M6T Research Study – Passenger Stated Preference Summary Report

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Job No 50547TBMT Reference Date Created Feb 2009

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1 Introduction

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1.1 Aims

The M6 Toll road (M6T) is the United Kingdom's first toll motorway. The 27 mile (43km) three lane motorway was designed to alleviate traffic congestion around Birmingham and was built under a public-private partnership scheme. The road was fully opened on 14th December 2004 and generated £45 million in revenue in its first full year of operation. On opening, the standard toll for cars was £2 but this has increased significantly to a current charge of £4. Its existence supports a range of choice modelling opportunities using Stated Preference (SP) and Revealed Preference (RP) data.

The research reported here was conducted as part of the project "A Study of the Impact of M6 Toll Road, Stage 2: Travel Demand Analysis, Utilisation and Willingness to Pay Study" undertaken by a consortium of AECOM, the Institute for Transport Studies University of Leeds, Hugh Gunn Associates and 4Cast. It covered both passenger and freight traffic and both willingness to pay research and detailed profiling of M6T users.

This summary is concerned with passenger traffic and with motorists' willingness to pay toll to save time. The principal aims of the analysis of private motorists' behaviour were to:

- Develop a transferable model explaining motorists' willingness to switch to a tolled route to save time; and

- Explain the extent to which motorists might change departure time as well as route in response to off-peak pricing or time savings.

The study objectives did not cover other dimensions of travel decision making, such as mode, destination or frequency choice. These are regarded to be less significant behavioural responses in the context of the provision of new tolled roads.

Within these broad objectives, the study account not only for time-toll trading but also examined the extent to which a broad range of other attributes, relating to traffic conditions and the infrastructure, might influence motorists' decision making. A range of research hypotheses to investigate were established at the outset of the study. The opportunity to address methodology issues was also taken.

1.2 Research Hypotheses

The hypotheses are broadly categorised into: whether they relate to how motorists respond to a range of variations in journey cost, including toll and fuel, and in time, including departure and in-vehicle time; the extent to which aspects of SP design and presentation influence the empirical findings; the heterogeneity of preferences across motorists; and a range of residual modelling issues.

Cost Hypotheses

- Does the response to toll depend upon the level of toll charge?
- Are there differences in sensitivity to higher and lower tolls?
- Does the reported sensitivity to toll depend upon whether tolls are being varied on an existing tolled motorway, whether tolls are being introduced on an existing un-tolled motorway or whether the toll charge is part of a possible new motorway?
- To what extent are fuel costs accounted for in route choice and, where they are, how does the fuel cost and toll coefficients compare?

Time Hypotheses

- Does the sensitivity to time variations differ according to the conditions of travel? At its simplest, are route specific time valuations apparent? More generally, we wish to test if the time sensitivity depends on a range of driving conditions and infrastructure.
- Is the sensitivity to time savings influenced by the duration of the actual journey in which it is offered?
- Do the benefits per minute of time saved depend upon the amount of time saved?
- Do earlier and later departures than desired have the same disutility?
- Are the unit valuations of earlier and later time dependent upon the extent of the departure time shift?
- How does variability in travel time influence behaviour and what is its value relative to mean travel time?

SP Specific Hypotheses

- Does offering travel times as differences relative to another route yield different valuation estimates than when absolute time values are used?
- Is the sensitivity to time and toll dependent upon the number of alternatives offered in the SP exercise and the number of other attributes included?
- How are the coefficient estimates impacted by the degree of realism with which respondents perceive the attributes offered to them?
- Does purchasing a time saving made up of three separate toll roads lead to a different valuation than if the same time saving is purchased as an extended toll motorway?

Preference Heterogeneity

- How are the sensitivities to time and cost systematically influenced by socio-economic and trip characteristics?
- To what extent is there random variation in preferences across the sample?

Other Issues

- To what extent can route specific constants be unpacked into valuations relating to a range of variables not typically entered into route choice models?
- Does the presence of information relating to traffic conditions have a bearing on route choice?
- To what extent are the SP responses and parameters estimated on them corroborated by RP evidence?
- How does the value of time vary over time, and are there differential rates of growth according to whether the numeraire in which the monetary valuation is expressed is toll or other driving costs?

1.3 Structure of Report

Chapter 2 sets out the principles underpinning the Stated Preference designs that have been. Data collection and important traveller characteristics are covered in chapter 3.

Chapter 4 reports the results of stated preference analyses on the route choice models and reports a preferred SP multinomial logit model prior to incorporating RP data and addressing random taste variation.

Chapter 5 reports the Revealed Preference models, both as separate models and jointly estimated with the SP data, and also specifies random parameters models.

Concluding remarks are provided in chapter 6.

2 Stated Preference Designs

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2.1 Overview

Given the wide range of issues to be explored, a large number of SP experiments were designed. A series of focus groups (AECOM et al, 2006) contributed to the specification of the SP exercises and the range of attributes to cover. The SP exercises can be broadly categorised into:

- A route choice exercise;
- A combined route choice and departure time choice exercise; and
- Abstract choice exercises containing ‘unlabelled’ alternatives

Standard orthogonal fractional factorial designs were used. Respondents were offered two SP exercises. The first was always a route choice exercise involving eight out of a set of sixteen scenarios. The second SP exercise could be any one of the three generic types of exercise, but with an emphasis on covering departure time choice and the various traffic and infrastructure related variables to be addressed by the abstract choice exercises.

2.2 Route Choice Designs

The existence of the M6T as the first tolled motorway in Great Britain provides an ideal real-world context upon which to base SP experiments exploring time and cost trading through route choice. It will be familiar to the vast majority if not all of those travelling in the corridor and it allows an opportunity to validate the SP responses and parameters against actual choices.

This context also allows important insights into the contentious issue of stated response to toll variations. The incentives to strategic biasing of responses to toll variations when a toll exists in practice may well be different to the incentives that exist when tolls are introduced on an existing, free motorway or when a new motorway funded by tolls is being considered.

Given that the SP exercise relates to an actual rather than hypothetical journey, the requirement that realistic attributes are offered to respondents was dealt by offering choices that relate to a specific section of a journey, with all else held constant.

Given that the current context is one where there is a clear choice of using a toll road for only a part of the journey, and that this will be the case with the provision of new tolled facilities, there is not only no need to present the SP scenarios as representing the entire journey but it is preferable to base the SP around only that portion where the decision is relevant, provided it is set in the context of an entire journey.

With the exception of the exercises dealing with travel time variability, the route choice SP exercises were based around the following three corridors, see Figure 2.1:

- The 27 mile M6T corridor
- An 80 mile corridor between M6 Junction 16 (Stoke) and the M1 Junction 18
- A 150 mile corridor between M6 Junction 19 (Knutsford) and M1 Junction 11 (Dunstable)

The choice context in the 27 mile M6T corridor was of primary interest and could in principle be applied to all ‘in-scope’ motorists whatever the length of their journey. However, focussing solely on this would have seriously limited the scope for examining many of the stated research hypotheses.

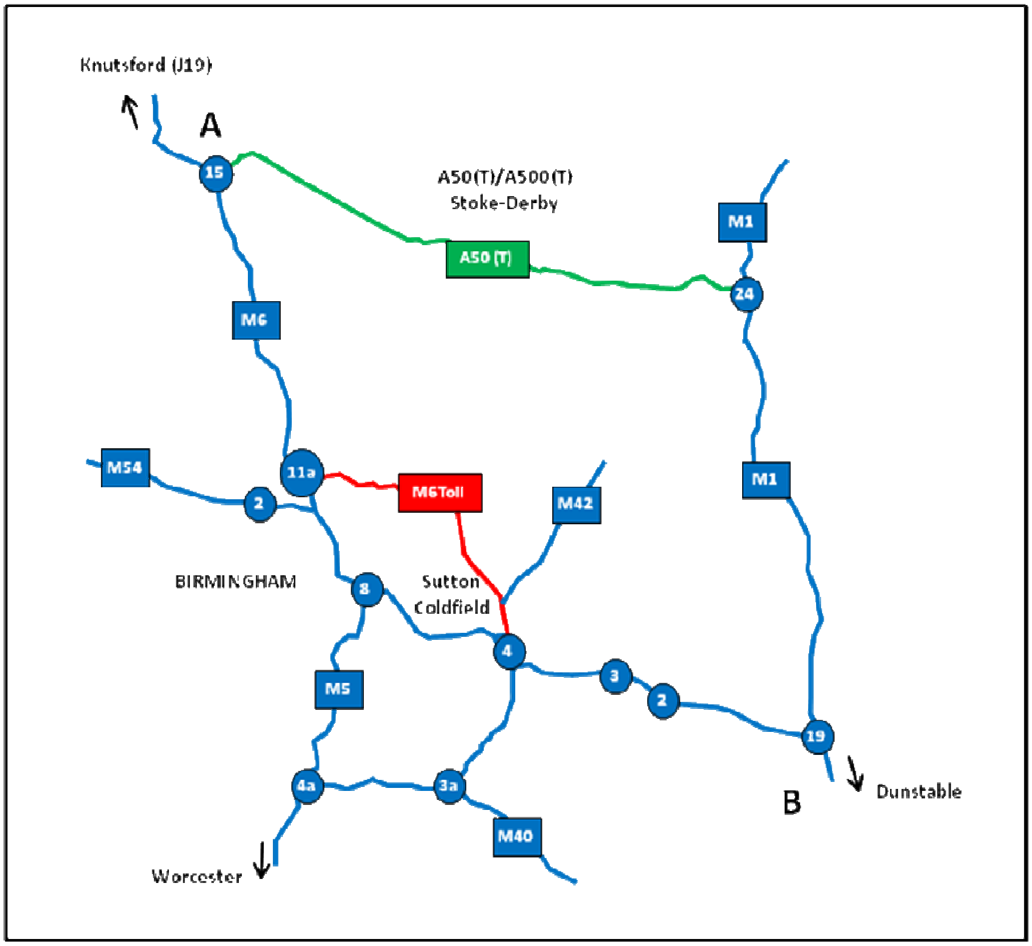

Figure 2.1: The M6T and Survey Corridor

The reasons for offering the Stoke to M1 corridor were that it is realistic to introduce the A50/A500 as a free alternative to the often highly congested M6, thereby introducing a wider range of time-cost tradeoffs and, because it is 10 miles shorter, permitting sensible fuel cost variations to be introduced that support analysis of the relative magnitude of toll and fuel coefficients.

The third route choice context, suitable for those making very long distance journeys, provided the opportunity to provide a wider set of time-toll trade-offs, as well as evaluating preferences towards an entirely new tolled motorway.

In the M6T corridor itself, those making short journeys that cover the M6T corridor but not the Stoke-M1 corridor were offered an SP route choice exercise that focussed simply on the section of journey where the M6T parallels the M6. There is no natural A road alternative here and hence only one of the 8 designs offered an A road.

The SP designs for the M6T corridor made large variations in travel time plausible on the existing M6 given the significantly different levels of congestion experienced on this route according to traffic and travelling conditions.

Some of the SP designs introduced differing levels of driver information systems. Respondents were presented with situations where there would be information on the conditions on the M6. These could be:

- Delays on the M6
- Delays on the M6 due to Roadworks
- Roadworks on the M6: Expect 25 minute Delay
- No Delays on M6

2.3 Route and Departure Time Choice

The route and departure time choice exercises were based around the M6T corridor the Stoke-M1 corridor. These contained four alternatives, the M6 and the M6T each at the current departure time and some different departure time. Motorists were offered the possibility of saving time and of paying lower tolls by changing their departure time. The exercise not only offered a broader range of trade-offs, including lower tolls than currently exist, but it also allowed the valuation of changes in departure time.

Two options were considered for this SP exercise either:

- Offer choices between travelling in specified peak and off-peak time periods; or
- Offer choices between travelling at different unspecified time periods

The former provided sensibly defined peak and off-peak periods with discounted tolls and quicker times on both routes in the off-peak. The latter offered lower tolls and quicker times if the journey was made at a different time to the reference journey

The main problem with the former is that many people will be travelling through the corridor in what would be defined as the off-peak and hence the information content of the SP choices would be poor since the peak would be generally slower and more expensive and involve travel at a less desirable time. The concern with the latter was one of realism, since the departure time shift might imply travel in the peak or closer to it.

However, it was considered that the possible lack of realism in the latter approach was offset by its guarantee of choices amongst alternatives that required trade-offs to be made and hence its richer informational content.

Separate SP exercises were designed relating to the M6T corridor and to the Stoke-M1 corridor to mimic those offered in the SP exercises relating solely to route choice.

Four levels of departure time change were offered. These were departing one or two hours either earlier or later. This enabled analysis of the extent to which earlier and later departure time shifts are valued differently and whether the unit valuation of a departure time shift depends on the amount of change to departure time.

The M6T toll was lower if the departure time is changed, and in some cases zero. The M6T option's journey time was quicker for the amended departure when it covered the Stoke-M1 corridor, as some of the time includes travel on the congested M6. Given the M6T is uncongested, it is not realistic to vary the M6T option's journey time when the exercise related only to the M6T corridor.

Not only did these designs provide insights into the extent to which motorist are prepared to change departure time, they also providd a broader range of times and tolls to support the analysis of non-linear effects.

2.4 Abstract Choice

The abstract choice exercises presented choices between 'unlabelled alternatives' (A and B). One of these aimed to estimate the relative valuation of time spent driving in six different types of traffic. The other two were aimed at obtaining time valuations of infrastructure characteristics and road conditions. These were: lane width, number of lanes, proportion of HGVs, road surface, information provision, speed cameras and lighting.

Abstract choice contexts are those which have no corresponding real world context, such as offering choices between option A and option B which are characterised by, say, different levels of time and cost. Valuation studies almost always use such choice contexts since the results cannot be influenced by extraneous factors related to real-world alternatives.

The purpose of these valuation exercises is, by definition, not to forecast behaviour but instead to value attributes that might be impacting on the alternative specific constants and to provide additional insights into attributes in the route choice exercise. For example, the presence of route specific constants is not conducive to transferability, but valuation results might enable the 'unpacking' of these constants. Similarly, time valuations might vary with traffic conditions which can be explored in an abstract choice exercise that specifically addresses this issue but cannot sensibly be covered in a route choice exercise covering a range of other attributes.

The abstract choice exercises address the relative disutility of time spent in different driving conditions as well as the fixed and duration related valuations of different types of infrastructure provision. The latter were identified in a series of focus groups (AECOM et al., 2006) that were undertaken with drivers in the corridor.

The first British value of time study (MVA et al. 1987) established that there were differences in the value of time according to the conditions in which that time was spent. It found that the value of time spent in congested traffic conditions, defined as time spent moving slowly or stopped due to congestion, was valued around 40% higher than time spent in free-flow conditions.

The study adopted the following conventions regarding the classification and description of driving conditions. These were:

- *Free flowing:* You can travel at your own speed with no problems over-taking
- *Busy:* You can travel pretty much at the speed limit, but you are forced to change lanes every now and then
- *Light congestion:* You can travel close to the speed limit most of the time, but you have to slow down every so often for no apparent reason
- *Heavy congestion:* Your speed is noticeably restricted, frequent gear changes required
- *Stop start:* You are forced to drive in a "stop-start" fashion
- *Gridlock:* You are only able to move at a crawl at best, and spend quite a lot of time stationary

The SP exercise presented different proportions of time spent in differing travel conditions in relation to alternative toll levels.

A further SP exercise related to a motorway journey of either 20 or 45 miles and the choice between two unlabelled alternatives described in terms of journey time, the proportion of traffic made up by heavy goods vehicles (HGVs), the number of speed cameras present, the level of information provided and the width of the lanes.

A similar exercise presented a choice between two options described in terms of journey time, the quality of the road surface, the number of lanes and the presence of lighting. The road surfaces were the M6T, the high level, jointed M6 as around Birmingham, a concrete section of the M6 and the standard M6. Respondents were then asked to rate, on a ten point scale, each road surface in terms of noise and bumpiness.

2.5 Additional SP Designs

The study also conducted a repeat of the 1994 UK value of time study SP exercise for motorway users. This took place amongst those intercepted during the various surveys who were not in-scope for the SP exercises based around the possibility of using the M6T. The aim of this aspect of the study was to test whether the sensitivity to toll charge exhibited the same variation over time as the sensitivity to other driving costs. It would also contribute to the limited evidence base relating to inter-temporal variations in the value of time.

In addition, the SP data was supplemented with RP data relating to actual choices between the M6T, the existing M6 and an A road alternative.

All the SP exercises were administered as mail-back self completion questionnaires. Surveys were conducted in November 2006 at road-side interview sites, motorway service areas and through postal contact of a database of M6T users. Completed questionnaires were returned by 3235 motorists, yielding 29158 SP choice observations. The repeat of the 1994 SP exercise yielded 787 motorists and almost 6000 choice observations.

Table 2.1: SP Exercises

Corridor	Term Routes	Attributes	Comment
Route Choice Exercises			
Stoke-M1	M6 v M6T v A50/A500 M6 v M6T v A50/A500 M6 v M6T v A50/A500 M6 v M6T v A50/A500	Time, Toll, Fuel Time, Toll, Fuel Time, Toll, Fuel Time, Toll	Absolute Times M6T quicker M6 slower
	M6 v M6T v A50/A500	Time, Toll, Fuel	Toll on M6
	M6 v M6T v A50/A500 M6 v M6T v A50/A500 M6 v M6T	Time, Toll, Fuel Time, Toll, Fuel Time. Toll	Extended M6T Higher Toll
	M6 v M6T extended	Time, Toll	Extensions
Knutsford-Dunstable	New Motorway v M6 v M6T	Time, Toll	
M6T Corridor	M6 v M6T v (A Road) M6 v M6T M6 v M6T M6 v M6T M6 v M6T M6 v M6T M6 v M6T	Time, Toll Time, Toll Time, Toll Time, Toll Time, Toll, Information Time, Toll, Information Time, Toll, Information	Absolute Times M6T quicker M6 slower Different tolls M6 Roadworks M6 Accident M6 Congestion
Route Choice Exercises (Reliability)			
Current Journey	M6 v M6T	5 times, toll, big delay	Vary around 2½ hours,1½ hours, 1 hour, 3½ hours, and 4½ hours
Current Journey	M6 v M6T	Late Arrival, Toll	Pay toll to reduce / remove late time
Route and Departure Time Choice Exercises			
M6T Corridor	M6T v M6	Time, Toll, Dep Time	
Stoke-M1	M6T v M6	Time, Toll, Dep Time	
Abstract Choice Exercises			
15 / 45 miles 15 / 45 miles 15 / 45 miles 15 / 45 miles	Route A v Route B	Types of Time Free Flow (FF), Busy (B) Light Congestion (LC) Heavy Congestion (HC) Stop Start (SS), Gridlock (G)	FF & SS v LC B & G v HC B & SS v LC FF & HC v B
20 miles 45 miles	Route A v Route B	Time, HGV, Cameras, Information, Lane Width	
20 miles 45 miles	Route A v Route B	Time, Surface, Lighting, Lanes	

3 Data Collection

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3.1 Overview

The M6 Toll Study involved the collection of two major sets of survey data in order to gain a greater understanding of the composition of the M6 Toll user market, the willingness to pay tolls, and the relative importance of specific trip attributes in the decision making process. The first survey, which is referred to as the utilisation survey, was undertaken with a random sample of M6 Toll users who were contacted at the M6 Toll booths and through the M6 TAG database held by the M6 Toll operating company. This survey collected a wide range of data on the characteristics of the respondent, the details of their usage of the M6 toll road, and their reasons for using the toll road in preference to the non tolled alternatives.

The second set of survey data that was collected in the study was the SP surveys exploring travellers' willingness to pay. The SP survey sample was to be drawn so as to include a representative sample of users and non-users of the M6 Toll road. The utilisation survey with the M6 Toll users provided the mechanism for the distribution of SP questionnaires to users of the toll road. But in order to obtain SP surveys with non users of the toll road a data collection strategy was devised that combined motorway slip roadside interview (RSI) surveys and surveys at motorway service areas (MSAs) as a means of making contact with travellers in scope.

3.2 Survey Types and Locations

The location of the respective surveys is shown in Figure 3.1.

The SP questionnaires were distributed through a combination of RSIs, contacts at MSAs and by post to a database of M6T users. The survey locations were selected to capture those who would be travelling in the M6T corridor, although clearly not all would be and hence motorists were screened for an appropriate journey. The surveys were conducted in November 2006.

At the MSAs and motorway slip RSIs, those who were not in scope for the M6 Toll Study were handed a repeat of the 1994 UK value of time study questionnaire for motorway users (HCG et al., 1999) adjusted as necessary for inflation and income growth but otherwise identical.

The principles behind the data collection procedure were representivity and cost effectiveness. Considerable efforts were made in specifying the form of data collection and its undertaking to ensure that a 'random' sampling approach was adopted within each survey type to ensure that bias was minimised for each survey type.

It was recognised that differential response rates would arise from the respective surveys and as such measures were taken to ensure that appropriate expansion factors could be applied to each survey record so as to reflect the overall market shares. In summary, the recruitment procedure for passengers of interest was:

- Surveys at Motorway Service Areas to capture long distance movements through the corridor with a particular emphasis on non M6T users to obtain a representative sample for the Willingness To Pay (WTP) data but additionally to obtain M6T utilisation data at low marginal cost;
- Surveys at the M6T cash and card payment booths to collect data for the utilisation survey and the WTP data at low marginal cost. TAG users were contacted separately through the Midland Expressway Limited (MEL) customer database; and
- RSI's on selected motorway slip roads to the north and south of the M6T to capture non-M6T users making shorter journeys for which the probability of using a motorway service area is relatively low.

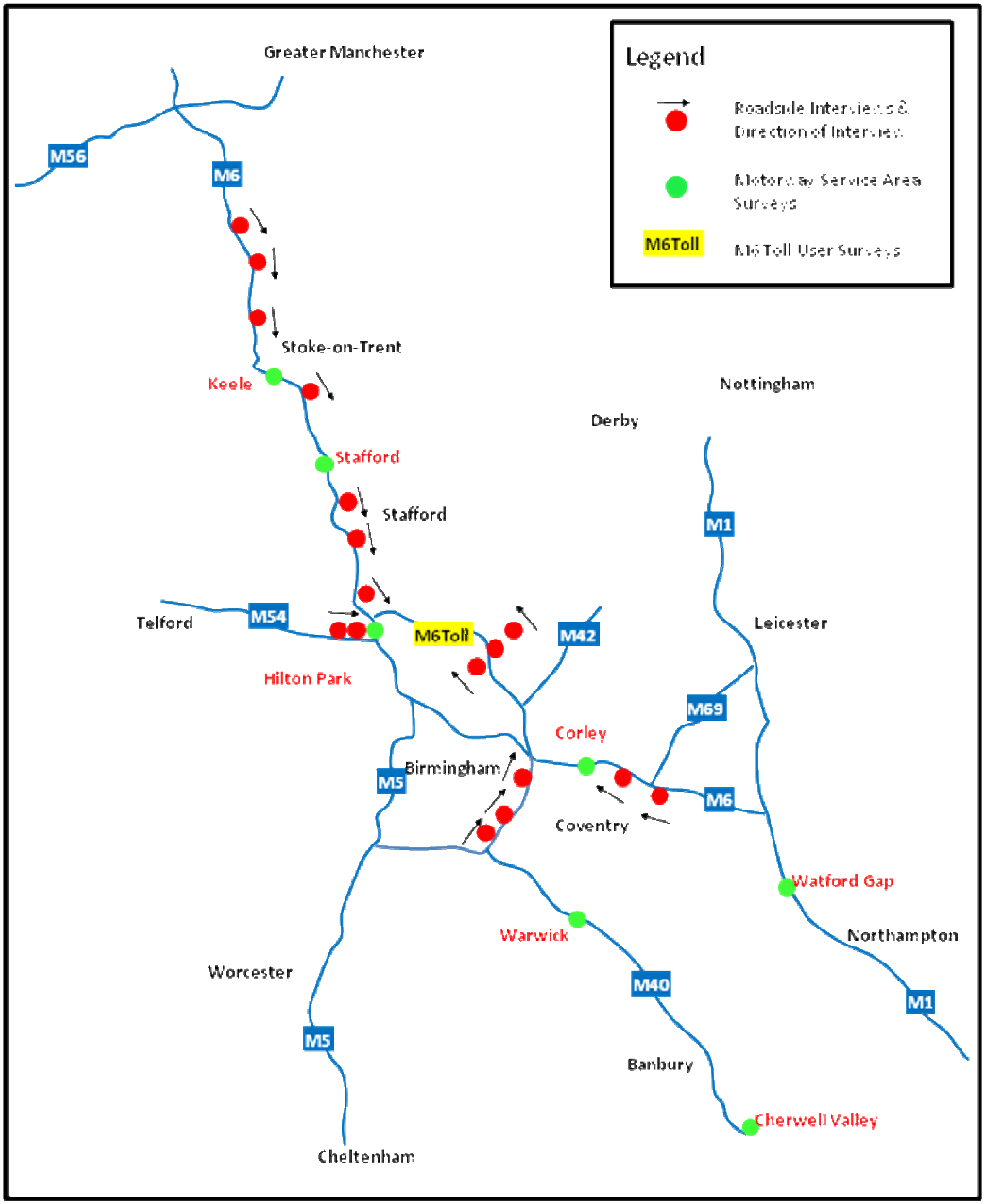

Figure 3.1 Survey Locations

There were two main issues relating to survey bias that were borne in mind in the selection of the sampling methodology. Firstly, inability to contact particular market segments; using a random sampling approach every person of interest should have an equal contact probability. Secondly, once contacted there should be an equal probability of the respondent completing the survey. However, barriers to completion of the survey do exist and often include the following:

- Not interested - material needs to generate interest by being attractively presented and well produced. The potential respondent should feel it worthwhile to take part in the survey, because it is important to them;

- No time - material should be as concise as possible; and
- Not able to understand – material should be as easy to understand as possible.

The approach adopted in the study was to ensure that random contact was made in each of the three different surveys and that due to the potential response bias in the self completion survey data was collected that would enable corrections to be made during the data expansion and weighting so as to achieve a representative sample.

3.3 Traveller Characteristics

Table 3.1 shows the journey purpose splits for the SP sample. It has to be borne in mind that the survey period covered a typical week, in a period when all schools were open.

Table 3.1: Journey Purpose

	Percent
Employer's business	34.0
Holiday	4.4
Personal business	5.8
Recreation/leisure	6.0
Shopping	0.8
Short break	3.5
To/from work/education	13.5
Visiting friends/relatives	27.2
Other Leisure	4.8

Just over a third of the M6 toll users were on business trips with another 27% visiting friends/relations. As would be expected the above purposes lead to a close relationship with the figures in Table 3.2 which show the proportion of M6 Toll users who have their toll charges reimbursed, 33%.

Table 3.2: Payment of M6 Toll Charge

	Percent
Employer	33.0
Other passenger	1.7
Self	60.6
Shared between group	1.1
Missing – not given	3.6

Table 3.3 shows that the majority of M6 Toll users are relatively infrequent users with less then 20% using the toll road more than once a week. This has an important bearing on how travellers view the toll charge as in the majority of cases the payment of the toll is an infrequent event. It could be inferred that in most cases where the use of the M6T is a daily option that the majority of people choose to be more selective in their use of the M6T. Payment of the toll on a daily basis by commuters would be a costly exercise with average monthly costs of around £150.

Table 3.3: Trip Frequency

	Percent
Daily	8.2
Several times a week	10.7
Weekly	9.4
Several times a month	16.7
Monthly	8.5
Several times a year	37.7
Once a year	3.8
Less than once a year	2.3
First time today	1.9

Tables 3.4 and 3.5 show the varying perceptions of travellers in the corridor as to the reliability of the respective route options. Interesting differences exist in the perceptions provided by the different respondents. In the case of the M6 56% of M6T users consider the M6 unreliable whereas only 35% of M6 users consider it unreliable.

The majority of M6T users consider the M6T reliable but there is a large proportion of M6 users who stated they did not know indicating that a significant proportion of M6 users never used the M6.

Table 3.4: M6 Users View of Reliability

	M6T User	M6 User	A User
Very reliable	0.8	2.9	0.7
Reliable	1.9	7.8	2.0
Usually reliable	9.6	24.1	6.6
Sometimes unreliable	23.2	25.3	15.2
Unreliable	28.9	16.9	22.5
Very unreliable	27.1	18.3	22.5
Don't know	8.5	4.7	30.5

Table 3.5: M6T Users View of Reliability

	M6T User	M6 User	A User
	Percent	Percent	Percent
Very reliable	48.2	18.9	38.4
Reliable	30.0	21.8	21.9
Usually reliable	16.7	15.1	11.9
Sometimes unreliable	2.1	3.2	0.7
Unreliable	0.6	1.7	0.7
Very unreliable	0.0	0.0	0.0
Don't know	2.5	39.2	26.5

Table 3.6 reports when the decision to use the M6T was made. The vast majority, 74%, decided prior to setting out and only 5%never considered using the M6T.

Table 3.6: When Made Decision as to Whether or Not to Use M6T

	Percent
Approaching the M6 Toll	5.9
During the course of journey	14.4
Never considered using M6T	4.8
Prior to setting out	73.7
Missing - Not Given	1.2

Table3.7 indicates what influenced decisions to use the M6T or not for those who decided during the course of their journey. Observed traffic conditions had the largest impact on decisions, followed by signs indicating delays on the M6. Radio messages influenced the decisions of 30% of those who decided en route but all other factors had a minor impact on decision making.

Table 3.7: Influences on Decision During Journey to Use M6T or Not

	Percent
Sign Indicating Delays on M6	44.4
Observed Traffic conditions	61.4
Other Passenger Influence	3.8
Radio Messages	29.6
Wanted Break from the M6	10.4
Wanted to Make up some time	14.4
Observed Road Works	12.2

Note: Multiple answers permitted. Percent denotes proportion of people who stated this as an influence and thus sums to more than 100%.

4 Stated Preference Analysis

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4.1 Overview

The preferred model form pools data across all the route choice SP exercises where we do not feel the need to allow for different scales across these exercises yet applies weights to account for the differential sampling. These models have 29158 observations from 2495 respondents.

The preliminary analyses examined the main effects attributable to the SP design variables in the conventional form of linear-additive utility functions. This was because the primary purpose of the analysis was to establish whether the different SP exercises yielded sensible results and to identify any issues involved in pooling data across the exercises. This chapter summarises the findings from the more detailed analysis and:

- examines whether the value of time varies by route type;
- reports analysis of the impact of journey duration on key model parameters;
- Whether the unit value of time varies with the size of the time saving;
- reports analysis of variations in motorists' sensitivities to toll charge;
- examines the values of earlier and later departure;
- reports on the impact of information provision on key model parameters;
- reports analysis of the effects of socio-economic and trip characteristics;
- type of time on routes, i.e. congested and uncongested;
- Travel Conditions: HGVs, Lane Width, Speed Cameras, Information; and
- Travel Conditions: Road Surface, Lighting and Lanes

4.2 Route Specific Values

Initial models estimated a single time coefficient for all routes, with any route specific effects captured by large alternative specific constants (ASCs). However, if the route specific effects are time dependent, we would expect the time coefficient to vary by route. Table 4.1 shows the route specific valuations from one of the SP route choice experiments. This shows little supporting evidence for route specific values of time.

Table 4.1: Route Specific Valuation Effects

	Coefficients
$ASC_{M6TCorridor}$	1.1788 (6.6)
$ASC_{M6TStoke\text{-}M1}$	1.7127 (8.9)
$ASC_{M6TExtended}$	1.7643 (3.2)
$ASC_{M6TBits}$	1.4279 (1.9)
$ASC_{M6TLong}$	0.5943 (1.9)
ASC_{NewM6}	0.4372 (0.4)
ASC_{NTH}	-0.4245 (0.5)
ASC_{STH}	-1.8915 (1.7)
ASC_{M6TNTH}	1.0317 (1.4)
ASC_{M6TSTH}	-1.1634 (1.4)
ASC_{NTHSTH}	-0.5157 (0.8)
ASC_{ALL3}	0.9699 (1.7)
$Time_{M6}$	-0.0524 (26.0)
$Time_{M6T}$	-0.0498 (6.3)
$Time_{A}$	-0.0557 (31.2)
$Time_{Bits}$	-0.0588 (5.9)

To support the findings with respect to route specific values of time reported in Table 4.1, we also report the results for the two SP exercises that most clearly address this issue. These are the exercise that offered the extended M6T and the exercise which presents the new tolled motorway. The results are respectively reported in Tables 4.2 and 4.3.

Table 4.2 shows the models derived from the SP exercises that offer a choice between travelling entirely on the M6, on an extended M6T and in two cases on an A road. It is therefore the exercise which most clearly provides insights into the relative valuation of time spent on each route.

Table 4.2: Extended M6T Route Specific Results

	Coefficients with M6T ASC	Coefficients without M6T ASC
ASC_{M6T}	4.4295 (2.7)	-
$Time_{M6}$	-0.0698(10.9)	-0.0778(10.7)
$Time_{M6T}$	-0.0973 (4.4)	-0.0501 (6.4)
$Time_{A}$	-0.0730(10.5)	-0.0813(10.3)
Toll	-0.0066 (8.7)	-0.0063 (9.1)
Fuel Yes	-0.0087 (6.1)	-0.0086 (5.8)
θ_1	1.0	1.0
θ_2	0.62 (6.1)	0.63 (5.9)
θ_3	0.54 (2.8)	0.52 (2.7)

Note: Scale (θ) t ratios are with respect to one. The weights for the M6, M6T and A road were 3.31, 0.70 and 2.13. This makes little difference to the results.

What is noticeable about the models in Table 4.2 is the very large ASC for the M6T. This could well stem from a very high correlation with the M6T time coefficient in this exercise. Indeed, when the ASC_{M6T} is removed the M6T time coefficient falls considerably. However, we cannot take this as reliable evidence that time on the M6T has a lower disutility than the other roads since it is not realistic that ASC_{M6T} is zero and the value for the latter clearly influences the former.

Table reports analysis of the data relating to the Knutsford-Dunstable new motorway. This identified that there were strong correlations between the ASCs and time coefficients and these were removed and the model relies on the route specific time coefficients to detect any difference. The latter indicate only a marginal preference for time spent on the M6T over the M6.

Table 4.3: New Tolled Motorway Route Specific Results

	Coefficients
$Time_{M6}$	-0.0483 (5.3)
$Time_{M6TNew}$	-0.0435 (5.9)
Toll	-0.0031 (6.7)
ρ^2 (constants)	0.135

Note: The weights for the M6, M6T and A road were 2.06, 0.73 and 1.17. This makes little difference to the results.

Although the results are variable, there is no strong support for distinguishing the time coefficient between the M6 and the M6T. The indications are however in each model that the M6T, or an extended toll road, has a lower time disutility which is consistent with expectations.

4.3 Journey Duration

It is not uncommon that studies identify a positive effect on the value of time from journey duration, and there are a range of reasons why the value of time might increase with duration. For example, an activity must be important if considerable time is spent in pursuing it and thus the opportunity cost of time travelling can be expected to be high. The discomfort of travel might also increase more than proportionately with duration. A possible confounding effect is that those with higher incomes travel farther and that SP exercises for longer journeys offer larger travel time savings.

Initial models indicated that duration segmentation on the earlier and later time coefficients, nor on the toll coefficient, did not yield sensible outcomes. Instead, Table 4.4 reports models where a continuous effect has been specified on the time coefficients and ASCs alone.

The specification of the utility function to allow the ASC to vary with duration is:

$$U = ASC + \sum_{i=2}^{8} \alpha_i d_i + ...$$

where the d_i are dummy variables for 7 of the 8 time categories and here the arbitrarily omitted category is 45 minutes or less (1). ASC relates solely to the base category of 45 minutes or less whereas for, say, category 6 (241-360 minutes of actual time) the constant is ASC+α_6. The equivalent function to allow the sensitivity to time to vary by duration is:

$$U = \beta T + \sum_{i=2}^{8} \lambda_i d_i T + ...$$

T is the SP journey time. The time coefficient for the base actual time category is β whilst for category 4 (121-180 minutes) it is $\beta+\lambda_4$. Analogous functions are specified to examine whether the sensitivity to earlier and later time and to toll depend on the actual time category.

The more monotonic the effect across more category specific coefficients then the greater the confidence we can have that journey duration really does impact on relevant parameters of route choice models.

For the effects of journey duration on the travel time coefficient, we have specified a function of the form:

$$U = \alpha T + \beta AT^{\lambda} T + ...$$

where AT is the actual time for the journey made and T is the SP journey time. The marginal utility of travel time (MU_T) is therefore a function of the actual time:

$$MU_T = \alpha + \beta AT^{\lambda}$$

Similarly, we have separately allowed the ASC for the M6T (ASC_{M6T}) to vary with journey duration as:

$$U = ASC_{M6T} + AT^{\lambda} ASC_{M6T} + ...$$

whereupon the ASC will depend upon the actual journey time.

A value of λ of zero means that the actual journey duration does not impact on the ASC or time coefficient. A value of λ greater (less) than one implies that the incremental ASC or time coefficient increases more (less) than proportionately with journey duration, although the variation in the overall time coefficient or ASC also needs to take the base coefficient or ASC into account.

Table 4.4: Continuous Estimation of Journey Duration Effects

	Values of Time	ASC

$ASC_{M6TCorridor}$ $ASC_{M6TStoke-M1}$ $ASC_{M6TExtended}$ $ASC_{M6TLong}$ ASC_{NTH} ASC_{STH} ASC_{M6TSTH} ASC_{NTHSTH} ASC_{ALL3}	1.1825 (16.5) 1.6168 (16.7) 1.5069 (10.0) 0.5242 (3.1) -1.9989 (15.2) -3.5332 (6.8) -2.3756 (7.9) -1.9514 (7.0) 0.7844 (2.3)	0.9259 (10.6) 1.3231 (9.6) 1.3504 (7.5) 0.2506 (1.9) -1.9439 (8.6) -3.4241 (5.3) -2.3851 (8.5) -1.9180 (5.5) 0.6416 (2.5)
$ASC_{M6T}*AT^{\lambda}$	-	0.0043 (3.9) λ=0.9
$Time_{M6}$	-0.0425 (10.5)	-0.0522 (25.9)
$Time_{M6T}$	-0.0366 (8.2)	-0.0482 (14.7)
$Time_{A}$	-0.0478 (12.3)	-0.0574 (27.4)
$Time_{Bits}$	-0.0333 (6.7)	-0.0467 (16.8)
$Time*AT^{\lambda}$	-0.00031 (2.7) λ=0.7	-
Earlier	-0.0207 (25,4)	-0.0209 (24.8)
Later	-0.0214 (23.7)	-0.0216 (23.7)
Delays M6	Base	Base
M6 delays due to	0.2960 (2.3)	0.3259 (4.4)
Exp 25m delays	0.9997 (6.3)	1.0369 (7.3)
No M6 Delays	-0.3632 (3.6)	-0.3393 (3.6)
Toll	-0.0053 (30.4)	-0.0053 (33.6)
FuelYes	-0.0061 (14.5)	-0.0062 (9.5)

What is encouraging is that the λ coefficients recovered by the iterative search process for the effects on the time coefficients were the same for the reported and network data. The network data provided the better fit, in both cases, whilst the interactions with the ASCs are statistically superior to the interactions with the time coefficients. The implied monetary values of time and values of the ASCs for each model are given in **Table**4.5.

Table 4.5: Implied M6T Values of Time and ASC by Duration

Journey distance	Values of Time	ASC
30m	7.54	29.35
60m	7.93	31.00
120m	8.57	34.08
180m	9.12	37.00
240m	9.62	39.83
300m	10.08	42.58

The point elasticity of the value of time with respect to journey time across a range of actual travel times are set out in Table4.6. These compare to the somewhat higher (distance) elasticity of 0.22 estimated from meta-analysis by Wardman (2004) and duration elasticities of 0.36 for business, 0.41 for commuting and 0.32 for other purposes from the re-analysis of the 1994 UK Value of Time study data by Whelan and Bates (2001). All these seem implausibly high in the context of the large range of travel times relevant to inter-urban travel.

The latter work allowed the sensitivity to cost to vary with the level of cost. This could explain the differences between the results if, due to different traffic speeds, the variation in times was greater than the variation in costs. However, given that we are here dealing largely with motorway travel, the variations in speeds ought not to be large and segmentation by cost would be expected to provide similar results.

Table 4.6: Value of Time Duration Elasticity

Journey Distance	Elasticity
30m	0.06
60m	0.09
120m	0.14
180m	0.17
240m	0.20
300m	0.22

There could be a confounding effect here from either journey purpose or income, Those with higher incomes tend to have higher values of time and to travel farther. Data indicates that those on business travel farther on average than commuters but it is leisure travellers who travel farthest. Further analyses revealed that the duration effect is retained in models which also account for journey purpose and income effects.

4.4 Size of Time Savings

The SP exercises covered a wide range of time savings offered by the M6T, and its extended variants, over the current M6 and A roads. The logit model can be specified in terms of differences between routes. This is convenient when examining variations in a unit valuation according to, say, the size of the time difference since we can segment, using dummy variables, according to the time difference or alternatively specify a function that is non-linear in differences. If there are three routes, then two time differences represent the competition between the three routes in time terms.

In doing this, we have specified the utility function relating to time in difference form as follows:

$$U_{M6T} = \sum_{i=1}^{n} \alpha_i d_{1i} (T_{M6} - T_{M6T}) + \sum_{i=1}^{n} \beta_i d_{2i} (T_A - T_{M6T}) + \sum_{i=1}^{n} \gamma_i d_{3i} (T_{M6} - T_{New})$$

where T_{M6}, T_{M6T}, T_A and T_{New} denote the journey time on the M6 alternative, existing and extended M6T alternatives, A road alternatives and the new motorway.

The terms d_{1i}, d_{2i}, and d_{3i} are dummy variables denoting n different categories of time difference for each of the three differences in route times to which separate coefficients are estimated.

The purpose of this function is to determine whether variations in the α_i, β_i and γ_i across time saving categories indicate that the unit value of time depends upon the size of the time saving offered by the M6T, the extended M6T or new motorway. The results of the piecewise estimation are given in Table 4.7.

Thus a time difference between the M6 and M6T ranging between 46 and 60 minutes has a coefficient of 0.0304 for the Stoke-M1 corridor designs but 0.0455 for the M6T corridor design. Rows 1, 3, 5 and 6 support a unit valuation that falls as the time saving increases, and indeed the variation is appreciable.

The direction of change is in line with both prospect theory and the more conventional property of diminishing marginal utility. Nonetheless, row 4 indicates that the unit valuation increases with the size of the time saving, with some support from the results in row 2.

Table 4.7: Piecewise Estimation of Time Saving Effects (M6T over M6)

		Coefficients
1	Stoke-M1 corridor ($Time_{M6}$ -$Time_{M6T}$)	

	≤15	0.0775 (8.0)
	16-30	0.0363 (9,6)
	31-45	0.0387 (13.8)
	46-60	0.0304 (12,4)
	>60	0.0289 (9.7)
2	M6T corridor ($Time_{M6}$ -$Time_{M6T}$)	
	≤15	0.0387 (5.0)
	16-30	0.0464 (12.4)
	31-45	0.0484 (16.3)
	46-60	0.0455 (18.8)
3	Extended M6T ($Time_{M6}$ -$Time_{M6T}$)	
	≤15	-
	16-30	0.0796 (12.2)
	31-45	0.0805 (18.4)
	46-60	0.0594 (18.5)
	>60	0.0513 (20.3)
4	M6T North and South Extensions ($Time_{M6}$ -$Time_{M6T}$)	
	≤15	-0.1880 (12.7)
	16-30	0.0259 (6.0)
	31-45	0.0371 (12.1)
	46-60	0.0484 (19.8)
	>60	0.0606 (27.8)
5	Knutsford-Dunstable new motorway ($Time_{M6}$ –$Time_{New}$)	
	≤15	-
	16-30	-
	31-45	-
	46-60	0.0613 (13.1)
	61-75	0.0491 (18.8)
	75+	0.0397 (18.2)
6	Route and Departure Time Designs ($Time_{M6}$ -$Time_{M6T}$)	
	≤15	0.0597 (5.4)
	16-30	0.0452 (11.6)
	31-45	0.0383 (13,4)
	46-60	0.0324 (16.0)
	>60	0.0146 (2.9)
	Log Likelihood	-23881.8
	ρ^2 (constants)	0.135

We conducted further analysis into this duration effect by specifying time differences between alternatives but allowing non-linear effect as follows:

$$U_{M6T} = \alpha_i (T_{M6} - T_{M6T})^{\lambda_1} + \alpha_2 (T_A - T_{M6T})^{\lambda_2}$$

If the λ_1 and λ_2 coefficients are greater (less) than one, then the unit valuation increases (falls) as the time difference increases. Values of one indicate that there is no variation in the unit valuation according to the level of time saving. The results are presented in Table 4.8. This model implies only limited variation in the unit value according to the size of the time saving, and indeed contradictory effects for the two sets of time difference.

Table 4.8: Non-Linear Continuous Functions of Time Savings

	Coefficients	
$Time_{M6}$-$Time_{M6T}$	0.1694 (31.1)	λ_1=0.7
$Time_A$-$Time_{M6T}$	0.0061 (13.5)	λ_2=1.3
Toll	-0.0045 (30.5)	

Finally in this investigation of size effects, we estimated a model of the form:

$$U_{M6T} = \alpha T_{M6T} + \gamma T_{M6T}(T_{M6} - T_{M6T})$$
$$U_A = \beta T_A + \delta_1 d_1 T_A T_{Diff} + \delta_2 d_2 T_A T_{Diff}$$

The marginal utility of time for the M6T is α plus γ multiplied by the time difference between the M6 and M6T. Note this is not simply a pure effect on the marginal utility of time for the M6T since the T_{M6} term will impact on the utility of the M6. We also allowed the marginal utility of time on the A road to vary around β according to the absolute time difference between the A road and M6 (T_{Diff}) and whether the A road offers a gain on the M6 (d_1) or a loss (d_2). The results are reported in **Table**4.9.

Table 4.9: Continuous Estimation of Size Effects

$ASC_{M6TCorridor}$ $ASC_{M6TStoke-M1}$ $ASC_{M6TExtended}$ ASC_{NTH} ASC_{STH} ASC_{M6TSTH} ASC_{NTHSTH} ASC_{ALL3}	1.2541 (17.1) 1.3985 (11.5) 1.7472 (14.3) -2.1539 (6.8) -3.6454 (5.4) -2.3311 (7.6) -2.0200 (4.8) 0.7874 (4.5)
$Time_{M6}$	-0.0463 (14.1)
$Time_{M6T}$	-0.0434 (17.3)
$Time_{A}$	-0.0510 (15.2)
$Time_{Bits}$	-0.0309 (9.0)
TimeALoss	-0.00022 (5.3)
TimeAGain	0.000077 (2.5)
$Time_{M6-M6T}$	0.000064 (1.7)
Early	-0.0194 (20.3)
Late	-0.0201 (21.1)
Delays M6	Base
M6 delays due to	0.2667 (3.3)
Exp 25m delays	0.9468 (6.4)
No M6 Delays	-0.3882 (3.9)
Toll	-0.0051 (32.2)
FuelYes	-0.0062 (9.2)
Log Likelihood	-22664.4
ρ^2 (constants)	0.180

The marginal utility of time on the M6T is found to diminish as the time saving increases. However, the effect ($Time_{M6-M6T}$) is not significant and is in any event relatively minor. For a time difference of 10 minutes, the value of time is 8.4 pence per minute, falling to 7.8 pence per minute for a 60 minute time difference.

The model recovers a statistically significant effect on the $Time_A$ coefficient for both gains (TimeAGain) and losses (TimeALoss) relative to the M6. The unit value of time increases as the loss becomes larger and falls as a saving becomes larger. The value of time on an A road is 9.9 pence per minute for a 5 minute gain relative to the motorway falling only slightly to 9.6 pence per minute for a 30 minute saving. The corresponding figures for 5 and 30 minute losses relative to the free motorway are 10.2 and 11.3 pence per minute.

In summary, the data does not support the presence of a size effect. Some of the models are quite clear that there is no such effect. Whilst others are more suggestive of an effect, the results are not entirely consistent with each other and the amount of variation in the unit value of time tends to be relatively small.

4.5 Toll Charge

The main issues considered were:

- Do gains and losses in toll have the same impact on decision making?
- Does the marginal disutility of toll depend upon the level of the toll charge?
- Are the responses to toll dependent on whether they occur on an existing toll motorway, on an extension to an existing toll motorway, on an entirely new toll motorway, or are introduced on an existing toll free motorway?

The initial modelling of toll effects specified a piecewise model, involving dummy variables to represent each toll level relative to a base. The results from the initial models seemed to indicate that that there is a diminishing marginal utility of toll charge as the toll increases. The pattern of results from the piecewise estimation was not particularly clear, with the possible exception of a diminishing marginal utility as tolls increase. This pattern of results could be due either to some protest or strategic biasing against higher tolls, whereupon the spreading of a fixed disutility across larger tolls even with constant marginal utility would imply diminishing estimated average and marginal effects, or due to a genuine non-linearity.

Specific formulations of the utility function to test particular hypotheses relating to toll sensitivity were then examined. These are all for utility functions which enter toll (T) in its usual linear-additive form but with additional terms to test these hypotheses. This takes the form:

$$U = \alpha T + \beta d_1 + \lambda\, d_2 T$$

The dummy variables d_1 and d_2 represent some feature of the toll or the context in which it is charged. Here the dummy variable term d_1 represents a factor that might be expected to have a constant (additive) effect on utility independent of the toll level. This might be a protest against the introduction of tolls on a currently untolled motorway, whereupon we would expect β to be negative. The interaction term composed of dummy variable d_2 allows the utility effect to depend upon the level of toll. We might hypothesise that the sensitivity to toll is different for increases on the current toll level. Thus d_2 would denote tolls in excess of 350p, whereupon the toll coefficient would be $\alpha+\lambda$, otherwise it is α. Additional interactions can be entered as appropriate.

An additive dummy variable was specified simply to denote whether or not a route had a toll. This was found to be far from significant. Nor was there a remotely significant effect when an incremental term was entered to denote the introduction of a toll on an existing free motorway.

An incremental toll effect was specified for increases on the current level of 350p. This was an interaction of a dummy variable denoting an increase in toll and the toll variable itself. A significant negative coefficient was returned, consistent with the results of the piecewise estimation.

Table4.10 reports the models containing the significant effects on the toll coefficient that have been detected. These are all interaction terms which impact on the sensitivity to toll. It is not surprising that the coefficient for toll on the entirely new motorway is less than that for toll on the extended motorway which in turn is less than that for toll on the existing motorway. Given that the new and extended motorways all include tolls of over 350p, the relevant comparison is with the base toll coefficient and the incremental effect for tolls over 350p.

The toll coefficient is 38% lower when new motorways are being considered and it is 15% lower when relating to an extension to the M6T. Relative to the toll coefficient without any amendment for the 350p effect, the corresponding figures are 43% and 17%.

The fuel cost coefficient is specified only for those who consider fuel cost. By the same token, we can allow for those who do not consider toll. It emerged that the only significant effect here was from whether the employer pays, with sharing the toll and some other person paying having no effect.

Table 4.10: Incremental Toll Effects

	Coefficients

$ASC_{M6TCorridor}$ $ASC_{M6TStoke-M1}$ $ASC_{M6TExtended}$ $ASC_{M6TLong}$ ASC_{NTH} ASC_{STH} ASC_{M6TSTH} ASC_{NTHSTH} ASC_{ALL3}	1.3353 (10.9) 1.8729 (17.1) 1.9992 96.2) 0.7840 (5.9) -1.9776 (8.6) -3.4614 (5.3) -2.2912 (8.0) -1.9687 (5.6) 1.7819 (5.4)
$Time_{M6}$	-0.0523 (25.7)
$Time_{M6T}$	-0.0615 (13.3)
$Time_{A}$	-0.0576 (27.3)
$Time_{Bits}$	-0.0445 (15.2)
Earlier	-0.0201 (21.2)
Later	-0.0209 (19.1)
Delays M6	Base
M6 delays due to	0.3330 (4.1)
Exp 25m delays	1.0641 (7.3)
No M6 Delays	-0.3424 (3.3)
Toll	-0.0047 (17.3)
Incremental Toll Effects Toll> £3.50 Toll New Motorway Toll Extended M6T	 -0.00062 (4.3) 0.0020 (3.4) 0.00082 (3.2)
Fuel Yes	-0.0061 (9.6)

It could be argued that the incremental effect for toll increases is not detecting a response bias but is only reflecting a widely held view that losses are valued more highly than gains. But it might then be reasonable to expect non-linear effects of a reduced marginal sensitivity for larger toll increases in line with prospect theory or an increasing marginal sensitivity in line with diminishing marginal utility. Whilst the former was detected when tested for, it was not statistically superior to the additive effect relating to all increases on the current level.

Given that the possible protest response has been isolated by the incremental term for toll increases, and that this is broadly in line with other evidence indicating a divergence between toll and other cost coefficients obtained from meta-analysis, we are inclined to view the base toll coefficient along with the fuel coefficient after allowing for whether they impact on decision making to be our most reliable indicators of underlying preferences.

The toll coefficients for new or extended motorways are lower, appreciably so in the former case, and their relative magnitude is plausible. This finding could reflect strategic biasing of responses and we would not recommend that these effects are carried through into forecasting.

4.6 Earlier and Later Time

The issues tested in this modelling were whether earlier and later departures have equivalent disutility, and whether the unit value of displacement time depends on the amount of displacement time itself.

Changes to departure times were specified as one or two hours earlier than the current departure or else one or two hours later. The models so far reported have distinguished between earlier and later time, although the two are far from significantly different, but they have not distinguished by the amount by which the departure time changes. Unpacking this a little, we can specify separate terms for each of the levels of earlier and later time.

When we replace the earlier and later time terms with two dummy variables each denoting the different magnitudes of earlier or later time, we obtain the coefficient estimates reported in Table4.11. Transforming them into a per minute effect, we find that there is little support for distinguishing according to the amount of departure time change as well a close similarity of the earlier and later time valuations.

Table 4.11: Level Specific Earlier and Later Time Coefficients

	Coeff (t)	Per Min Effect
Earlier 1 hr	-1.1612 (13.5)	0.019
Earlier 2 hrs	-2.5331 (24.7)	0.021
Later 1 hr	-1.4502 (18.3)	0.024
Later 2 hrs	-2.4940 (24.2)	0.021

4.7 Effect of Information Provision

There was some evidence from initial model results that the value of time was lower where information was provided. This implies that the information is taking some of the influence on decision making that would otherwise be attributed to journey time. However, in subsequent models with somewhat larger data sets, there was no statistically significant effect from information provision on either the time coefficient estimates or the ASCs.

4.8 Socio-Economic and Trip Characteristics

The method adopted to explore these effects is the standard procedure of specifying dummy variable terms, either as additive or interaction effects, to determine whether a particular level of a socio-economic or trip characteristic induces a different sensitivity to changes in time and cost or different alternative specific constants. The process is in part guided by theoretical expectations; for example, we might expect the sensitivity to cost variations to differ across income groups.

The utility function with respect to an ASC, time (T) and cost (C) might be specified in the form:

$$U = ASC + \sum_{i=1}^{I}\sum_{j=2}^{J}\gamma_{ij}d_{ij} + \alpha_0 T + \sum_{i=1}^{I}\sum_{j=2}^{J}\alpha_{ij}d_{ij}T + \beta_0 C + \sum_{i=1}^{I}\sum_{j=2}^{J}\beta_{ij}d_{ij}C + \ldots.$$

There are I categorical variables with J levels each. The dummy variables (d_{ij}) are specified for all but one level of each variable. Thus the constant term is modified by the γ_{ij}, the time coefficient is modified by α_{ij} and the cost coefficient is modified by β_{ij}. Thus if a particular category of a socio-economic variable was responsible for a lower sensitivity to cost relative to the arbitrarily omitted category, we would expect the appropriate β to be positive.

The variables covered by this segmentation analysis were:

- Journey purpose, of business, commuting, holidays/short breaks, visiting friends and relatives, and other leisure
- Leg of journey
- Time of travel
- Other occupants, distinguishing between adults and children
- Whether the respondent was the main driver
- The proportion of traffic on each route made up of HGVs
- The perceived reliability of each route, in terms of arrival time at destination, according to the categories of very reliable, reliable, usually reliable, sometimes unreliable, unreliable and very unreliable
- Whether the respondent had to be at their destination at a particular time
- Whether the toll would be paid by the respondent, shared with others or reimbursed by the employer
- Frequency of trip making in the M6T corridor
- Whether the decision to use the M6T or not was made prior to setting out, during the course of the journey, as the M6T was approached or whether the M6T was never even considered, and what influenced the decision if it was made during the course of the journey
- Attitudes to toll payment, including level of agreement with tolls on existing motorways, using tolls to replace fuel duty, tolls and new motorways and tolls as a sensible means of funding additional road infrastructure. Response scales were strongly agree, agree, neither agree nor disagree, disagree and strongly disagree

- Age group, collected as under 18, 18-24, 25-34, 35-44, 45-54, 55-64, 65-74 and over 74.
- Gender
- Income group, obtained as annual household income before tax in bands of under £10k, £10-19k, £20-29k, £30-39k, £40-49k, £50-59k, £60-69k, £70-79k, £80-89k, £90-99k and £100k and over. Respondents could state that they did not wish to disclose their income.

Purpose

We might expect the toll coefficient to vary by purpose. Commuters would be frequent payers, and hence an income effect might be apparent whereupon they become more sensitive to toll. On the other hand, those on business journeys can be expected to be less sensitive to toll because they do not personally incur the cost. There was variation in the toll coefficient for business travellers but this was very limited. Moreover, this disappeared when specifying a term indicating whether the employer pays..

With regard to the time coefficients, some perverse results were apparent. Business travellers had a lower time coefficient than leisure travellers, as also did commuters. Similarly, a significant route specific constant showed business travellers to be less favourable towards the M6T which again seems odd. These effects are not confounded with a duration effect since they were still apparent when journey duration and income effects were specified. We therefore did not retain these journey purpose effects.

Where journey purpose had more of a reasonable impact was on the valuations of departing earlier and later. Commuters had a higher value of departing later as did business travellers although not to the same extent. However, there were no differences in earlier departure time valuations. Those travelling for holidays or short breaks and those visiting friends or relatives had lower values of both earlier and later departures but they were sufficiently similar that they could be combined into a single term representing adjustment time.

Leg of Journey

No discernible differences were apparent according to leg of journey.

Time of Travel

There was no clear pattern in time parameters or ASCs according to time of travel categories.

Occupancy

Given that occupancy could conceivably impact on all the coefficients, separate models were estimated for alone and group travel. Both the toll and fuel coefficients were similar for the two categories (-0.0053 and -0.0049 for toll, -0.0059 and -0.0061 for fuel). Nor did the departure time coefficients differ, but there was a hint of variation in the ASCs and the travel time coefficients.

When we focussed on the ASCs, we found that those with other occupants were more inclined to use the M6T. This seems sensible, given that the time benefits will accrue to more people. However, as far as the marginal utility of time is concerned, there were no significant differences for those with children. There was a significant influence from those travelling with adults and those travelling with any others. The former was the stronger effect. It denoted that those travelling with other adults had a lower marginal utility of time, presumably because the company provided makes the travel time less onerous.

Main Driver

No differences were apparent between the parameters for whether the respondent was the main driver or not, although it would be difficult to detect any effect given that 96% of respondents were the main driver.

Proportion of HGVs

Whilst this does not vary for any individual within the SP exercise, it will vary across individuals and routes and therefore could explain different preferences for the M6T according to perceptions of how the traffic is made up of HGVs and indeed it could be expected to influence the marginal utility of time.

Given that the SP choice context in which differences in the proportion of HGVs is most likely to have an impact is that based on the M6T corridor initial analysis was restricted to these scenarios. However, no significant effect could be discerned.

Even when we broadened the analysis to include the existing M6T scenarios within the Stoke-M1 corridor and additionally allowing for an impact on the marginal utility of time, no statistically significant impacts could be recovered.

Reliability

As with HGVs, this is a variable that will not vary across SP scenarios but will vary across individuals and routes. Since it relates to perceptions of arrival time reliability, the analysis need not be restricted to the routes within the M6T corridor. Four categories of perceived reliability were found to have a significant effect. These were for very reliable, reliable, usually reliable/sometimes unreliable, and for a category covering those who did not know. A monotonic and statistically significant relationship of the expected form was apparent for the three first categories. A significant effect could not be estimated for the remaining category of unreliable.

Destination Arrival Time Constraint

This did not have a significant effect on preferences.

Toll Payment

Relative to a base of paying the toll oneself, there are three other categories. These were share the cost, another passenger paid or the cost is reimbursed by the employer.

The only significant effect was from whether the employer reimbursed the cost when, as expected, there was a lower sensitivity to cost, although not a zero effect as might be expected. When we entered an additional interaction with business travel, this was not significant. The fact that the sensitivity to cost is not zero could be because respondents have not answered along these lines in the SP exercise, treating it as personal travel, or because they might not actually claim the toll back due to the transaction costs involved.

M6T Corridor Trip Frequency

This data was collected as a categorical variable and various combinations were tested. Whilst it was possible to estimate some significant coefficients, there was no consistent or theoretically expected pattern to the results.

When Made M6T Decision

Whilst there were a number of statistically significant effects here, particularly relating to factors that influenced decision making during the course of the journey, they tended to have the wrong sign.

The only significant effect that we believe should be persisted with here was the somewhat large aversion to using the M6T, as expressed through a route specific constant, for those who stated that in practice they never considered using the M6T. This effect is hardly surprising.

Attitudes to Toll Payment

The results of this analysis, although hard to implement in practice, were particularly disappointing. A number of significant but wrong sign effects were estimated. We have not persisted with these, and moreover we are not sure of the reasons underpinning these estimates.

The only significant and sensible effect was that those who strongly object or object to paying for tolls on an existing motorway had a less favourable constant relating to the M6T.

Age Group

We allowed the various age categories to impact on the ASCs, time coefficients and departure time coefficients, and the sensitivity to toll. The only significant effect was that those aged 65 or more had a stronger preference for the M6T.

Gender

Males were found to be less likely to use the M6T, in terms of an incremental impact on the route specific constants, and were less averse to changing their departure time. However no other gender specific effects were discerned.

Income

We specified five income categories plus a category relating to those who did not wish to disclose their income relative to a base of those with incomes less than £20k per annum. The five income categories other than the latter were £20-39k, £40-59k, £60-79K, £80-99K and £100k and over.

The effects on the fuel coefficient were often insignificant and did not by any means suggest a clear pattern. By contrast, the incremental effects on the toll coefficient were very impressive, denoting a monotonic reduction in the sensitivity to toll charge as income increased.

Table 4.12 reports models with statistically significant and expected sign coefficients for the incremental effects covering the socio-economic and trip characteristics. The incremental effects are denoted by italics. ASCs for the M6T for the three exercises containing information were far from significant, as was an incremental variation in time values, and are therefore not included.

Two models are reported according to whether trip duration is allowed to impact on the ASC or on the time coefficients. Reintroducing scales for the different SP designs made no material difference to the results.

Whilst the monotonic income effect is both encouraging and rare, it should be noted that the variation in the value of time with income will not be large. Indeed, when we converted the income categories into amounts of income the implied income elasticity was only 0.2.

The other effects also tend to be relatively minor, with the exception of, as might be expected, the variable denoting that the M6T would never be considered whilst differences in reliability across routes could have quite large effects not that far removed from some of the route specific constant. For example, a very reliable M6T compared to an unreliable M6 is equivalent to a journey time difference of around 11 minutes.

Table 4.12: Impact of Socio-Economic Variables

$ASC_{M6TCorridor}$	1.2830 (8.4)	1.0985 (7.7)
$ASC_{M6TStoke-M1}$	1.7110 (11.0)	1.4896 (8.7)
$ASC_{M6TExtended}$	1.4477 (4.1)	1.3480 (3.9)
$ASC_{M6TLong}$	1.0090 (6.4)	0.7880 (4.9)
ASC_{NTH}	-1.2498 (6.5)	-1.2248 (6.3)
ASC_{STH}	-2.6989 (4.7)	-2.6700 (4.6)
ASC_{M6TNTH}	0.7339 (4.8)	0.7101 (4.5)
ASC_{M6TSTH}	-1.4945 (4.9)	-1.5115 (4.9)
ASC_{NTHSTH}	-1.2076 (3.3)	-1.1965 (3.3)
ASC_{ALL3}	1.4280 (7.4)	1.3930 (7.6)
ASC_{M6T}Never M6T	-1.1218 (6.1)	-1.1140 (6.2)
ASC_{M6T}Male	-0.3475 (3.3)	-0.3466 (3.3)
ASC_{M6T}Age65+	0.4664 (2.4)	0.4453 (2.3)
ASC_{M6T}Others	0.3529 (4.2)	0.2985 (3.5)
ASC_{M6T}ObjectTolls	-0.4769 (5.2)	-0.4791 (5.2)
Very Reliable	1.1384 (9.6)	1.1454 (9.8)
Reliable	0.7527 (6.5)	0.7646 (6.8)
Usually/Sometime Reliable	0.4602 (6.4)	0.4635 (6.6)
Unreliable	0.1776 (2.0)	0.1795 (2.0)
Acttim**λ	-	0.00046 (3.8)λ=1.3
$Time_{M6}$	-0.0509 (20.8)	-0.0588 (34.9)
$Time_{M6T}$	-0.0527 (15.5)	-0.0626 (14.0)
$Time_{A}$	-0.0561 (24.2)	-0.0639 (36.6)
$Time_{Bits}$	-0.0460 (14.2)	-0.0570 (20.5)
Time*Acttim**λ	-0.00011 (3.3) λ=1	-
Time-OthAdults	0.0068 (2.4)	0.0057 (2.1)
Earlier	-0.0257 (17.5)	-0.0254 (17.4)
Later	-0.0235 (11.7)	-0.0237 (11.9)
Later-EB	-0.0035 (2.2)	-0.0035 (2.2)
Later-Comm	-0.0064 (2.3)	-0.0066 (2.4)
Adj-HolsSB	0.0077 (2.6)	0.0081 (2.7)
Adj-VFR	0.0050 (2.7)	0.0053 (2.9)
Adj-Male	0.0036 (2.6)	0.0036 (2.5)
M6 delays due to	0.3819 (4.8)	0.4078 (5.1)
Exp 25m delays	1.1082 (6.5)	1.1423 (6.7)
No M6 Delays	-0.3668 (3.8)	-0.3450 (3.7)
Toll	-0.0062 (13.6)	-0.0063 (13.7)
Toll-Inc£20k-39k	0.0004 (1.1)	0.0004 (1.1)
Toll-Inc£40k-59k	0.0009 (2.0)	0.0009 (2.0)
Toll-Inc£60k-79k	0.0011 (2.6)	0.0011 (2.6)
Toll-Inc£90k-99k	0.0014 (3.2)	0.0014 (3.2)
Toll-Inc£100k+	0.0022 (4.6)	0.0022 (4.5)
Toll-IncDK	0.0006 (1.3)	0.0006 (1.3)
EmpPay	0.0014 (9.5)	0.0014 (9.5)
Toll>£3.50	-0.00080 (4.9)	-0.00078 (4.7)
Toll New motorway	0.0024 (4.5)	0.0025 (4.5)
Toll Extended M6T	0.00091 (2.7)	0.00093 (2.8)
FuelYes	-0.0057 (9.8)	-0.0057 (9.8)
ρ^2 (constant)	0.248	0.248
Log Likelihood	-20775.62	-20762.05

The travel time variability SP exercise offered choices between travelling via the M6T with a low level of travel time variability but paying a toll and the M6 with on average

4.9 Type of Time

Eight different SP exercises were used, offering trade-offs between the same type of time for the whole journey and a mixture of two other types of time as follows:

- Free flowing and stop start versus light congestion: 15 miles
- Free flowing and stop start versus light congestion: 45 miles
- Busy and gridlock versus heavy congestions: 15 miles
- Busy and gridlock versus heavy congestions: 45 miles
- Busy and stop start versus light congestions: 15 miles
- Busy and stop start versus light congestions: 45 miles
- Free flowing and heavy congestion versus busy: 15 miles
- Free flowing and heavy congestion versus busy: 45 miles

This approach avoids offering too many types of time in any one scenario, which might have proved too difficult for respondents, and provides a clear contrast between a specific type of time and two different types of time, one of which was expected to be valued more highly and one less highly than the type of time offered for certain.

Models based on the complete dataset showed that in only selected cases did the coefficient estimates exhibit the expected relativities. Inspection of the data revealed a significant number of non-traders within the data in the sense that they always chose the same option in each of the nine choice scenarios. There is no obvious dominance of one option over the other in the designs, and nor is there any compelling reason to always prefer one alternative over the other as might exist in a mode choice context due to strong mode specific preferences.

Models were therefore produced that excluded the non traders and these led to the decision to combine the results into a single model to obtain a unique set of relativities and obtain the benefit of estimating to a much larger data set than for any of the separate models.

Table 4.13 presents the pooled models. The types of time are in order of expected disutility and scales of each of the separate exercises are represented by the θ terms.

Table 4.13: Pooled Types of Time Model – Non Traders Omitted

	Coefficients
ASC-Free Flow Busy	1.7620 (7.3)
ASC-Light Congestion Heavy Congestion	1.1500 (6.1)
Free Flow	-0.1924 (13.8)
Busy	-0.2019 (13.9)
Light Congestion	-0.2131 (16.1)
Heavy Congestion	-0.2518 (11.7)
Stop Start	-0.2311 (13.1)
Grid Lock	-0.3642 (9.0)
$\theta_{SP3\text{-}1A}$	1.00
$\theta_{SP3\text{-}1B}$	0.39 (14.4)
$\theta_{SP3\text{-}2A}$	0.66 (4.2)
$\theta_{SP3\text{-}2B}$	0.36 (14.7)
$\theta_{SP3\text{-}3A}$	0.97 (0.4)
$\theta_{SP3\text{-}3B}$	0.30 (17.1)

θ_{SP3-4A}	0.99 (0.0)
θ_{SP3-4B}	0.38 (13.3)

Note: t ratio of the scale parameters (□'s) are calculated with respect to one.

The preference for free flow and busy is equivalent to 9.2 minutes of free flow time or 4.8 minutes of grid lock time. The corresponding figures for the preference for light and heavy congestion were 6.0 and 3.2 minutes. Despite that this constant effect could detract from the strength of the variation in time values, the results the model look quite sensible.

Table 4.14 expresses the time disutility's relative to a base of free flow . The valuations increase throughout except for the valuation of stop-start time. There is little difference between free flow time, busy and light congestion. Heavy congestion has a relatively high premium whilst gridlock is particularly disliked.

Where a distinction is made between different types of car travel time, previous studies tend to limit it to time spent in free flow conditions and time spent in congested traffic conditions. A review of British evidence relating to the relative valuation of time spent in congested and free flow traffic (Wardman, 2001a), covering 21 observations, found the ratio to average 1.48 with a standard error of 0.07. The range was between 1.04 and 2.01. The results presented here are consistent with the review evidence which seems to relate most closely to heavy congested conditions.

Table 4.14: Time Relativities

	Relative Values
Free Flow	1.00
Busy	1.05
Light Congestion	1.11
Heavy Congestion	1.31
Stop Start	1.20
Grid Lock	1.89

4.10 Travel Conditions: HGVs, Lane Width, Speed Cameras, Information

Table reports the findings of the final model estimated on data pooled across the various exercises.

Table 4.15: Travel Conditions - HGVs, Lane Width, Speed Cameras, Information

	Coefficients (t ratios)
Time	-0.1450 (13.3)
HGV*Time (Interaction of HGV and time)	-0.0009 (5.1)
Info 0 (No information provided)	Base
Info1 (Information on whether delays)	-0.0240 (0.2)
Info2 (Information on whether delays and cause of delays)	0.1295 (2.1)
Info3 (Information on amount of delays and cause)	0.2372 (2.9)
Wide*Time (Interaction of Wide and Time)	0.0084 (3.5)
Standard (Base category of a standard (3.35m) lane)	Base
Narrow*Time (Interaction of Narrow and Time)	-0.0144 (4.6)
Police Camera (Variable denoting presence of police speed cameras)	-0.4038 (2.2)
SC (number of speed cameras on the journey)	-0.1829 (2.7)

Note: t ratio of scale (θ) with respect to one.

The coefficients for Time and HGV*Time are highly significant. Information on whether there are delays (Info1) is not significant whilst information on whether there are delays and the causes of them (Info2) and information on the amount of delay expected and its causes (Info3) are significant. Information on the amount of delays is more highly valued than simple information on there being delays and this would be expected.

Police speed cameras are disliked as too are the number of speed cameras. The value of time is increased by 0.7% for every one percentage point increase in the proportion of HGVs, wide lanes reduce the value of time by 5% and narrow lanes increase the value of time by 9%. These results seem sensible. This model returns a valuation of an additional speed camera on a journey to be equal to 1.26 minutes.

4.11 Travel Conditions: Road Surface, Lighting and Lanes

The final abstract choice SP exercise offered trade-offs between journey time, road surface, the number of lanes and whether lighting was provided. The road surface was described as being like the M6T, like the standard M6, like the high-level (jointed) section of the M6 and like the concrete section of the M6. Motorists should be very familiar with each of these types of surface.

Given that road surface can impact both in terms of smoothness of ride and noise, we asked respondents to rate each of the four surfaces in terms of smoothness of ride and noisiness separately, ranging from one (very quiet/smooth) to ten (very noisy/bumpy). The purpose of this was to make the results potentially more transferable and to aim to discern separate impacts for noise and bumpiness.

Table 4.16 reports the findings of models pooled across the shorter distance and longer distance exercises with $\theta_{SP5\text{-}2}$ indicating the extent to which the scale for the longer distance exercises differs from the shorter distance. The model allows the effects to vary with journey duration, on the grounds that the benefits of different road surfaces, number of lanes and presence of lighting will depend upon exposure. These are the interaction terms (Concrete*Time, High*Time, Lighting*Time, 4 Lanes*Time and 2 Lanes*Time).

Table 4.16: Travel Conditions - Road Surface, Lighting and Lanes

Variable	Coefficients (t ratios)
Time	-0.1744 (8.2)
M6	Base
M6T*Time Interaction of M6T and Time	-0.0024 (0.8)
Concrete*Time Interaction of concrete and time	-0.0213 (4.8)
High*Time Interaction of high level and time	-0.0157 (4.6)
No Lighting	Base
Lighting*Time Interaction of Lighting and Time	0.0171 (3.6)
4 Lanes*Time Interaction of 4 Lanes and Time	0.0120 (4.4)
3 Lanes	Base
2 Lanes*Time Interaction of 2 Lanes and Time	-0.0183 (4.0)
$\theta_{SP5\text{-}2}$	0.49 (8.2)

Note: t ratio of scale (θ) with respect to one.

The incremental effect for the M6T surface is far from significant. The remaining effects are highly significant. Travelling on a concrete surface adds 12.2% to the value of time whilst it is a 9.0% uplift for the high-level jointed surface. The presence of lighting reduces the value of time by 9.8%. With regard to the number of lanes, 4 lanes would reduce the value of time by 6.9% compared to three lanes but 2 lanes would increase the value of time by 10.5%. These results correspond with the lane width results, where an improvement had a lesser effect than a deterioration.

5 Revealed and Stated Preference Route Choice Models

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5.1 Revealed Preference Data

The SP data was collected either through roadside interviews (RSIs),contact at motorway service areas (MSAs), or else by postal questionnaires to a database of M6T users. As previously noted, the overall sample is therefore not a purely random sample and hence not directly representative of the share of each route in the corridor. This is important not least because those choosing the M6T can be expected to have higher values of time.

However, the sample obtained through the RSIs and at the MSAs can be taken to be reasonably representative. Table denotes the shares of each route in the total sample of usable RP observations and in the RSI/MSA sample. The final column reports the weights we have used in weighted estimation to correct for the unrepresentative sample when the analysis is based on this maximum RP data set of 3031 observations.

Table 5.1: Split of Sample By Route and Source of Data

	RSI/MSA	All Sample	Weight
A Road	122 (10.3%)	144 (4.7%)	2.15
M6	325 (27.6%)	329 (10.9%)	2.53
M6T	732 (62.1%)	2558 (84.4%)	0.74

We have developed two sets of RP models here. One set is estimated on network data whilst the other is based on reported travel times and costs supplemented by network data where reported data is missing.

The advantage of a model based on reported data is that it can reflect the perceptions that drive actual choices in a way that network data cannot. However, it does suffer one serious shortcoming, and one that seems to be apparent here, that the chosen alternative is reported to be more attractive, perhaps to justify the actual choice made, than it really is. It seems that this here manifests itself in the M6 times being reported to be too long by M6T users. There is also an issue of missing reported data either because the respondent does not know the journey time on the alternative, but has nonetheless made a decision, or does not appreciate that details are required for unchosen as well as chosen routes.

The choice context involves the required time-cost trade-offs: the M6 is free but typically congested to varying degrees; the M6T is quicker but more expensive due to the toll charge; the A road option can sometimes be quicker than the commonly congested M6 but in any event offers a different set of trade-offs relative to the M6T. However, even though we have the time-cost trade-offs necessary for value of time estimation, a stumbling block is that the toll is the same for all motorists and hence from a statistical point of view cannot be disentangled from those effects discerned by the ASC[1].

Given concerns about mis-reporting, where the chosen route is cast in a better light relative to the alternatives than it really is, perhaps to justify the actual choice made, the reported and network based journey times were compared and the results are shown in Table 5.2.

Table reports the mean reported (REP) and network (NET) times for the three routes, along with the standard error (in brackets) and number of observations, for those using each route. These figures are based on there being for any motorist both network and reported times for a particular, but not every, alternative. Hence the samples for reported and network times are the same for any alternative in the first three rows.

[1] However, we do have a toll coefficient from the SP modelling which provides a surrogate for its utility effect. The constant toll is not a problem for the process of validating the SP modelling results against actual choices but this was not within the remit of this aspect of the study.

Table 5.2: Origin-Destination Reported and Network Times

Route Used	A_{REP}	$M6_{REP}$	$M6T_{REP}$	A_{NET}	$M6_{NET}$	$M6T_{NET}$
A	86 (5.7) 137	93 (8.0) 34	60 (5.0) 77	84 (5.4) 137	87 (8.8) 34	66 (5.3) 77
M6	161 (14.6) 84	152 (5.9) 310	153 (10.1) 115	125 (9.6) 84	139 (4.2) 310	136 (7.5) 115
M6T	176 (4.0) 933	201 (2.7) 1627	160 (2.2) 2358	140 (2.4) 933	154 (1.9)1627	141 (1.6) 2358

	$M6\text{-}M6T_{REP}$	$M6\text{-}M6T_{NET}$	$A\text{-}M6T_{REP}$	$A\text{-}M6T_{NET}$
A	31.1 (4.4) 30	8.5 (1.0) 30	15.1 (2.0) 70	10.4 (1.1) 70
M6	15.9 (3.5) 120	7.5 (0.4) 120	39.3 (6.0) 61	15.6 (1.4) 61
M6T	34.8 (0.7) 1604	7.8 (0.1) 1604	47.6 (1.6) 933	17.2 (0.4) 933

For A road users, the reported times are broadly similar to the network based values. The difference between the A road and the M6T is broadly similar for the network and reported data. However, this is clearly not the case for the difference between the M6 and M6T times, where the M6T is perceived in a much better light relative to the M6 than it really is. Given that these are A road users, it would seem that this latter discrepancy is more due to perceptions than to any justification bias.

The M6 users report journey times consistently higher than the network based times, with the discrepancy largest for the A road. This may well stem from unfamiliarity and a view that A roads must be somewhat slower. They report the difference between the M6 and M6T to be a little larger than the network difference. It is the difference between the A road and M6T where there is the greatest divergence between the network and reported times. Again, given that the M6 users do not use either of these routes, it would seem more reasonable to attribute this divergence to misperception or to previous bad experiences on A roads rather than justification bias.

Finally, the M6T users report all routes to be longer than the network times. Whilst justification bias might lead to under-reporting of the M6T times, the difference between the reported and network absolute times are somewhat larger for the A road and M6. However, when we actually look at the mean differences, the reported difference between the M6 and M6T exceeds the network difference between M6 and M6T by about the same margin as the reported difference between the A road and M6T exceeds the network difference between the same two routes.

Whilst we cannot be definitive about the causes of the discrepancy between reported and network times, it would not be unreasonable to expect some difference to be attributable to the approximations of network models and the fact that they aim to estimate actual rather than perceived times. Nonetheless, the evidence would support an element of misperception influencing the reported times.

5.2 Final Revealed Preference Models

A substantial amount of work was undertaken to explore the appropriate model form for the revealed preference models and to identify the main variables of interest. The results from the preliminary models clearly indicated that there is no compelling need to specify a hierarchical formulation in the place of the multinomial logit model.

Along the lines of the SP models, we have explored whether socio-economic and trip characteristics influence, as appropriate, the ASCs or the sensitivity to time and cost variations. Functional form issues have also been explored and additional explanatory factors which vary across individuals but not SP scenarios have been introduced.

The additional main effects entered are the perceived reliability of each route, and the proportion of HGV's on the route. The former can reasonably be taken to represent how reliable the overall journey was expected to take on each route. However, the proportion of HGVs is, at least for the M6T, likely to be dominated by the HGVs on that particular section of route, and this should be borne in mind when interpreting the results.

The segmentation variables were: journey purpose; who pays the toll; when the decision was made about whether to use the M6T, and the factors behind it if a decision was made en-route;

attitudes to tolls; income; trip frequency; gender; age; number of occupants, with distinctions between adults and children; and whether the respondent was the driver.

The functional form issues that have been examined are whether larger time savings have different unit value and whether the unit value of time is a function of the overall journey duration.

The models containing significant effects are reported in Table for both the network data and the reported data. The final models do not contain many additional variables. Nonetheless, they have a goodness of fit (ρ^2) with respect to constants which far exceeds that typically obtained in choice models and is far better than for the models without the incremental effects.

We specified quadratic terms to discern non-linearities in the sensitivity to time variations. The squared terms were significant but the coefficients relating to time were not significant. This function indicated quite strong increases in the marginal sensitivity to time with journey duration. We therefore proceeded with a more flexible function of the form of

$$U = \alpha T^{\lambda}$$

with a search process across different λs in units of 0.1 to determine that with the best fit. It turned out that the best fitting models were λs of 1.5, indicating strong variation in the marginal utility of time with respect to time. This finding is consistent with that in the SP analysis in the sense that the value of time increases with journey duration.

Table 5.3: Final RP Models

	Network	Reported/Network
ASC-M6T	1.0480 (8.3)	0.9710 (7.7)
ASC-A	-0.6346 (7.4)	-0.6550 (7.6)
TimeNET α λ	-0.00476 (15.4) 1.5	-0.00482 (14.9) 1.5
TimeREP α λ	-	-0.00251 (11.4) 1.5
Toll	-0.005	-0.005
Reliable	1.0190 (12.3)	1.0040 (12.1)
Unreliable	-0.4110 (4.7)	-0.2886 (3.3)
%HGV	-0.0123 (5.0)	-0.0062 (5.0)
NeverCons	-3.8200 (10.5)	-3.7021 (10.2)
ObsTraffic	-0.9484 (4.9)	-0.9650 (5.0)
ObjectNew	-0.4724 (4.3)	-0.4513 (4.1)
SenseNew	0.3907 (3.9)	0.4292 (4.3)
Log Likelihood	-1992.70	-1980.72
ρ^2 (constants)	0.239	0.261

Note: The mean values of %HGV for the M6T (10%), M6 (43%) and A Road (28%) are used where no value was reported. This makes little difference to the coefficient estimate compared to removing missing data.

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

With regard to the addition of new terms, the reliability of each route was found to have a significant effect. This is in line with the SP analysis. Routes which were very reliable or reliable were more likely to be chosen, and the effect relative to unreliability is stronger than the ASC favouring the M6T. Routes which were unreliable or very unreliable were less likely to be chosen. The base categories are usually reliable and sometimes unreliable.

The proportion of traffic made up by HGVs (%HGV) has the expected effect on choice, although the magnitude of the effect varies across the two models.

The 5% who stated that for their actual journey they never considered the M6T (NeverCons) have a strong alternative specific constant against its use, as would be expected. The effect far exceeds the ASC-M6T. For those who decided on whether or not to use the M6T during the course of their journey, two from the seven possible answers had significant effects. These related to observed traffic conditions (ObsTraffic) and whether the driver wanted to make-up some time.

The coefficient on the variable relating to making-up time was negative, the opposite of what would be expected. It was therefore not retained. Given the negative coefficient for ObsTraffic reduces the likelihood of using the M6T, it would seem that the traffic conditions on the M6 were not as bad as perceived.

We were unable to discern any significant effects from a range of socio-economic interactions. This is typical of RP models, although here a number were not far removed from significant at the usual 5% level. Nonetheless, we note that the SP models did not discern many socio-economic effects.

Table5.4 denotes the values of time implied by the time coefficients in **Error! Reference source not found.** so as to support comparison across models given that the functions are non-linear. There is strong variation in the values of time, with the absolute values appearing more plausible for the reported data. The elasticity of the value of time with respect to time is 0.5, higher than obtained in the SP analysis but broadly providing the same message that the value of time increases with duration.

Table 5.4: Implied Marginal Values of Time

Journey Duration	Network Times	Reported Times
60 minutes	11.1	5.8
120 minutes	15.6	8.3
180 minutes	19.2	10.1
240 minutes	22.1	11.7
300 minutes	24.7	13.0
360 minutes	27.1	14.3

5.3 Summary of Revealed Preference Modelling

It has not been possible to draw any firm conclusions about the causes of the discrepancy between reported and network time. However, it would be unreasonable not to expect some difference to be attributable to the approximations of network models and the fact that they aim to estimate actual rather than the perceived times upon which decisions are made. The evidence would support an element of misperception influencing the reported times. However, justification bias can also be expected.

There are a number of encouraging results regarding the RP models, particularly in terms of implied values of time and consistency with the findings of the SP analysis. This provides a firm basis for joint estimation with the SP data.

We would not expect to find a wide range of significant socio-economic effects in an RP dataset of this size. Nonetheless, the results are encouraging in that they tend to confirm rather than contradict the SP findings. For example, there are duration effects but no size effects in both the RP and SP models, whilst reliability has a common effect. The RP models are additionally able to detect an effect from the proportion of HGVs, which was not apparent in the main SP route choice models but did emerge as important in our abstract choice SP exercises.

We conclude that neither form of data is intrinsically superior to the other on the extent to which it reflects the times that underpin actual decision making. As far as estimating the impact on the marginal utility of time from actual time within the SP data, it makes little difference since the reported and network times for the actual journey are highly correlated. Indeed, we have seen that it did not turn out to have a large effect when introduced as an interaction in our SP models, but that the network data did provide a better fit.

In subsequent RP-SP models, we have used the network times as the interaction term. We have also proceeded to use both the network data and the reported/network data to represent time in the RP component within the RP-SP models estimated.

5.4 Simultaneous RP and SP Models

The results of the simultaneously RP and SP models are reported in Table5.5. This uses the Bradley-Daly method and constrains all the data sets save the RP to have the same scale. The model retains the formulation of the preferred SP model of allowing the SP time coefficients to vary with the actual time (AT). This takes the form:

$$U_{SP} = \alpha T_{SP} + \beta AT^{\lambda} T_{SP} + ...$$

where AT is the actual time for the journey made and T_{SP} is the SP related journey time. The marginal utility of travel time (MU_T) is therefore a function of AT:

$$MU_T = \alpha + \beta AT^{\lambda}$$

When it comes to the RP data, AT is not an interaction term but is the independent variable itself. In the pooled RP-SP model, the RP utility functions are specified as:

$$U_{RP} = \alpha AT + \beta \frac{AT^{\lambda+1}}{\lambda+1} + ...$$

-

so that MU_T is the same as for the SP utility function.

A number of important comments can be made on the basis of the empirical findings presented in Table5.5.

- Combining the RP and SP data does not make a greater difference to the parameters based solely on SP data.
- The RP scale (θ_{RP}) here exceeds one. Given the specification of the model, this denotes that there is less residual variation in the RP data than the SP data. The model is estimated in units of SP residual deviation. For forecasting purposes the coefficients need to be rescaled to be in units of RP residual deviation. This would require that all the coefficients are multiplied by 1.5.
- The λ parameter which drives the variation in the value of time with duration is little different to that in the preferred SP model
- The RP ASCs do not denote any difference between the A Roads and the (congested section of) M6, but there is again a strong preference for the M6T.
- The issue of whether to use reported or network travel times does not arise. The SP travel time coefficients are used, after rescaling, and these differ little between whether the RP-SP model is estimated on network or reported data.

The only additional effect that is apparent upon introduction of the RP data is that there is a dislike of HGVs specified as the proportion they form of traffic on the route in question. The HGV effect was apparent in the pure RP models and is significant in this pooled model despite not being significant in the pure SP models.

Table 5.5: Simultaneous RP-SP Models

	Coefficients
$ASC_{M6T\text{-}R}$	1.7227 (10.2)
$ASC_{M6TCorridor}$ $ASC_{M6TStoke\text{-}M1}$ $ASC_{M6TExtended}$ $ASC_{M6TLong}$ ASC_{NTH} ASC_{STH} ASC_{M6TNTH} ASC_{M6TSTH} ASC_{NTHSTH} ASC_{ALL3}	1.1032 (8.1) 1.4779 (10.2) 1.3145 (3.9) 0.9406 (7.1) -1.2026 (6.1) -2.6554 (4.7) 0.7956 (4.8) -1.4324 (4.7) -1.1529 (3.2) 1.4982 (7.6)
ASC_{M6T}Never M6T	-1.2160 (8.3)
ASC_{M6T}Male	-0.2632 (3.3)
ASC_{M6T}Age65+	0.4643 (3.0)
ASC_{M6T}Others	0.3814 (6.2)
ASC_{M6T}ObjectTolls	-0.4026 (5.2)
Very Reliable	1.1820 (11.1)
Reliable	0.8428 (8.3)
Usual/Sometime Rely	0.5441 (8.9)
Unreliable	0.2127 (2.8)
%HGV	-0.0049 (2.5)
$Time_{M6}$	-0.0508 (22.8)
$Time_{M6T}$	-0.0528 (16.1)
$Time_{A}$	-0.0565 (27.7)
$Time_{Bits}$	-0.0466 (14.6)
Time*Acttim**λ	-0.000037 (3.3) λ=1.1
Time-OthAdults	0.0077 (2.8)
Earlier	-0.0249 (17.3)
Later	-0.0233 (11.7)
Later-EB	-0.0037 (2.3)
Later-Comm	-0.0064 (2.3)
Adj-HolsSB	0.0077 (2.6)
Adj-VFR	0.0051 (2.7)
Adj-Male	0.0034 (2.5)
Delays M6	Base
M6 delays due to	0.3055 (4.2)
Exp 25m delays	1.0395 (5.9)
No M6 Delays	-0.4436 (3.5)
Toll	-0.0061 (13.4)
Toll-Inc£20k-39k	0.0003 (1.0)
Toll-Inc£40k-59k	0.0007 (1.8)
Toll-Inc£60k-79k	0.0010 (2.4)
Toll-Inc£90k-99k	0.0013 (3.5)
Toll-Inc£100k+	0.0020 (4.3)
Toll-IncDK	0.0005 (1.1)
EmpPay	0.0013 (9.2)
Toll> £3.m50	-0.0008 (4.9)
Toll New Motorway	0.0025 (4.6)
Toll Extended M6T	0.0009 (3.0)
FuelYes	-0.0056 (10.1)
θ_{RP}	1.56 (4.7)

Values of time and their elasticity values are reported in Table5.6.

Table 5.6: Implied M6T Values of Time and Elasticity by Duration

Journey Duration	Value of Time	Elasticity
30m	8.91	0.03
60m	9.20	0.07
120m	9.83	0.13
180m	10.49	0.19
240m	11.17	0.25
300m	11.87	0.30

5.5 Random Parameters Model

The final model addresses random taste variation. It is based on the joint RP-SP models reported in Table5.5, which contain socio-economic variables as well as main effects. Random taste variation is allowed in the ASCs and the toll coefficients as a result of the estimation of a mixed multinomial logit model.

Table 5.7 reports the random parameters model. We have allowed the ASC for the M6T to exhibit a normal distribution across the sample, but constrained it to be the same for $ASC_{M6T\text{-}RP}$, $ASC_{M6TCorridor}$, $ASC_{M6TStoke\text{-}M1}$ and $ASC_{M6TExtended}$. The estimated standard deviation is denoted $SD\text{-}ASC_{M6T}$. We have also allowed lognormal distributions of the toll coefficients specified for different income categories.

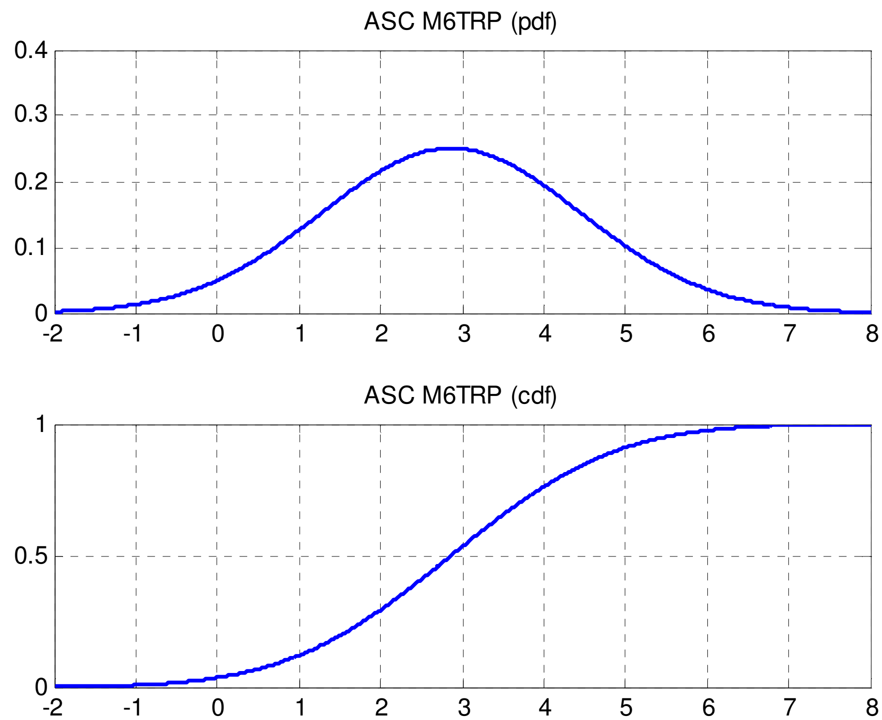
Table 5.7: Random Parameters Model

$ASC_{M6T\text{-}RP}$	2.8708 (16.5)	*Adj-HolsSB*	0.0119 (5.4)
$ASC_{A\text{-}RP}$	-0.1487 (1.8)	*Adj-VFR*	0.0076 (5.6)
$ASC_{M6TCorridor}$	1.8276 (13.7)	*Adj-Male*	0.0044 (3.7)
$ASC_{M6TStoke\text{-}M1}$	2.1270 (15.1)	M6 delays due to	0.9887 (7.4)
$ASC_{M6TExtended}$	2.0469 (7.8)	Exp 25m delays	2.3632 (15.1)
$ASC_{M6TLong}$	2.0265 (9.6)	No M6 Delays	-0.3966 (3.1)
ASC_{NTH}	-2.4259 (13.3)	*EmpPay*	0.0023 (11.0)
ASC_{STH}	-4.0472 (12.3)	*Toll> £3.50*	-0.0011 (8.6)
ASC_{M6TNTH}	1.7666 (14.6)	*Toll New motorway*	0.0019 (6.4)
ASC_{M6TSTH}	-0.5260 (2.3)	*Toll Extended M6T*	0.0007 (2.1)
ASC_{NTHSTH}	-1.2102 (6.9)	FuelYes	-0.0051 (16.1)
ASC_{ALL3}	2.8807 (19.6)	TollDK-Mean	-4.7572 (67.8)
$SD\text{-}ASC_{M6T}$	1.5925 (30.7)	TollDK-SD	0.5403 (15.3)
ASC_{M6T}Never M6T	-2.1321 (13.8)	Toll-<£10k-Mean	-4.5456 (35.2)
ASC_{M6T}Male	-0.4061 (4.2)	Toll-<£10k-SD	0.4528 (4.8)
ASC_{M6T}Age65+	0.7497 (4.3)	Toll-£10-29k-Mean	-4.6418 (80.3)
ASC_{M6T}Others	0.4776 (4.7)	Toll-£10-29k-SD	0.5228 (15.7)
ASC_{M6T}ObjectTolls	-0.2665 (4.1)	Toll-£30-39k-Mean	-4.7619 (61.2)
Very Reliable	1.3719 (17.0)	Toll-£30-39k-SD	0.5855 (15.2)
Reliable	1.0393 (13.8)	Toll-£40-49k-Mean	-4.7628 (62.0)
Usual/Sometime Rely	0.7021 (15.3)	Toll-£40-49k-SD	0.5473 (14.9)
Unreliable	0.3049 (5.3)	Toll-£50-59k-Mean	-4.7853 (62.3)
%HGV	-0.0014 (1.1)	Toll-£50-59k-SD	0.4837 (12.7)
$Time_{M6}$	-0.0841 (45.0)	Toll-£60-69k-Mean	-4.8107 (59.8)
$Time_{M6T}$	-0.0802 (38.7)	Toll-£60-69k-SD	0.3999 (9.9)
$Time_{A}$	-0.0898 (46.7)	Toll-£70-89k-Mean	-4.8453 (51.4)
$Time_{Bits}$	-0.0532 (19.4)	Toll-£70-89k-SD	0.4595 (10.4)
Time*Acttim**1.1	-0.000014 (2.7)	Toll-£90-99k-Mean	-4.9740 (28.4)
Time-OthAdults	0.0099 (4.6)	Toll-£90-99k-SD	0.4494 (5.8)
Earlier	-0.0377 (29.8)	Toll-£100k+-Mean	-5.0960 (38.8)
Later	-0.0348 (22.5)	Toll-£100k+-SD	0.4648 (7.8)
Later-EB	-0.0040 (2.6)	ρ^2 (constants)`	0.375
Later-Comm	-0.0106 (5.8)	Log Likelihood	-19117,9

The random parameters specification increased the ρ^2 goodness of fit statistic from 0.248 to 0.375, albeit with a finer income categorisation as well as the additional random parameters. This is an appreciable improvement in fit. The reduced residual variation means that the coefficients are generally larger than for the model in Table 5.5.

The SD-ASC_{M6T} term representing inter-personal taste variation in the ASC relating to the M6T is highly significant. The distribution of the RP ASC (ASC_{M6T-RP}) around its central estimate of 2.87, along with the cumulative distribution, are depicted by Figure 5.1. Although the normal expectation would be for an ASC favouring the M6T, it is not inconceivable that some would not prefer it, and the results show a small proportion having a negative ASC for the M6T.

Figure 5.1: Distributions of M6T ASC for RP Data (ASC_{M6T-RP})



The model also contains separate coefficients for 10 income categories, one of which denotes that the income is not known. These coefficients are allowed to follow a lognormal distribution, in order to avoid wrong sign values of time which can occur when normal distributions are specified.

For each income category, Table 5.8 reports both a mean and a standard deviation coefficient. In addition to the category representing those for whom the income level is not known (TollDK). there are nine pairs of coefficient estimates. Thus Toll-£30-39k-Mean represents the mean toll coefficient for those with a household income in the range £30 to £39,000 with Toll-£30-39k-SD denoting the standard deviation estimate for the same income group. These are absolute rather than incremental coefficients

In order to return a monotonic income effect, we have only had to combine income bands to a very limited degree. We have combined the £10-19,000 and £20-29,000 income categories and the £70-79,000 and £80-89,000 income categories.

What is impressive is that a monotonic effect is obtained across nine income categories. Values of time spent on A-roads (VoTA) and of time spent on the M6T (VoTM6T) for each income band are reported in Table 5.8. Mean and median values are given, and because the denominator term in the value of time calculation has a lognormal distribution, the median value exceeds the mean.

Whilst the effect of income on the value of time is a well researched theme, we are not aware of previous research that has obtained a pattern of results as impressive as those reported here. However, as in income segmentations here previously reported, the implied income elasticity is relatively minor.

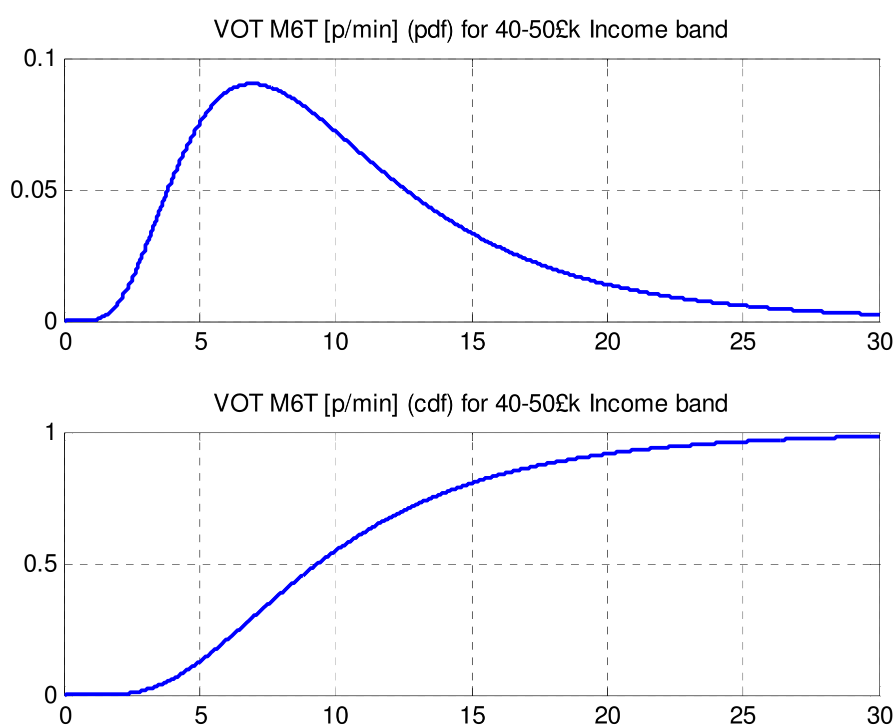
Table 5.8: Values of Time by Income Band

	Median		Mean	
	Value of Time A Roads	**Value of Time M6T**	**Value of Time A Roads**	**Value of Time M6T**
<£10k	8.46	7.55	7.63	6.82
£10-29k	9.31	8.32	8.12	7.25
£30-39k	10.50	9.38	8.85	7.90
£40-49k	10.51	9.39	9.05	8.08
£50-59k	10.75	9.60	9.56	8.54
£60-69k	11.03	9.85	10.18	9.09
£70-89k	11.41	10.19	10.27	9.17
£90-99k	12.98	11.59	11.73	10.48
£100+	14.67	13.10	13.17	11.76
Not Known	10.45	9.33	9.03	8.07

The degree of taste variation in the value of time is illustrated in Figure 5.2. The probability density function and cumulative distribution are reported for the value of time on the M6T for the £40-50,000 income group. Not only are the mean values broadly in line with previously reported values, the distribution of values across individuals seems reasonable.

The random taste variation is large relative to the limited systematic variation that we could detect in the ASC and particularly the toll coefficient according to socio-economic factors and trip characteristics. However, the two distributions of preferences are assumed to be independent of each other when in fact those with a stronger ASC in favour of the tolled road might also tend to have a lower sensitivity to toll.

Figure 5.2: Distributions of Value of Time (M6T for £40-50k Income Group



6 Conclusions

6 Conclusions

6.1 Introduction

This study has involved a major data collection exercise covering a wide range of different types of Stated Preference (SP) exercise addressing motorists' propensity to use various forms of new but tolled motorway infrastructure and a range of possible alternatives. In addition, it has collected route choice data relating to motorists' actual Revealed Preference (RP) choices between the tolled M6T, the M6 and an A road alternative. Motorists' willingness to pay for improved travel conditions has also been explored. This represents some novel research not just in the British context.

A wide range of models exploring a large number of issues relating to inter-urban car travel have been estimated. The main model deals with route and departure time choice and is based on almost 30,000 SP observations supplemented with over 3000 RP observations. Several other substantive models have been developed dealing with different types of travel time and different levels of infrastructure provision.

Extensive analysis has been conducted on the large amount of data collected. In general, the data appears to be of good quality and supports the development of robust SP and RP models which have generally provided very reasonable results covering a wide range of issues. A considerable amount of fresh empirical evidence is presented that contributes significantly to the existing body of evidence in this area, with some results providing new insights into motorists' behaviour and preferences in the context of inter-urban journeys.

The basic models yield a value of time of around 10 pence per minute for non-business travel. This is very much in line with previous research for longer distance car travel. However, as is often the case in SP studies, the value of time of around 12 pence per minute for business travellers was only a little higher.

The route choice analysis does not support a different value of time for the M6T relative to the M6. This was confirmed in the abstract choice SP exercise which dealt with this issue. Nor is there compelling evidence for a higher value of time on A roads. To some extent this conflicts with evidence we have found in support of the value of time varying with traffic conditions.

Numerous studies have found the value of time to increase with journey duration. We found both the preference for the M6T and also the value of time (but not both simultaneously) to increase with journey duration. The effect on the value of time was confirmed in the RP data. The values of time for different journey times and the associated elasticity implied by our SP modelling are as follows:

Journey Duration	**Value of Time**	**Elasticity**
30m	7.54	0.06
60m	7.93	0.09
120m	8.57	0.14
180m	9.12	0.17
240m	9.62	0.20
300m	10.08	0.22

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

A wide range of toll charges were covered across the large number of SP exercises. There was a greater degree of sensitivity to toll charges that were an increase on the then prevailing toll level of £3.50 than for reductions. The toll coefficient is 13% higher for increases, consistent with evidence from meta-analysis that toll charge is associated with a higher level of disutility than other costs presumably due to protest response. However, the introduction of tolls on the existing M6 did not attract any protest. The toll coefficient is 38% lower when an entirely new motorway is being considered and 15% lower when relating to an extension of the M6T. In the latter cases, any protest towards tolls may be expected to be tempered by a desire to see new and improved motorways and respondents could be expected to have a stronger desire to see a new motorway than an extension to the M6T. They may therefore inflate their stated willingness to pay. We might therefore treat responses to choice experiments which deal with new motorways with some caution

When we account for the employer paying the toll, the toll coefficient for reductions in tolls is very similar to the fuel price coefficient for those who stated that they took fuel costs into account in making their stated choices. This is encouraging. It also suggests that it is the toll coefficient for reductions that are the most appropriate to use.

When we do not account for the 65% who do not consider fuel costs in their SP responses, the fuel cost coefficient falls by 69%. This draws into some doubt values of time based either in part or entirely upon a fuel cost numeraire when no account has been made for those who do not consider fuel. However, for forecasting purposes, it is appropriate to use separate coefficients for the two types of motorist.

The value of earlier and later departures is very similar and the unit value varies little between one and two hour departure time shifts. A minute of departure time shift is equivalent to 0.4 minutes of in-vehicle time and this seems reasonable.

We tested the impact of a wide range of socio-economic and trip characteristics on how motorists respond to time and cost variations and on their preferences for the M6T over the other routes all else equal.

We found a strong and monotonic effect from the perceived level of reliability of each route. This had the effect of reducing the alternative specific constants (ASCs) favouring the M6T but by no means did it remove them. Compared to a perceived very unreliable route and for the average journey of around 2½ hours, a very reliable route was worth around 20 minutes, a reliable route was worth 14 minutes, a sometimes reliable route was worth 9 minutes and an unreliable route was worth 4 minutes.

There was a monotonic reduction in the toll coefficient across 6 household income categories, ranging from less than £20,000 to over £100,000 per annum. Whilst such a relationship is impressive by the standards of much empirical evidence, the effect on the value of time was surprisingly weak, implying an income elasticity of 0.2 or less when SP studies typically achieve a cross-sectional income elasticity of around 0.5.

A random parameters model, which allowed the toll coefficient to follow a lognormal distribution for each income group, extended the monotonic relationship to 9 income categories. This is the most impressive freely estimated effect that we are aware of in an extensive literature on this subject.

There were only a limited number of other statistically significant effects from a large number of socio-economic, attitudinal and trip factors that were tested. The only effect discerned on the time coefficient was for those travelling with other adults where the value of time was around 10% less.

The ASCs favouring the M6T were found to vary with several factors. Those who would never consider using the M6T were implied to have a negligible ASC. Whilst males and those who object to paying tolls had a weaker preference for the M6T and those aged over 65 and those with others in the car were more inclined to the M6T, the effect on the M6T is less than 33%.

We tested whether offering journey times as changes on the current level rather than as absolute amounts impacted on the coefficient estimates. We also tested whether the perceived credibility of the times and costs offered had a bearing on the responses provided. We have concluded that there is no evidence to support variations in the time coefficients according to whether time is presented in absolute or difference form. Nor does the means of presentation impact on the scale of the model whilst presenting differences does not induce size effects that are not present when absolute values are offered. The perceived credibility of attributes does not impact on their coefficient estimates and does not have a large impact on the scale of the model. This is, though, in the context that only one attribute was presented in difference form, whereas it is not uncommon that SP exercises present several attributes in difference form, and of course it is possible that credibility varies across SP scenarios whereas we here simply asked for an overall evaluation across all scenarios.

The travel time variability SP exercise has not produced credible results. This is despite following what is now a fairly standard approach in this context of offering five varying journey time scenarios and arguably having a relatively realistic scenario where the M6T provided a means of achieving both quicker and less variable journey times rather than the more typical but less realistic trade-off of less variability but at the expense of longer average times.

It is not uncommon that studies of motorists' time valuations distinguish between different types of time. The simplest distinction is between free flow and congested time but some recent studies have specified three categories of free flow, slowed down and stop-start. We have here distinguished between six categories of time. The types of time and relative valuations are:

Free Flow	1.00
Busy	1.05
Light Congestion	1.11
Heavy Congestion	1.31
Stop Start	1.20
Grid Lock	1.89

Whilst not a monotonic effect, the results are both impressive and original. They correspond reasonably with a valuation of around 1.5 in the British context which is obtained for the valuation of what is termed congested time relative to free flow.

The other abstract choice exercises also provided a number of interesting findings. The value of time would increase by 0.7% for every percentage point increase in the proportion of HGVs on a route. We were also able to detect an effect from the proportion of HGVs on actual route choice.

Wide lanes (3.75m) reduce the value of time by 5% compared to standard lanes (3.35m) whilst narrow lanes (3.0m) increase the value of time by 9%. 4 lane motorways would have a 7% lower value of time compared to standard 3 lane motorways whilst 2 lanes motorways would increase the value of time by over 10%. Deteriorations in standards therefore seem to be more highly valued than improvements.

With regard to road surface, which can impact on both noisiness and ride quality, a concrete surface adds 12% to the value of time compared to a standard surface whilst high level jointed sections of motorway increase the value of time by 9%. However, as in the route choice models, there is no justification for distinguishing between the disutility of travel time on the M6 and M6T surfaces. It would seem that it is the noise associated with the road surface rather than the ride quality that drives the different values of time.

An additional speed camera on a journey is valued at 1.26 minutes whilst the presence of lighting reduces the value of time by 10%.

We have been able to develop what seem like robust RP models which provide a firm basis for rescaling of the SP parameters to e consistent with actual choices and thereby appropriate for forecasting. Combining the RP and SP data in a jointly estimated single model does not materially alter the results obtained by the stand-alone SP model. The scale parameters estimated indicate that the SP based parameters would have to be inflated by a factor of 1.5 for forecasting purposes. We proceeded to introduce random taste variation into this model for the alternative specific constants relating to the M6T and for the sensitivity to toll. The taste variation that is present is not particularly large, consistent with the limited variations in model parameters according to socio-economic characteristics.

These joint models provide a suitable means for forecasting the effects of different toll scenarios and different time saving benefits on the demand for a tolled road and on the surrounding road network. Another aspect of the study is undertaking this task. Despite covering a large number of variables and allowing the time coefficients to vary by route, we are left with relatively large constants favouring the M6T which we have been unable to 'unpack' into the factors causing this preference. However, this is not just present in the SP models but also manifests itself in the RP data to a broadly similar degree.

The repeat of the 1994 study turned out to be a well worthwhile exercise conducted at low marginal cost as part of the main data collection exercise. As with other studies that have conducted repeat exercises, there is evidence that the value of time is not increasing anything like in line with income as the Department for Transport's conventions would predict. Indeed, as is apparent in other repeat studies of motorists' choices, there is evidence that the value of time is falling over time.

As for preferences towards toll and other driving costs, there is no support for differential rates of change over time. We might have expected motorists to become less sensitive to toll, much as they became less sensitive to parking charges over time, once they became accustomed to such charges. However, this is not empirically supported.

Further Research

A number of issues for further research arise out of the findings that have emerged from the analysis reported here.

There are preferences for the M6T independent of attitudes towards it and the characteristics of each route. This is not an artefact of the SP method since it is also apparent in real choices. Whether such preferences are unique to the M6T requires further research. For example, comparison with other studies might indicate the extent to which ASCs depend on the length of the tolled facility or the quality of the existing routes.

We have conducted the most extensive segmentation of time into different types that we are aware of. Typically up to three categories are included in studies of motorists' time values but here we have specified six. Further corroboration is needed though[2], using more sophisticated means of presentation and exploratory research into motorists' perceptions of and attitudes towards different types of time. It would also be illuminating to explore whether the relative valuations of different types of time vary across the characteristics of motorists and their journeys.

Some interesting and potentially very significant findings have emerged from our inter-temporal analysis. Further detailed research is required to cast much more light on the theoretical and practical reasons why the value of car travel time is not increasing over time in line with income or indeed might not be increasing at all. It would be illuminating to observe trends in the public transport market. The evidence that attitudes to tolls might change over time also requires further investigation.

There is scope for more sophisticated analysis of the degree of competition between routes, building upon the multinomial logit model reported here, and for specifying more extensive random taste variation with correlation between the spread associated with different coefficients.

[2] We have repeated this SP exercise in the United States. We obtained a monotonic valuation across the different types of time but otherwise similar results to those obtained here.