contact rate could not be easily explained because there

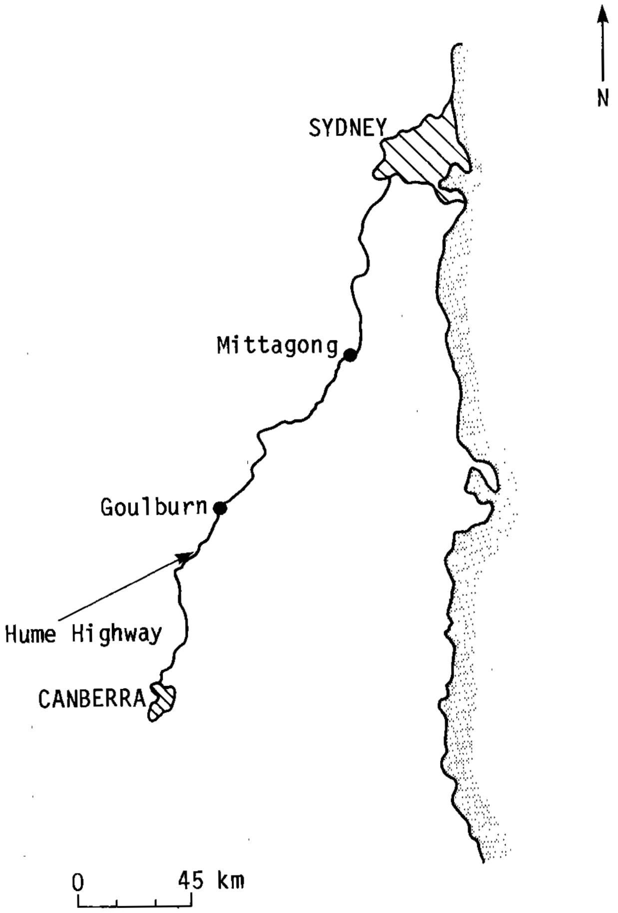

Figure 2.1-Map of ends of journey and on-route interview location

was no factor influencing Sample II, apart from a previous interview, which would not affect Sample III in the same way. This does indicate that sampling Option C could have an unexpectedly high loss rate between addresses collected and actual interviews achieved.

Sample III started with a random sample of 62 number plates drawn from the 335 cars which did not stop at the interview site; 13 (21 per cent) were lost during number plate tracing. The loss included some vehicles whose number plates and descriptions matched with the registration records but were recorded as not being in use. Also no match between the number plate and descriptions occurred in two cases. Other losses were caused by vehicles registered to car yards, large private businesses or hire car companies.

TABLE 2.1-THE SAMPLE SIZES

	Sample		
	Onsite interviews	*Home re-interviews*	*Number plate tracing*
Sample of number plates recorded	-	-	62
Number plates traced	-	-	49
Phone numbers obtained	-	23	35
Stopped at interview site	36	-	-
Contacted	32	10	23
Interviewed	29	7	20

Source: BTE VTTS survey (1983).

The loss of 14 more (29 per cent of those remaining) occurred because the names and addresses of registered owners were not in the telephone directory. Often the initials for the registered name and those in the directory differed for the same address. This could be checked in Canberra due to the small size of the directory, but in larger cities would be an arduous task for commonly occurring names. Therefore, a larger loss rate could be expected for this sampling method in cities bigger than Canberra (population approximately 230 000).

The telephone number lookup success rate could also be expected to decrease as the telephone directory gets older and outdated. The survey reported here was done with a directory that was two months old.

Of the remaining 35, 23 were contacted and 20 interviewed. This means that only 32 per cent of the sample of number plates recorded yielded an interview. For a similar survey the 95 per cent confidence interval is between 21 and 43 per cent. Therefore, it would be advisable to record four to five times as many number plates as interviews required. To avoid unnecessary costs it may not be necessary to process all the number plates at first, or it may be possible to cluster interview addresses to limit interviewing costs.

COMPARISON OF SAMPLE CHARACTERISTICS

The responses to questions 1 to 20 (see Questionnaire in Appendix I) in Samples I and III were compared to test the sampling methodology of sampling Options B and D. The business related questions were not compared because only five respondents in Sample I and three in Sample III were on business trips, not all of which were paid for by the employer.

The responses to the questions provided three types of data to be analysed, nominal, ordinal and interval. In some cases nominal responses had to be aggregated because of the large number of categories to which responses were received. For example, to the question concerning occupation (Question 16), there were 12 possible categories (see showcard 4 in Appendix I) and responses were obtained in 10 of these. This means that for both samples the expected frequency in all cells of the contingency table is less than five and the Chi squared test cannot be used (Siegel 1956). Therefore, the responses were aggregated into 'employed' and 'not in the workforce'. The Chi squared test could then be used and indicated no difference between the samples on this basis at the 10 per cent significance level. Nie et al (1975) and Hull and Nie (1981) was used to analyse the data and perform the calculations used to test for any difference between the two samples. Table 2.2 summarises the main statistical tests and the results at the 10 per cent significance level[1]. Only the responses to questions 6b and 20 were significantly different at this level. For all other questions no significant difference was found between the two samples. The details of any aggregation required are described in the comments column of the table.

The significant difference for question 6b, the maximum time to complete the journey, appears to be the result of larger values reported by some respondents in Sample I. In fact, one reply was eight hours representing a mean speed of less than 40 km/hour. The elimination of this value from the sample still gave a significant difference at the 10 per cent significance level, but at the 5 per cent level no difference was found.

The possible explanation of the question 18 result is the increased awareness of the income of other members of the household when the interview is conducted at home, particularly if other household

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1. A level of significance α, means that no difference between the samples with a probability of occurrence of less than α was detected. This is equivalent to a confidence level of $1-\alpha$.

TABLE 2.2-TWO SAMPLE TESTS

Question	*Test used*[a]	*Result*[b]	*Comments*
2	χ^2	NSD	Responses aggregated to sedan and not sedan
3	χ^2	NSD	Only 1 with trailer
4	χ^2	NSD	Responses aggregated to own and not own
5	t & F	NSD	
6a	t & F	NSD	
6b	t & F	SD	See text
7	t & F	NSD	
8	χ^2	NSD	Aggregated to you and other
9	χ^2	NSD	Aggregated to business and non-business
11	t & F	NSD	
12	MW & KS	NSD	
14	MW & KS	NSD	
15	MW & KS	NSD	
16	χ^2	NSD	Responses aggregated to employed and not in workforce
17	MW & KS	NSD	
18	MW & KS	SD	See text

a. All data analysis was done using Nie et al (1975) and Hull and Nie (1981). The names of the tests indicate the main test(s) used.

b. At the 10 per cent significance level.

Notes: χ^2 = Chi squared, main test in SPSS CROSSTABS procedures.
t & F = t-test and F-test from SPSS t-test procedure.
MW & KS = Mann Whitney U and Kolmogorov-Smirnov two sample test from SPSS NPAR TESTS procedure.
NSD = No difference between samples at 10 per cent significance level.
SD = Samples tested were different at 10 per cent significance level.

Source: Derived from BTE VTTS survey, 1983.

members are present. The difference between the samples is shown by the average category response from Sample I only increasing by one from question 17 (personal income) to question 18 (household income), whereas for Sample III the change was three.

The fact that tests on the two samples show no significant difference, except for questions 6b and 18, suggests that Option D may provide a satisfactory sampling method *provided* a survey site is carefully chosen.

CHAPTER 3-VALUE OF TRAVEL TIME SAVINGS

To calculate the value of travel time savings for each respondent a multilinear equation is fitted to the values obtained for scenarios in the rating task (question 19) by ordinary least squares regression. Then the VTTS for the respondent can be calculated from the fitted equation.

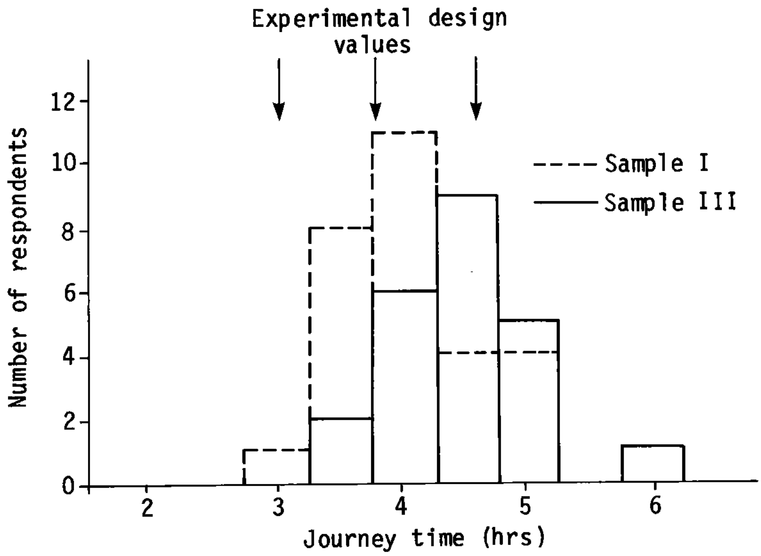
The multilinear equation for the experimental design with time and cost at three levels, time uncertainty and road type at two levels, squared terms for time and cost, and all linear by linear interactions is:

$$V = B_o + B_1T + B_2(3T^2-2)+B_3C + B_4(3C^2-2) + B_5t+B_6r + B_7TC + B_8Tt + B_9Tr + B_{10}Ct + B_{11}Cr + B_{12}tr \quad (3.1)$$

where: V is the value obtained from the respondents in the rating task;
- B_o is a constant;
- B_i i=1,...,12 are coefficients of the respective terms;
- T is the normalised time of the journey;
- C is the normalised cost of the journey;
- t is normalised time uncertainty; and
- r is road type.

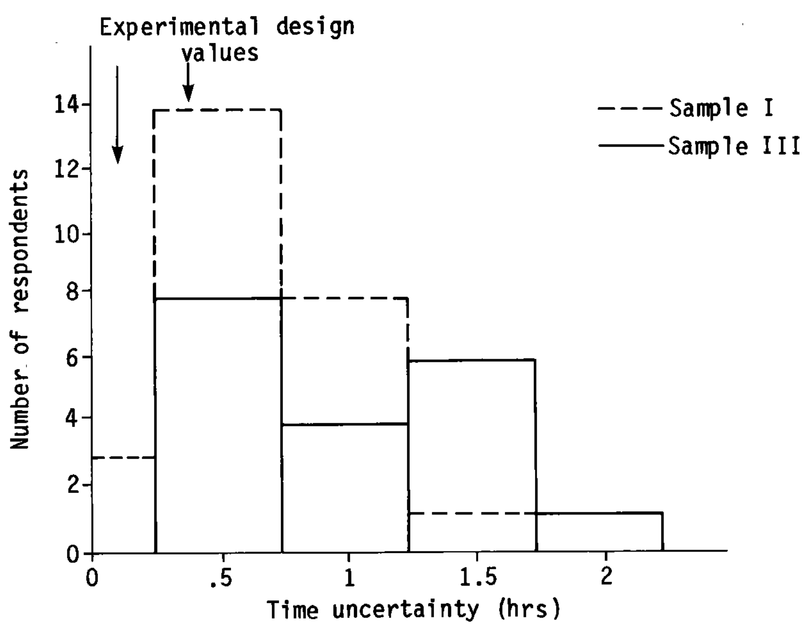
The terms with coefficients B_2 and B_4 are the normalised squared terms for time and cost respectively. The linear by linear interactions are those with coefficients $B_7$to B_{12}.

All parameters were normalised after their ranges were chosen. The values used (Table 3.1) were selected by examination of answers given to questions 6(a), 6(b) and 7 in Sample I. Figures 3.1 to 3.3 show how the values used relate to the responses in Samples I and III. The maximum value for time uncertainty was restricted to prevent overlapping of time ranges in the scenarios with non-zero uncertainty.



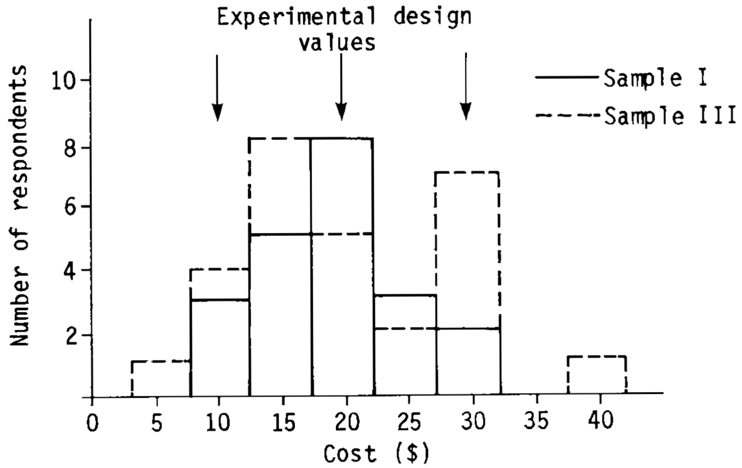
Source: BTE VTTS Survey, 1982.

Figure 3.1-Average journey times of Sample I and III respondents



Source: BTE VTTS Survey, 1983.

Figure 3.2-Time uncertainty of Sample I and III respondents



Source: BTE VTTS Survey, 1983.

Figure 3.3-Journey costs of Sample I and III respondents

Road type was treated separately due to the difficulty in describing roads in a consistent manner understandable to those being interviewed. The form used in the experimental design was that there are two road types described as single lane or dual lane. A single lane road has one lane for each direction of travel and a dual lane road has two lanes for each direction. Due to the varying state of the road between Canberra and Sydney and the varied perceptions by drivers of road conditions, the current road state could be described as about half-way between the two extremes.

The parameter coefficients obtained from the experimental design analysis were examined to see if any parameters could be eliminated

TABLE 3.1-ACTUAL AND NORMALISED VALUES IN THE EXPERIMENTAL DESIGNS

Variable	*Normalised values*	*Actual values*	*Units*
T	-1 0 1	3 3.75 4.5	Hours
C	-1 0 1	10 20 30	Dollars
t	-1 1	0 30	Minutes
r	-1 1	2 4	Lanes

for a full scale study. This could allow a smaller experimental design to be used. Sample III yielded coefficients that showed all non-linear terms were not significantly different from zero with approximately equal frequency, but this frequency was not high enough to justify the deletion of any parameters from the experimental design.

Once the coefficients of equation 3.1 have been estimated, VTTS can be calculated. The principle used is that a driver's value of time is the increase in cost he is willing to pay to save a stated amount of time. This is calculated from his valuation (utility) function by following a curve of constant valuation (disutility). Hence, the value of a time decrease ΔT is calculated by determining the additional amount ΔC required to hold the valuation constant, with all other variables unchanged. This is achieved by holding the valuation V to a constant determined by some initial condition, keeping time uncertainty and road type fixed, and calculating the additional cost required to balance the decrease in time. The result of doing this to equation 3.1 is:

$$\begin{aligned} V = {} & B_0 + B_1(T-\Delta T) + B_2(3(T-\Delta T)^2-2) + B_3(C + \Delta C) + B_4(3(C+\Delta C)^2-2) \\ & + B_5 t + B_6 r + B_7 (T-\Delta T)(C + \Delta C) + B_8(T-\Delta T)t + B_9(T-\Delta T)r \\ & + B_{10}(C + \Delta C)t + B_{11}(C + \Delta C)r + B_{12}tr \end{aligned} \qquad (3.2)$$

Subtracting equation 3.1 from 3.2 and solving for ΔC yields

$$\Delta C = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}, \text{ if } a \neq 0 \qquad (3.3)$$

or $\Delta C = -c/_b$, if $a = 0$, $b \neq 0$ (3.4)

$$\begin{aligned} \text{where } a &= 3B_4 && (3.5) \\ b &= B_3 + 6B_2C - B_7\,\Delta T + B_7\,T + B_{10}t + B_{11}r && (3.6) \\ c &= \Delta T(-B_1 + 3B_2\,\Delta T - 6B_2\,T - B_7C - B_8t - B_9r) && (3.7) \end{aligned}$$

If both a and b are zero there is no discernable relationship between cost and time, within the limits of the range of the experimental design.

The characteristics of the samples are shown in Table 3.2.

Only two respondents had a valuation function which, when tested by the F-test, showed that no relationship existed as all the coefficients (B_i, i=1,..,12) were not significantly different from zero. A total of six people had valuation functions for which there was no direct cost-time trade off, although some of these had an indirect relationship via the interaction terms. Two respondents' current travel characteristics, either time or cost, were well outside the experimental design. The respondent in Sample II, who was outside the design due to a very large cost response, was within the design when interviewed at Mittagong as part of Sample I.

Of those on business trips, two paid the journey costs which suggests that their responses should be reliable. Business travellers who do not pay the costs of the journey are generally regarded as unreliable because they are not out of pocket for increased costs and do not directly gain from cost decreases. Only non-business drivers were included in the following analysis.

TABLE 3.2-SAMPLES AFTER REGRESSION

	Sample	
	Home re-interviews	*Number plate tracing*
Number of respondents	7	20
Number with significant valuation functions	6	19
Number with no direct cost-time trade off	1	5
Number outside of design	1[a]	1
Business travellers	1	3
Business travellers who paid themselves	1	1

a. Response in Sample I was within design.

Source: BTE VTSS survey (1983).

COMPUTATIONAL PROBLEMS

When using FM a number of computational problems arise due to its fully disaggregate nature. The main problems are:

- how to distribute the overall time change amongst the individual respondents;
- interpretation of some of the model properties;
- restrictions on current situation and value of the time change to lie within experimental design range; and
- what to do with respondents with insignificant regressions or no time-cost trade off.

Distribution of time change

As FM produces a model for each respondent, rather than a single aggregated result, the question of how to calculate the overall value of a time change arises. Transport system improvements are usually described as changing the trip time by an average amount but individual driver's time changes which contribute to the average change are not known. Therefore, it is difficult to estimate the value of an individual's time change when only the average time change can be estimated for a project evaluation.

The following methods could be used to distribute the time change for the calculation of the corresponding cost change:

1. Everyone is considered to travel in the average situation and to have the same time decrease;
2. Changes occur about the mid-point of the experimental design and the same time decrease is used for all respondents;
3. The time decrease is the same for each person but happens around their own current situation; and
4. The time decrease is distributed in proportion to the individual's present journey time, then the cost change is calculated about the individual's current journey characteristics.

Method 1 is the closest to the situation with aggregate models where time changes are calculated about an 'average' situation. Method 2 appears very unrealistic, but allows examination of the biggest time changes without the time parameter going outside the design range.

Methods 3 and 4 would appear to be the closest to what actually happens. As no information concerning the distribution of time decrease benefits amongst travellers exists, both methods provide a simple way of distributing the benefits and calculating the change in cost about the individual's current travel situation.

People with a linear cost-time relationship have VTTS which depend on the size of the time change but are independent of the context. Therefore they will have the same VTTS if any of methods 1, 2 or 3 are used for the calculation.

Figure 3.4 illustrates some of the characteristics associated with the calculation methods. Simplified parametric curves (only T, C, T^2, C^2 and TC terms used) are shown for one of the interviewed drivers and they illustrate the differences between the methods in terms of the constant valuation curve used when calculating VTTS. The curves are determined by substituting either the drivers' present situation, the average of all drivers interviewed or the midpoint of the experimental design into equation 3.1 to determine the appropriate valuation.

The curve determined by the present travel situation experienced by the driver is well above the curves determined by the midpoint of the experimental design and the average conditions experienced by all drivers. The present situation curve has only positive values of time for the time range used in the experimental design. Conversely, the other curves both can give negative values of time. In the positive marginal value of time region (negative slope) the methods will give similar results but only the top curve will yield positive values for all time decreases within the experimental design range. These properties are illustrative and may not be typical of other drivers.

These observations cannot be generalised so special tests will be needed for every case investigated.

A model property

The properties of the experimental design make it important that the design region covers the full range to be expected in practice. An allowance of a margin for the examination of changes to variables such as time and cost should be made because results become unreliable when values outside the design region are used or implied.

Outside the experimental design region the curves turn around due to their elliptic or hyperbolic form determined by equation 3.2. Time decreases which result in a journey time of less than 2.7 hours (outside of design), go into a region where the valuation curves determined by the midpoint or average do not exist. Therefore such a time decrease goes outside of the time-cost trade off process described by the curve. This may represent a budget constraint or be artificially induced by the experimental design used.

If it is a budget constraint the appropriate treatment will depend on the situation. Consider a constant valuation curve that has a maximum within the experimental design range, as illustrated by the midpoint and average curves. If the time change was due to general road improvements, the maximum value of time changes up to the total time change could be used to value the time benefit resulting from the improvements, because road users are not forced to maximise the time decrease. Whereas, if a separate toll road was introduced, road users would have the choice of paying the whole toll or travelling by a different route. In this case, a negative total time value or the change going outside the time-cost tradeoff region, indicates that the toll road would not be used by the road users because it yields no net benefit.

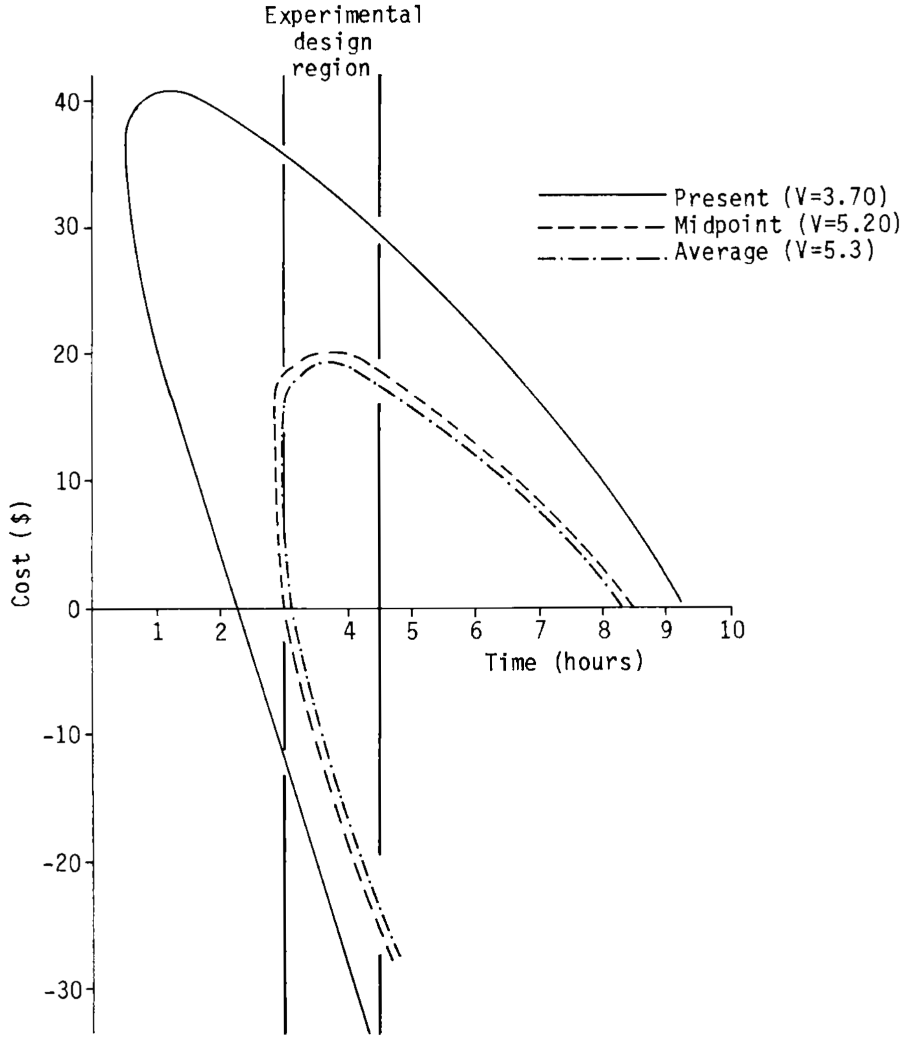
Restriction to experimental design range

Although Figure 3.4 shows the trade off region ending outside the experimental design region, in a number of valuation functions analysed this occurred within the design range. So the treatment of VTTS estimates resulting from such valuations requires careful consideration and explanation.

When VTTS were calculated from the pilot survey data, negative marginal VTTS were allowed for an individual and his total VTTS retained in the analysis provided it was positive. Negative total VTTS were rejected from the analysis and not set to zero. An alternative approach, which was not tried, would be to maximise VTTS within the limits of the time change being considered.

In the pilot survey it was possible to examine each individual record. This may not be possible with large surveys but it is important to be aware of the occurrence and to make an explicit decision on how to treat it.

A VTTS calculation issue which has not been considered so far is the restriction on the VTTS to lie within the range of the cost parameter in the experimental design. The treatment of this is particularly important for the larger time changes because even though the average VTTS is within the design limits, individual values could be outside. These outside values could greatly affect the average VTTS at the ends of the time change range, so that they cannot be excluded. Therefore, individual values which went outside the range were included (provided



Source: BTE VTTS Survey, 1982.

Figure 3.4-Illustrative parametric valuation curves for a driver (simplified equation used)

values for smaller time changes were within the range), if they were less than 0.5 normalised cost units outside the cost range.

Only Sample III respondents were fully analysed due to the very small size of Sample II. This prevented comparison of the VTTS of the two samples but, given the similarity of responses to other questions, they could be expected to not be greatly different. To allow examination of the overall effect of the different calculation methods, all four methods were used to calculated the average VTTS for Sample III.

Treatment of insignificant responses

Two approaches to calculation of the VTTS of respondents with insignificant regression relations or no time-cost trade off were used. In the first approach they were excluded from the calculations and in the second they were set to zero VTTS (ie no monetary benefit) and included in the calculation.

COMPARISON OF RESULTS

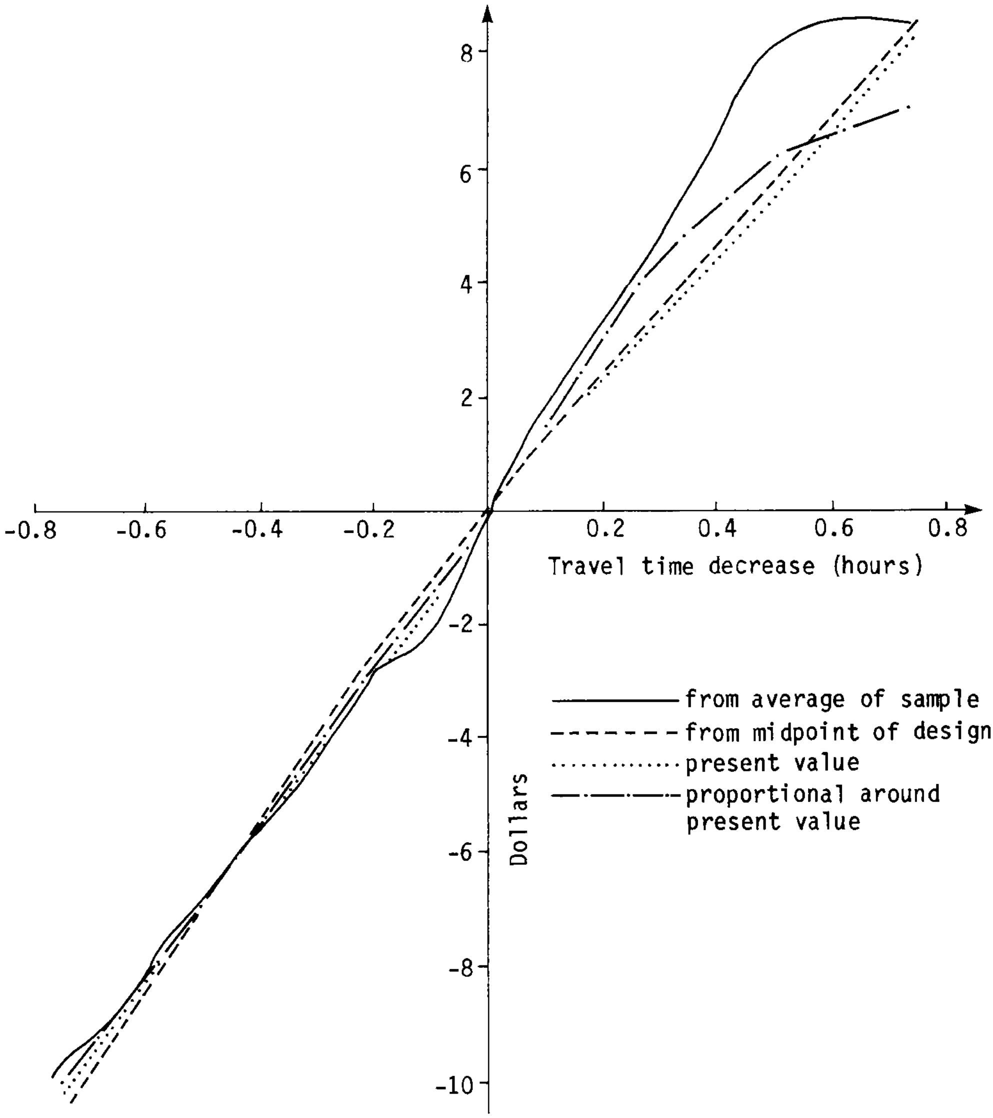
All four methods of distributing the time change and the two ways of treating insignificant responses were used to allow comparison of their effects. The results are summarised by Figures 3.5 and 3.6 where it can be seen that the calculation methods did not greatly affect the average VTTS (usually well within the variance). The results are not presented in the usual (misleading) dollars per hour form but are shown as the value of given time changes.

Although, as shown above, the method of calculation could have a significant effect on the individual values, the treatment of special cases which were either set to zero or excluded had a greater effect on aggregate results.

The rollover of some of the curves for large time decreases results from two causes. The first is the elimination of some respondents when the time change could not be compensated for by a cost change. The second is the result of some individual VTTS becoming too large to be included (well outside of design range), and as they were important contributors to the average VTTS their exclusion decreased the average.

This may be overcome be deleting those respondents from the sample and recalculating all values without them. The extent of the problem can be limited by choosing sufficiently wide experimental design ranges but they are all restricted by the need to provide feasible travel options. Hence, a compromise may be required. In the pilot survey, the ranges were restricted by the inclusion of the time uncertainty variable, leading to a relatively frequent occurrence of values outside the range. In this case respondents could not be deleted as it would greatly diminish the sample size but in a larger sample it is an option that should be considered.

The variances in the VTTS calculated were large, showing a wide dispersion in values in the sample, and as a result it is not possible to reach any statistically significant conclusions about the differences between the curves. Generally this would be expected with

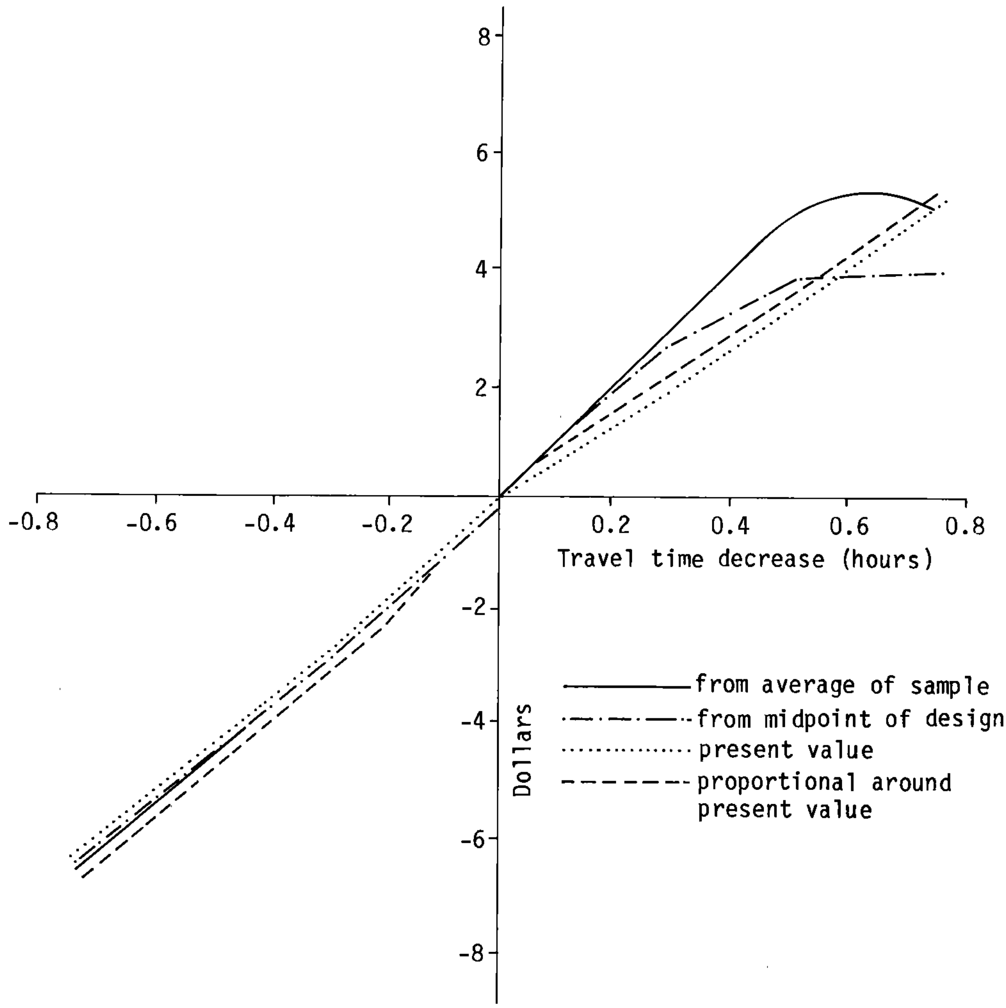


Source: BTE VTTS Survey, 1983.

Figure 3.5-Average values of travel time savings for Sample III (non zero values only)

any pilot survey of this size. For values calculated for a large sample it would be useful to indicate the confidence intervals for the VTTS calculated.

Most of the curves in Figures 3.5 and 3.6 are close to straight lines. This does not represent a failure of the non-linear form of the models but shows that averaging tends to linearise the overall result.



Source: BTE VTTS Survey, 1983.

Figure 3.6-Average values of travel time savings for Sample III (zeros included)

CHAPTER 4-CONCLUDING REMARKS

The pilot survey of ACT drivers revealed no important difference between the sampling options. Therefore, it might be acceptable to consider that drivers who stop at a particular location can provide a representative sample. The location needs to be carefully chosen so that a sizeable proportion of drivers stop there.

The FM approach has been used to calculate VTTS but its application raised several new difficulties as a result of the fully disaggregate nature of the method. The main difficulties are what to do with respondents with no time-cost trade off or whose time-cost trade off region places a restriction on the experimental design ranges, how to calculate VTTS and how to decide if an individual VTTS is feasible so it can be included in the average VTTS. For a large survey this must be done automatically by a computer, not by individual inspection by the experimenter, and would require careful treatment during the data analysis. This has the potential to severely limit the application of FM and other fully disaggregate methods.

The overall outcome is that FM, although theoretically suitable, requires considerable care in its application. In particular the VTTS attributed to each respondent needs to be carefully examined. Also, the survey instrument may be difficult to use at road side locations and, as it cannot be self-administered, incurs a cost and time penalty.

Although this Paper has only examined the VTTS derived from the valuation functions, the effects of changing the time uncertainty of a journey or the road type could also be investigated. The examination of road type effects is limited by the difficulty of describing a road by only one parameter, but could be aided by a study of drivers' perceptions of roads and their conditions.

APPENDIX I-SURVEY INSTRUMENTS

This appendix contains the various survey instruments used in the pilot study. The questionnaire is that used for interviews based on the tracing of number plates (Sample III) and contains all the questions used in the survey. The data for the rating task was obtained by a modification to the questionnaire that deleted the rating task (question 19) and the question concerning the time since they last made the journey (question 1). A few changes to the tense of the questions were also required because Sample I was taken during the journey. The re-interview survey (Sample II) used a questionnaire consisting of questions 1, 7, 11, 12 and 19.

The scale for placing the rating cards on is shown in reduced form, the size used was approximately 600 mm by 300 mm.

Additionally, the interviewers were supplied with detailed instructions. This was particularly true of the rating task, although most respondents found it simpler than anticipated.

QUESTIONNAIRE USED FOR INTERVIEWS BASED ON NUMBER PLATE SURVEY

ROAD TRAVEL TIME STUDY

(Canberra Sydney Full at Home Questionnaire)

SECTION 0: TRIP INFORMATION

Q1: How long ago did you last travel between Canberra and Sydney?

..........days
..........weeks

SECTION 1: VEHICLE DETAILS

Q2: What type of vehicle did did you make the journey in?

Sedan (2/4 door)..........	1
Hatchback sedan (3/5 dr)..	2
Station Wagon.............	3
Sports car................	4
Utility/Panel Van.........	5
Minibus/Passenger Van.....	6
Motor Caravan.............	7
Four wheel drive..........	8
Other (specify)...........	9

....

Q3: Did you tow a trailer or caravan on this journey?

Yes.......................	1
No........................	2

Q4: Was this vehicle .. (READ OUT)

Your own vehicle..........	1
A vehicle belonging to a member of your immediate family...................	2
A vehicle belonging to a friend or relative........	3
A company car.............	4
A hire car (rented).......	5

Q5: How many people (including yourself) travelled *in this vehicle* on the trip between Canberra and Sydney. Please include all children.

Write in number ....

SECTION 2: TRIP DETAILS

Q6: Now think about the journey or part of the journey between Canberra and Sydney (one-way)

(a) What would be the *minimum* travel time you would normally expect to make this trip in that vehicle? Please *include rest and fuel stops bus exclude overnight stays.*

Write in number of

hours ....

(b) What would be the *maximum* travel time you would normally expect to need to make this trip in that vehicle? *Again, include rest and fuel stops but exclude overnight stays.*

Write in number of

hours ....

Q7: What do you estimate the one-way cost of the journey between Canberra and Sydney was? Please include costs associated with running the vehicle, for example, fuel and oil costs. Do not include accommodation or food costs.

If "don't know"/"not sure"

Well, what would be your best guess?

Write in estimate $.........

Don't know	98
Won't answer	99

Q8: Who paid the majority of the costs? (READ OUT)

You yourself................	1
Someone else travelling with you........................	2
Shared between the people travelling.................	3
A business or company.......	4
Someone else (specify)......	5

....

Q9: **Show Card 1** (if neccessary)

Why did you make the trip? Which of the reasons shown on the card represents your main purpose for making the trip?

Going or returning from holiday....................	1
Touring....................	2
Going to, or returning from visiting friends or relatives..................	3
Other personal reasons......	4
Business trip (ASK Q10).....	5

Q10: Ask only if Code 5 in Q9 - Business trip

(a) Was the whole of this trip devoted to business?

Yes....................	1
No.....................	2

(b) How many days in total did it take you to complete the business part of this trip - excluding travelling time?

Write in: ....

(Note: round up to nearest day)

Ask everyone

Q11: How many days in total did the trip take? That is, from the time you left home to the time you returned?

Write in: ....

(Note: round up to nearest day)

Q12: On short trips, that is 300-400 kms (for example Sydney to Canberra), how often do you take a break from travelling to eat, rest or refuel? (READ OUT)

Always.....................	1
Frequently.................	2
Sometimes..................	3
Never......................	4
(don't know)...............	98

SECTION 3: CLASSIFICATION

I have a few questions for classification purposes. Of course, all the information you give will be totally confidential.

Q13: Check back to Q10. IF "business trip" (Code 5) ask Q13 - otherwise skip to Q14

(a) **Show Card 2**
What position do you hold in that company? Which description on the card fits you best?

Managing director or owner..	1
Sales or Marketing Manager..	2
Other senior manager........	3
Sales person................	4
Other employee..............	5

(b) Could you please tell me exactly what your company does? (PROBE FULLY)

If more than one activity, ask:

'What would be the main activity?'

....

....

....

....

(c) How many employees does that company have in total?

Less than 5................	1
6-10.......................	2
11-20......................	3
21-50......................	4
51-100.....................	5
101-500....................	6

Q13 (cont)

More than 500..............	7
Don't know.................	98
Won't answer...............	99

(d) How many company cars does that business operate in total?

Less than 5................	1
6-10.......................	2
11-20......................	3
21-50......................	4
51-100.....................	5
More than 100..............	6
Don't know.................	98
Won't answer...............	99

Tell everyone

All information you give will be totally confidential.

Q14: Age: Show Card 3 (if necessary)

Into which of these age groups do you fall?

.......years **Card code** ....

Q15: Sex: Record

Male.......................	1
Female.....................	2

Q16: Occupation: Show Card 4 (if necessary)

(Which of these groups best describes your present occupation?)

What is your occupation?
....

Card code ....

Q17: Personal income:
Show Card 5

Which of these groups best describes your personal income *before* tax and other deductions?

Card code ....

Q18: Household income:
Show card 5

Into which of these groups would the *combined* income of all the people living in your household fall?

Card code ....

Q19: Rating task

I would now like you to do the following task.

I have a number of cards on which a possible trip between Canberra and Sydney (one-way) is described. Such a trip may or may not exist at present. Here is an example **(show yellow card).** As you can see, the description of the trip consists of the time taken, the cost of the trip and the type of road (explain).

I want you to place each of these cards somewhere on this scale **(show scale).** The top of the scale **(green card, read out)** represents a very good trip and the bottom of the scale **(red card, read out)** represents a very poor trip.

If you consider the trip described on a card to be a 'Good' trip - you would place it near to the top of the scale - a 'Poor' trip would be placed lower down.

Now, place the cards on the scale. You can place 'trip' cards one on top of the other if you feel they are of equal value. Just place the cards where you think they should be relative to each other and to the 'Very Poor' and 'Very Good' cards already there.

Ensure that respondent understands the procedure and that the trips are hypothetical. Demonstrate if necessary.

Then hand over cards one at a time from shuffled pack reading out each card in turn. When all cards handed out and respondent is satisfied, record the scale position of each card.

Rating

CARD A.....	...	CARD H.....	...
CARD B.....	...	CARD I.....	...
CARD C.....	...	CARD J.....	...
CARD D.....	...	CARD K.....	...
CARD E.....	...	CARD L.....	...
CARD F.....	...	CARD M.....	...
CARD G.....	...	CARD N.....	...

Comments about interviewes response to Q19.

EXAMPLE CARD

Card example	
Time	Between 3 hours 30 minutes and 4 hours
Cost	$15
Road Type	dual lane

RATING TASK CARDS

CARD A		CARD B	
Time	3 hours	Time	Between 2 hours 45 minutes and 3 hours 15 minutes
Cost	$10	Cost	$10
Road type	single lane	Road type	dual lane
CARD C		**CARD D**	
Time	Between 2 hours 45 minutes and 3 hours 15 minutes	Time	3 hours
Cost	$20	Cost	$30
Road type	single lane	Road type	dual lane

CARD E		CARD F	
Time	Between 2 hours 45 minutes and 3 hours 15 minutes	Time	Between 3 hours 30 minutes and 4 hours
Cost	$30	Cost	$10
Road type	single lane	Road type	single lane
CARD G		**CARD H**	
Time	3 hours 45 minutes	Time	3 hours 45 minutes
Cost	$20	Cost	$20
Road type	single lane	Road type	dual lane
CARD I		**CARD J**	
Time	Between 3 hours 30 minutes and 4 hours	Time	4 hours 30 minutes
Cost	$30	Cost	$10
Road type	dual lane	Road type	single lane
CARD K		**CARD L**	
Time	Between 4 hours 15 minutes and 4 hours 45 minutes	Time	Between 4 hours 15 minutes and 4 hours 45 minutes
Cost	$10	Cost	$20
Road type	dual lane	Road type	dual lane

CARD M		CARD N	
Time	4 hours 30 minutes	Time	Between 4 hours 15 minutes and 4 hours 45 minutes
Cost	$30	Cost	$30
Road type	dual lane	Road type	single lane

SHOW CARDS

Reasons for travelling **CARD 1**

- GOING ON OR RETURNING FROM HOLIDAY
- TOURING
- GOING TO OR RETURNING FROM VISITING FRIENDS OR RELATIVES
- OTHER PERSONAL REASON
- BUSINESS TRIP

Company position **CARD 2**

1. MANAGING DIRECTOR OR OWNER
2. SALES OR MARKETING MANAGER
3. OTHER SENIOR MANAGER
4. SALES PERSON
5. OTHER EMPLOYEE

Age group **CARD 3**

1. 15 - 19 years
2. 20 - 24 years
3. 25 - 34 years
4. 35 - 44 years
5. 45 - 54 years
6. 55 - 64 years
7. 65 years or more

EXAMPLES OF OCCUPATION GROUPS — CARD 4

1. PROFESSIONAL, TECHNICAL

   Architect, Engineer, Chemist, Physicist, Biologist, Vet, Medical practitioner, Dentist, Nurse, Teacher, Clergy, Religious order, Law professional, Artist, Entertainer, Draftsmen, Technician, Other Professional.

2. ADMINISTRATIVE, etc

   Executive (Government), Employer, Manager.

3. CLERICAL WORKER

   Book-keeper, Cashier, Stenographer, Typist, Other Clerical.

4. SALES WORKER

   Salesman, Commercial traveller, Proprietor, Shopkeeper.

5. FARMER, FISHERMAN, etc

   Farm manager, Farm workers, Farm foreman, Wool classer, Hunter, Trapper, Fisherman, Timber getter, etc.

6. MINER, QUARRYMAN, etc

   Well driller (oil or water), Mineral treater.

7. TRANSPORT, COMMUNICATION

   Deck/Engineer officers, Deck/Engine hand, Air pilot, Navigator, Driver (fireman-rail), Driver (road), Guard, Conductor, Inspector (transport), Telephone operator, Postmaster, Postman, etc.

8. TRADESMAN, etc

   Spinner, Weaver, Tailor, Cutter, Furnaceman, Roller, Watchmaker, Jeweller, Toolmaker, Machinist, Electrician, Metal Worker, Carpenter, Painter, Decorator, Bricklayer, Plasterer, Compositer, Engraver, Potter, Kilnsman, Miller, Baker, Butcher, Chemical/Sugar/Paper/Rubber worker, Tobacco preparer, Packer, TRADESMAN (Cont)

Wrapper, Equipment operator, Storeman, Freight handler, Labourer, Apprentice, Factory worker, etc.

9. SERVICE, SPORT, RECREATION

Fire Brigade, Policeman, Housekeeper, Cook, Waiter, Bartender, Caretaker, Cleaner, Barber, Hairdresser, Launderer, Dresser, Athlete, Sportsman, Photographer, Undertaker, other service workers.

10. MEMBER ARMED SERVICE

11. NOT IN WORKFORCE

Unemployed, Pensioner, Retired, Widowed, Divorced, Full-time student, Housewife.

12. INADEQUATELY DESCRIBED OR NOT SHOWN

INCOME GROUPS **CARD 5**

(Total income before tax and other deductions)

	Weekly Income	Income per annum
1.	less than $100	less than $5,200
2.	$100 to less than $210	$5,200 to less than $10,920
3.	$210 to less than $240	$10,920 to less than $12,480
4.	$240 to less than $280	$12,480 to less than $14,560
5.	$280 to less than $360	$14,560 to less than $18,720
6.	$360 to less than $400	$18,720 to less than $20,800
7.	$400 to less than $450	$20,800 to less than $23,400
8.	$450 to less than $500	$23,400 to less than $26,000
9.	$500 to less than $550	$26,000 to less than $28,600
10.	$550 to less than $600	$28,600 to less than $31,200
11.	$600 to less than $650	$31,200 to less than $33,800
12.	$650 or more	$33,800 or more

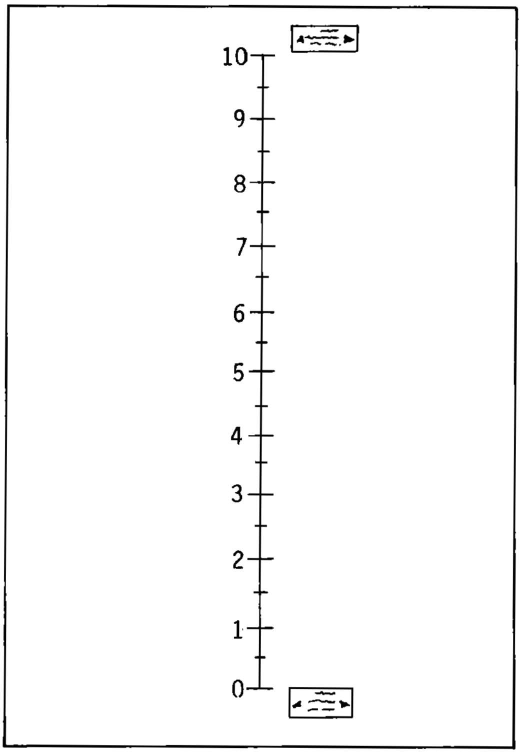


Figure I.1-Rating task scale

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