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THE MODELLING OF MOTORCYCLE OWNERSHIP AND COMMUTER USAGE: A UK STUDY

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ABSTRACT

This paper presents work, undertaken for the UK Department for Transport, to help determine how policy could affect motorcycle usage.

There are two important choices that determine potential motorcycle use: the decision to own a motorcycle, and contingent upon that, the decision to use a motorcycle for a particular trip. This research has addressed both of these, and this paper describes the development of models to represent these decision processes.

The motorcycle ownership model predicts the number of motorcycles a person owns and the engine sizes of these motorcycles, depending on the characteristics of the person and the average purchase cost. The structure of the ownership model is a disaggregate nested logit model, with structural parameters to measure the sensitivity of choice of engine size relative to motorcycle ownership.

Existing travel surveys contained insufficient information to model the mode-choice decisions of motorcycle owners. Therefore, new surveys were designed incorporating stated preference discrete choice experiments. This also allowed us to collect data to examine how motorcycle usage may change as a result of policy and the impact of other important influences, such as weather. The data was used to develop nested logit models of mode-choice. These models also give some insight as to how the ability to inter-lane filter influences mode choice.

This is the first UK study that models both motorcycle ownership and mode choice. It provides useful insights for policy makers and illustrates the potential for modelling motorcycles within the same framework as other transport modes.

MOTORCYCLES: PREVIOUS RESEARCH AND THE POLICY AGENDA

Motorcycles are a frequently ignored mode in transport planning, and when researched are generally considered mainly from a safety perspective, and rarely on equal terms with other modes. In fact, a quick analysis of TRR publications since 1996 revealed that in total only twelve papers were detected by a search on "motorcycle" and/or "motorbike"; nine of these were safety related, one stated the argument for considering motorcycles as a full mode of transport (1), and only two presented modelling regarding motorcycle ownership and use (2,3). It is also notable that the two papers that do look at ownership and use, focus on the role of motorcycles within developing countries, and to date there has been little published research regarding the modelling of motorcycle use within developed countries.

However, within the UK in recent years there has been an increasing awareness of motorcycles. In May 1999, the Government set up the 'Advisory Group on Motorcycling' as a means of investigating the potential of increased motorcycle use for reducing congestion and pollution. There were three primary terms of reference for the group:

- To look at the safety record of motorcyclists and agree measures that would improve safety
- To look at the environmental impact of motorcycles and if necessary agree measures to be taken
- To look at the role of motorcycles in integrated transport policy and to assess the scope for further enhancing their benefits through traffic management

In 2001, the Department for Transport commissioned a 6 month study into 'Motorcycling and Congestion'. The main aim was to provide the Department with an initial appreciation of the potential effects of a commuter mode shift to motorcycles, particularly from car. The study investigated the ways in which motorcycles are ridden in congested areas, and the extent to which motorcyclists benefit when compared to car or public transport travel. This was done by means of a literature review, surveys and the observation of riding characteristics in congested conditions, and an efficiency assessment – the degree to which a transfer to motorcycle frees space, which in turn depends on the mode transferred from (4).

This paper presents research undertaken for the UK Department for Transport (DfT) and Transport for London (TfL) that builds on this prior work, and carries it forward by developing better methods to quantify the extent of mode share that may readily transfer to motorcycle. The models that have been estimated help determine how policy could affect motorcycle usage.

There are two important choices that determine potential motorcycle use: motorcycle ownership and choice of motorcycle for travel: both have been addressed in this study in order to predict the impact of policy on motorcycle use and the related impact on road congestion reliably. As motorcycle owners are a small fraction of the population, significant reductions in traffic congestion can come about only if the level of ownership rises.

TRENDS IN UK MOTORCYCLE OWNERSHIP

An analysis of the data recorded in the UK government Vehicle Information Database (VID) between 1993 and 2001 has been undertaken to gain a better appreciation of the recent trends motorcycle ownership. There has been a considerable increase in stock over the period; the 2001 stock represents a 36 % increase over the 1993 stock. Information was supplied by the DfT on the number of motorcycles registered in Great Britain (GB) broken down by:

- Engine size
- County/unitary authority
- Maker code

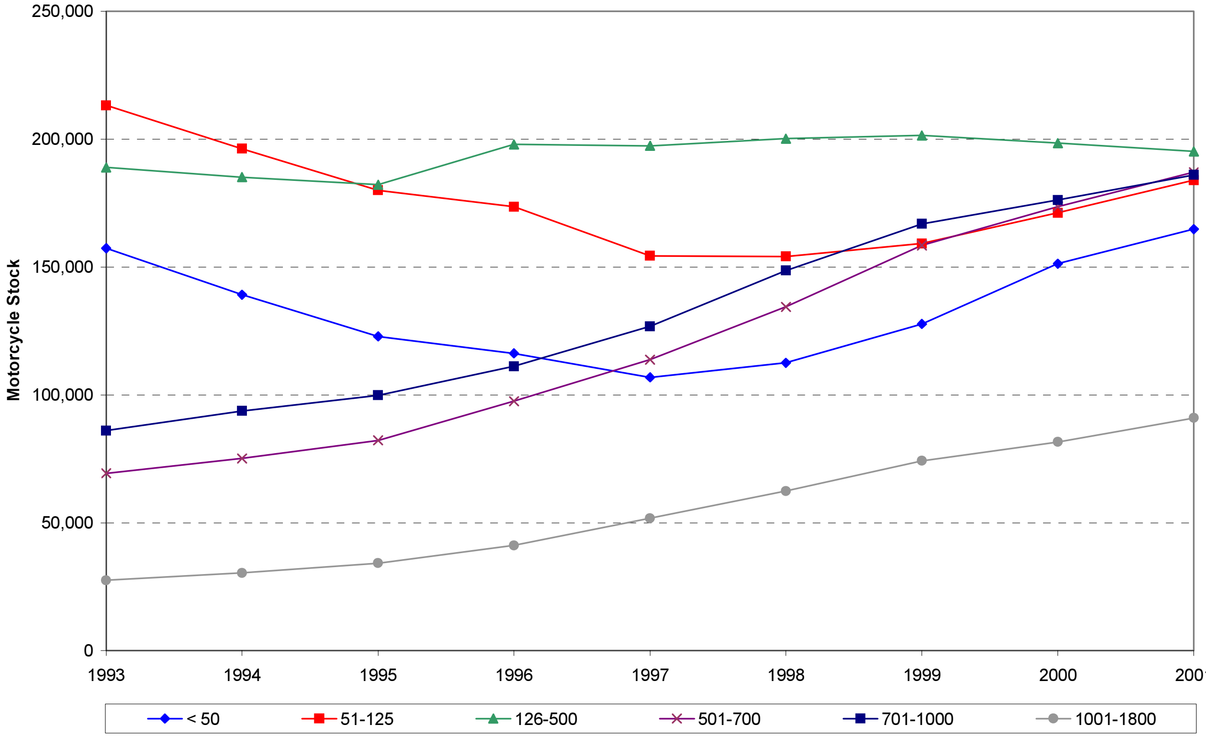

FIGURE 1 Trends in Motorcycle Stock by Engine Size (in cc), 1993-2001.

It can be observed that there was a drop in the number of the smallest bikes (<50cc) between 1993 and 1997, which was subsequently reversed, resulting in the 2001 stock being slightly above the 1993 levels. The shape of the 51-125cc band plot is similar, but these have not returned to 1993 levels. In the 126-500cc band, numbers have remained more stable over the period, with the 2001 stock slightly above 1993 levels. However the main trend that is shown here is that the overall growth in stock is driven by the large engine size bands. All three (501-700, 701-1000 and 1001-1800) show steady growth throughout the period.

THE MODELLING OF MOTORCYCLE OWNERSHIP

The motorcycle ownership models developed here reflect personal ownership. It is the opinion of the study team that the decision to purchase and use a motorcycle is a personal one, not a household one, although household characteristics, for example, presence of children may influence the decision. Whilst the VID data is useful for understanding trends in ownership at an aggregate level as it contains information on the characteristics of all currently registered motorcycles, the database contains no information on the characteristics of those owning each type of motorcycle. It is therefore necessary to consider other data sources to obtain information about "who" owns these motorcycles in order to build a disaggregate ownership model.

The ownership models have been estimated from two data sets. The first is the National Travel Survey (NTS) data, which contains on average 6,100 observations per year, and provides information on the number of motorcycles each individual within the survey sample owns and the engine sizes of those motorcycles. Data from 1992 to 2001 has been used so as to identify a sufficiently large sample of motorcycle owners. The second data set is the 2000 Family Expenditure Survey (FES), which contains an additional 11,000 records. Given the large changes in total stock between 1993 and 2001, it was felt to be important to boost the volume of more recent data, and the FES data provides a larger sample of households per year than the NTS. The FES data provides information on the number of motorcycles each individual within the sample owns but does not provide engine size information. For both the NTS and FES samples, information was supplied at the person level (e.g. personal income, age, occupation), the household level (e.g. the number of adults and children in the household) and the location of the household (e.g. metropolitan area). From these datasets it can be observed that 98.5% of the sampled population own no motorcycle, 1.4% own one motorcycle and 0.2% own two or more motorcycles.

The motorcycle ownership model predicts both the number of motorcycles owned and the engine sizes of these motorcycles. In terms of numbers of motorcycles, zero, one and two-plus motorcycle alternatives are identified. The number of individuals owning more than two motorcycles is very small and therefore there is insufficient data to distinguish ownership of more than two motorcycles in the models. Six engine size alternatives are also distinguished:

- E1: up to 50cc
- E2: 51 – 125cc
- E3: 125 – 500cc
- E4: 501 – 700cc
- E5: 701 – 1000cc
- E6: 1001 – 1800cc

For the two-plus motorcycles alternative, the choice of engine size for both of the motorcycles is modelled. Where an individual owns more than two motorcycles, then the engine sizes of the two motorcycles with the highest annual mileages are modelled. The model structure is illustrated in Figure 2. The parameter θ is used to account for the different error variation associated with the choice of engine size relative to the choice as to how many motorcycles to own.

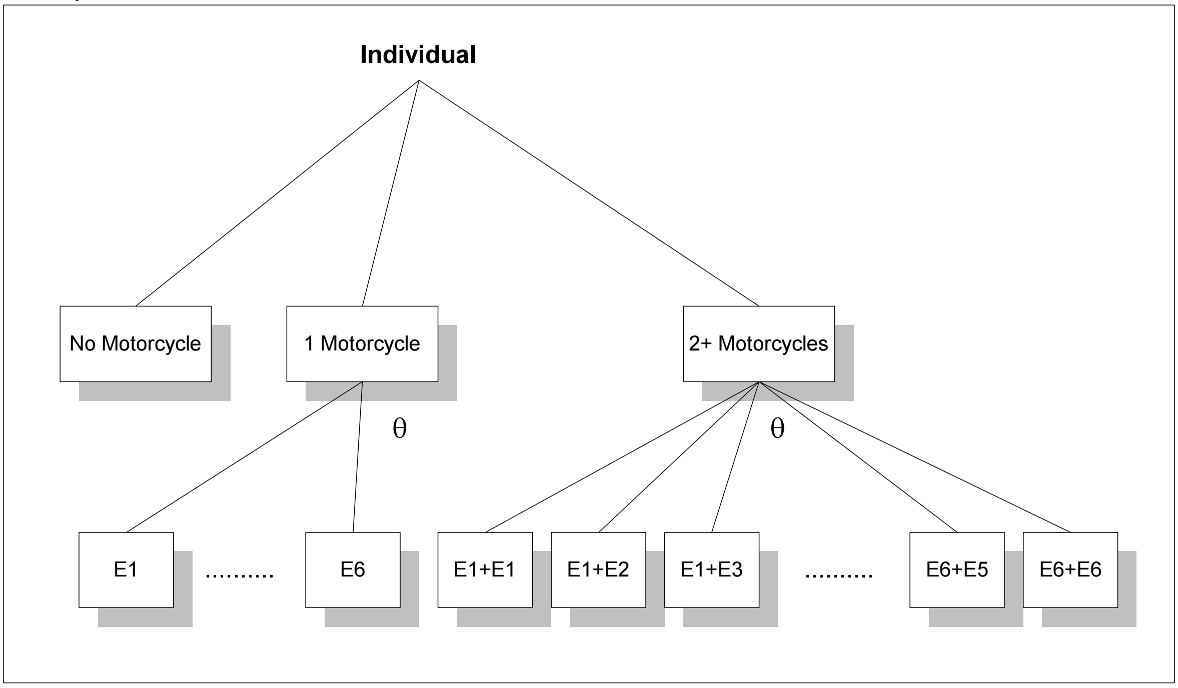

FIGURE 2 Motorcycle Ownership Model Structure.

Under the two-plus motorcycles alternative there are a total of 36 engine size alternatives, one for each possible combination of first and second motorcycle engine size band. It is assumed in the modelling that the utility of an engine size combination can be expressed as the sum of the utility of each of the two separate engine size alternatives; this assumption is necessary as there is relatively little data on multiple motorcycle ownership and so it is not possible to estimate different utility functions for the 36 possible engine size combinations.

The NTS data provides engine size information, and thus allows choice to be specified at the bottom of the tree structure where six engine size alternatives are distinguished. The FES data only provides information on the number of motorcycles owned, the engine sizes of these motorcycles are not known. Therefore choice is specified higher up in the tree in the FES data, at the number of motorcycles level. The model structure used allows the NTS and FES data to be combined in a statistically efficient manner to provide joint coefficient estimates. The estimation of the discrete choice models was undertaken using ALOGIT (5). A series of models were estimated to find the best explanation to describe the number of motorcycles and motorcycle engine size per person. The model has been specified such that the fit to the data is maximised whilst maintaining plausibility and simplicity.

TABLE 1 Ownership Model Results

Variable description	Estimate	t-ratio
Unit cost of motorcycle split by engine size (industry costs, not retail)	-3.30E-04	-3.2
Terms on the One Motorcycle Alternative:		
ASC on "one motorcycle" alternative	-6.20	-30.5
Dummy, males	2.15	-16.7
Dummy, persons aged 16-24 relative to those aged 45-59	-0.469	-2.9
Dummy, persons aged 25-34 relative to those aged 45-59	0.496	-5.2
Dummy, persons aged 35-39 relative to those aged 45-59	0.604	-5.3
Dummy, persons aged 40-44 relative to those aged 45-59	0.402	-3.3
Dummy, persons aged 60-69 relative to those aged 45-59	-0.991	-6.1
Dummy, persons aged 70 plus relative to those aged 45-59	-1.69	-7.6
Dummy, persons in households with one car	0.322	-4.7
Dummy, persons living in households without children	0.340	-4.6
Dummy, persons with incomes under £ 9,000 p.a. (2001 prices)	-0.430	-4.6
Dummy, persons in the professional and managerial SEG group	-0.326	-3.9
Dummy, persons living in London relative to those in Wales or non-metropolitan England	-0.402	-3.8
Dummy, persons living in Metropolitan areas relative to those in Wales or non-metropolitan England	-0.783	-6.6
Dummy, persons living in Scotland relative to those in Wales or non-metropolitan England	-1.01	-6.1
Terms on the Two Motorcycles Alternative:		
ASC on "two plus motorcycle" alternative	-11.3	-14.1
Dummy, males	4.66	-6.1
Dummy, persons aged 16-24 relative to those aged 25-plus	-2.12	-3.6
Dummy, persons with incomes of at least £ 15,000 p.a. (2001 prices)	0.687	-3.1
Dummy, persons living in London and Metropolitan areas relative to those in Wales or non-metropolitan areas in England	-0.620	-2.6
Dummy, persons living in Scotland relative to those in Wales or other non-metropolitan areas in England	-2.50	-2.5
Terms on the Engine Size Alternatives:		
ASC, engine size 51-125cc relative to <50cc	-0.801	-3.7
ASC, engine size 126-500cc relative to <50cc	-0.309	-1.2
ASC, engine size 501-700cc relative to <50cc	0.197	-0.6
ASC, engine size 701-1000cc relative to <50cc	-0.778	-1.2
ASC, engine size 1001-1800cc relative to <50cc	-2.04	-3.2
Constant reflecting higher probability of second engine size being equal to the first	0.713	-3.0
Dummy, males on < 50cc engine size	-1.98	-8.9
Dummy, males on > 700cc engine size	1.14	-2.4
Dummy, persons aged 16-19 on < 50cc engine size	3.24	-7.6
Dummy, persons aged 16-19 on 51-125cc engine size	1.72	-4.0
Dummy, persons aged 50 plus on < 50cc engine size	0.670	-3.3
Dummy, persons aged 50 plus on > 500cc engine size	-0.592	-3.8
Dummy, persons with incomes under £ 7,000 p.a. (2001 prices) on > 500cc engine size	-0.814	-3.4
Dummy, persons with incomes of at least £ 20,000 p.a. (2001 prices) on > 700cc engine size	0.701	-4.7
Dummy, persons with semi-skilled or unskilled manual occupations on < 50cc engine size	0.740	-3.7
Dummy, persons in zero car households on < 125cc engine size	0.670	-4.2
Tree and Scaling Parameters:		
Scaling coefficient applied to the FES data relative to the NTS data	0.632	-4.9
Structural tree coefficient, theta (see Figure 2)	0.588	-4.9
Observations	72196	
Final log(likelihood)	-6807.9	
Degrees of freedom	40	
Rho²(0)	0.975	

The results of the final model are presented in Table 1. A purchase cost term (in 2001 indices) is included, which uses information from the National Statistics data on motorcycle sales. This data reflects unit costs of motorcycles split by engine size, from which the average cost of a motorcycle of each size can be determined for each year. The costs are industry costs, not retail costs.

In interpreting the structural parameters the value for FES_Scale of less than one implies that there is more error in the FES data than the NTS data. The lack of engine size information in the FES data means that this result is plausible. Similarly, the value of theta implies that there is more error in modelling the decision of how many motorcycles to own compared to the decision of choice of engine size.

It is interesting to note that the positive constant shows that multiple motorcycle owners have an increased probability of the second motorcycle having the same engine size as the first. This may be individuals that are comfortable with a certain level of performance but use an older bike for utilitarian trips such as commuting and a newer model for leisure – this would seem to fit with anecdotal evidence from multiple motorcycle owners expressing concerns about leaving their new motorcycles parked all day in areas where they may be subject to theft. This also suggests that multiple motorcycle owners may not be strongly associated with the increase in purchase of smaller machines, although this has not been directly tested.

Because of the small number of observed motorcycle owners, the ownership models are estimated from a sample of households from 1992 to 2001. The VID trend analysis presented earlier demonstrated significant changes in stock over this period, and differential patterns of growth by engine size band and region. Consequently the models have been recalibrated so that they replicate the engine band shares in the 2001 VID data.

The census and the VID data were used to calculate an overall mean ownership propensity, and the split between those owning one and two or more motorcycles was obtained from the 2000 and 2001 NTS and FES data. From the VID data the total number of registrations by engine size band for GB were extracted, allowing the proportions of motorcycles belonging to each engine size band to be calculated. This data allowed us to determine targets for recalibrating the sample in the ownership model. The targets were met by iteratively adding a constant to each alternative. The constants were recalculated for each iteration until the absolute difference between the predicted demand and target demand for each alternative was less than one, which was selected as appropriate in this context to indicate convergence.

SURVEYING OF MOTORCYCLISTS TO UNDERSTAND THEIR USAGE PATTERNS

Whilst Revealed Preference (RP) data was judged to be more appropriate given the nature of decisions for the ownership models, Stated Preference (SP) data was considered more appropriate for development of the usage models. The low incidence of motorcycle ownership in the population meant that RP travel databases did not provide adequate information on the choices that have been made. It was therefore necessary to collect new sources of information on these aspects of travel behaviour in this study. Both RP and SP data about motorcycle usage were collected. The decision to collect SP data was also driven by the desire to investigate a number of potential policy responses, for example the effects of introducing motorcycle parking costs, changing lane widths and introducing parking security measures. The responses to such policies are difficult to measure from RP sources as the incidence of the emerging policy measures are typically quite small, and in some cases the policies are still under consideration and so have not yet been implemented.

One particularly important issue in setting the scope for the data collection was the specification of who should be surveyed. In examining the potential for mode switching to motorcycle from other modes there are two distinct groups that can be considered. The first is existing motorcycle owners who can increase their existing use of motorcycle, the second is non-owners who would need to purchase a motorcycle and possibly even undertake additional training in order to use this mode for their travel. It was judged that the quantification of likely mode switches to motorcycle for non-motorcycle-owning respondents was simply too complex to undertake in this study and as such the usage modelling concentrated on usage for existing motorcycle owners.

The main area of interest to the study was the relationship between motorcycles and congestion. The usage model therefore concentrated on the choice of mode for journeys made during the AM peak period (defined for this study as between 7am and 10am). The journeys were also required to include travel into or within an urban area.

The survey contained a number of separate sections, which collected important information relating to both existing motorcycle ownership and use, and the constraints and personal circumstances that could influence the ability to modify the existing usage behaviour.

The first section of the questionnaire collected information on the respondent's motorcycle and car ownership and general usage profiles. In the next section of the questionnaire, respondents were asked to focus on the most recent peak period weekday journey they had made in the previous two weeks. A number of details were collected about this trip, such as the origin and destination, time of travel, whether there was any flexibility in the time at which they travelled and the purpose of the trip. Respondents were also asked to provide information on the journey time and cost they would expect for both their motorcycle and a credible alternative mode for their journey, and were asked to indicate which they had used for the journey in question. This data provided the base inputs for the SP experiments and the subsequent RP modelling.

Respondents were then presented with a 'within-mode' SP experiment in which they were asked to choose between two hypothetical motorcycle journeys. The variables in this experiment were specified to collect information relating to factors that could make one motorcycle journey better than another:

- Congestion in general motor vehicle lanes

- General traffic lane width
- Advance stop lines
- Distance from parking to destination
- Parking security
- Parking costs

Each respondent was presented with four choice pairs in this within-mode experiment.

Which option would you prefer for your journey in the AM peak period if you had to use your motorcycle?

Option A	Option B
The traffic in the general motor vehicle lanes will be subject to mild congestion **The general traffic lanes are not wide enough for filtering, you have no access to alternative lanes** You have legal access to advanced stop lines	**The traffic in the general motor vehicle lanes will be freely flowing** **The general traffic lanes are wide enough for filtering** You have legal access to advanced stop lines
You will be able to park your motorcycle within 5 minutes walk of your destination **You will be able to park at a location with no special security measures for motorcycles** **Your motorcycle parking will cost £2 per day**	You will be able to park your motorcycle within 5 minutes walk of your destination **You will be able to park at a location with an immovable object to lock your motorcycle to** **Your motorcycle parking will be free**

Prefer Option A ☐ **Prefer Neither** ☐ **Prefer Option B** ☐

FIGURE 3 Example within-mode choice pair.

Following the within-mode experiment, respondents were asked to participate in a 'between-mode' SP experiment. This experiment presented the respondent with choices between motorcycle and another credible transport mode. The experiment was designed to provide information on the factors which may influence the decision of which mode to use for a journey:

- Expected weather for the day
- Distance from parking to destination for motorcycle and car
- Motorcycle parking security
- Parking costs for motorcycle and car (first 4 choices)
- Congestion charging for motorcycle and car (second 4 choices)
- Journey time difference for non-motorcycle mode
- Reliability of non-motorcycle mode
- Public Transport fare – other modes travel costs held constant but parking and charging varied

Each respondent was presented with eight choice pairs in this between-mode experiment. An example choice pair from the Motorcycle-Car between-mode experiment is presented in Figure 4, in this choice the respondent is presented with parking costs but in later choices these would be replaced by congestion charges.

Which option would you choose for your journey in the AM peak period?

You expect there to be light intermittent rain during the day

Motorcycle	Car
Journey takes the same time as by motorcycle now	Journey takes 5 minutes more than by car now There are often unpredictable delays causing you to be 10 minutes late
You will be able to park your motorcycle within 5 minutes walk of your destination You will not know in advance whether you will find a space with security measures	You will be able to park your car within 5 minutes walk of your destination
Your travel costs by motorcycle will stay at the level you reported Your motorcycle parking will be free	Your travel costs by car will stay at the level you reported Your car parking will be £15 per day

Choose Motorcycle ☐ **Choose Neither** ☐ **Choose Car** ☐

FIGURE 4 Example between-mode choice pair: Motorcycle-car choice with parking costs.

The respondent was then asked a number of questions about factors that may have influenced their choice behaviour. This included questions on the maximum number of days that the respondent could use their motorcycle in a typical week, their perception of risk of having an accident on their motorcycle at different times of the day, and their perception of the risk of their motorcycle being stolen from different locations. Finally a series of questions were asked about the respondents' personal and household characteristics to provide data that may be useful in identifying potentially different behaviour according to background or circumstance. This included questions on age, gender, household composition, working status, socio-economic group, dress code, personal income, and membership of any motorcycling clubs.

Respondents were initially recruited by telephone from a sample frame of motorcycle owners whose contact details were available from an omnibus survey. Those that agreed to participate in the survey were given the option of a subsequent telephone interview (requiring the mail-out of the choice cards for the SP exercises) or a self-completion survey available through the internet. The access to the internet survey was strictly controlled with each respondent being given a unique identifier allowing a single interview to be completed; this avoided any potential sample bias from being introduced by interest groups distributing html links to the survey site.

Quotas were set for the recruitment to ensure that there was sufficient representation of each of the key groups that were to be examined within the model, including geography and mode pair; in addition quotas were set for motorcycle size. A target of a total of 480 completed interviews was set. Some difficulties were encountered with recruiting respondents within some of the quota categories from their sample frame; after data cleaning a sample of 343 respondents were available for modelling.

THE MODELLING OF MOTORCYCLE MODE CHOICE

An examination of the choice behaviour in the second experiment showed that the motorcycle option was favoured in most cases, even when the motorcycle was not the chosen mode for the observed journey. The experiments were designed to explore the impact of policy options but the alternatives offered were constrained to realistic situations. The choices were also designed to explore the impact of increases in the travel time for modes other than motorcycle, to investigate the potential switches to motorcycle if other modes became less attractive. As a result of these design aspects it is not surprising to see the motorcycle alternative generally favoured over other modes across the choices (1), although this level of preference was not anticipated.

In general it would have been desirable to have obtained more trading between modes, with the above results suggesting that many of those currently using their motorcycle are not particularly responsive to the policy changes that were examined. A large proportion of those respondents not using their motorcycle for the trip in question did not stay with their current mode, in fact quite significant numbers always chose the motorcycle alternative. This may suggest that the participating respondents viewed the changes to the alternative modes as quite large and more insight into trading may have been obtained by examining smaller changes in journey time etc. However, it is important to remember that all of the respondents participating in these exercises owned a motorcycle and therefore had an inclination towards this mode already, albeit not always for AM peak period trips.

The SP and RP data have been used to estimate the mode choice model parameters in a nested logit model. The advantage of the joint analysis approach is essentially that the data sets are complementary. In particular, the credibility and realism of the RP data combines well with the efficiency and flexibility of the SP data. A secondary estimation procedure to correct the alternative-specific constants is also required, but this is more appropriately performed using aggregate mode shares, during the model application.

The nested logit model included the RP data and the two SP data sources from the within-mode and between-mode experiments. These two experiments contain a number of common variables and the joint estimation allows the factors relating to the choice between motorcycle journeys to be combined with those relating to the choice between motorcycle and an alternative mode.

There are therefore a number of different scale parameters in the model estimation to combine the three separate, but correlated, sources of data. The structural form of the model is presented in the following figure. Separate scale parameters are applied to the utility equations for each data set to take account of differences in unexplained error in each data set: the SP between-mode data is used as the reference data set with an implied scale parameter of 1.0. Scale parameters are also used to examine differences in relative unexplained error variation between different mode combinations in the between-mode choices with Motorcycle-car used as the base; these are estimated jointly from the RP and SP between-mode data. All the scales in the model are therefore relative to the SP between-mode Motorcycle-car choice.

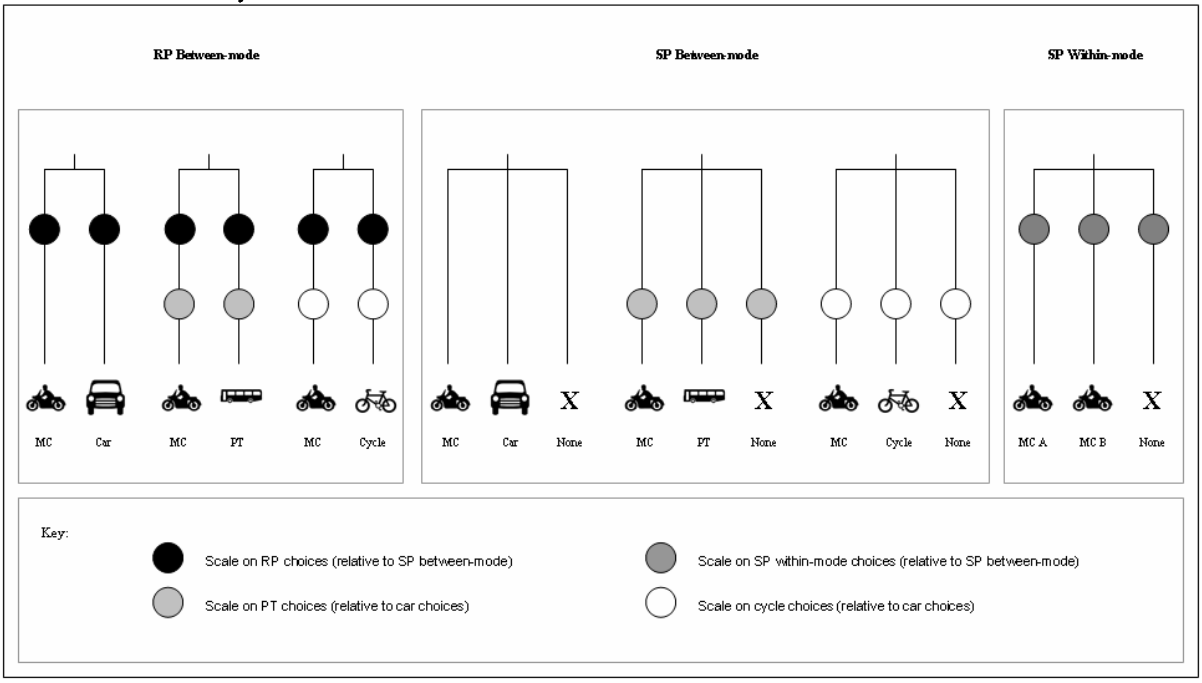

FIGURE 5 Tree structure illustrating scaling applied to utility functions for each data source.

Utility functions were specified for each of the possible mode alternatives. For the between-mode models (SP and RP) there were four possible mode alternatives: motorcycle, car, public transport and bicycle. It is noteworthy that each respondent only evaluated two of these alternatives in their SP experiment, i.e. motorcycle and their best alternative. They also only provided service information for these two modes for the RP model. For the within-mode model there were two different abstract motorcycle alternatives. Each SP model also included "neither" alternatives for each mode choice pair with an associated utility function. For each respondent, only the utilities for the alternatives actually specified in their pair-wise choices were included in their mode choice alternative set. These nested logit models were estimated using ALOGIT (5).

An important advantage of the SP approach is that several responses can be collected from each individual. This reduces substantially the cost of data collection and allows for more advanced experimental designs. However, the collection of multiple responses means that each respondent's basic preferences apply to the series of responses that he or she has given: those responses are therefore interdependent. 'Naïve' analysis methods that assume the independence of observations are therefore in principle invalid. This issue is compounded by the correlations that may exist between the RP and SP data, which in the case of this study are not independent. While a number of methods can be used to correct for the interdependence of observations, experience has shown that a good practical method is to use the 'jack-knife' procedure. This is a standard statistical method for testing and correcting model mis-specifications. In general, the application of the procedure to SP data has confirmed that the coefficient estimates themselves are not greatly affected by the specification error of assuming independent observations (6). However, the significance of the coefficient estimates is often overstated by the naïve estimation.

This jack-knifed model reflects the usage of motorcycle compared with other mode alternatives, for persons who own motorcycles, for journeys made in the AM peak.

TABLE 2 Mode Choice Model Results

Variable description	Estimate	t-ratio
Terms on the Motorcycle Alternatives		
Journey Costs (pounds)	-0.1541	-7.2
Journey time (mins), for each min of Motorcycle journey < 20mins	0.0168	0.8
Journey time (mins), for each min of Motorcycle journey >20mins	-0.0053	-0.9
Parking walk time (mins), with no parking security	-0.0241	-4.7
Parking walk time (mins), with parking security	0	n/a
Monthly use, London & Metropolitan, Commute: 6-12 month users	2.2673	3.8
Monthly use, London & Metropolitan, Non-commute: 12 month users	1.7604	3.5
Monthly use, London & Metropolitan, Non-commute: 6-11 month users	0.865	1.6
Monthly use, "Other" Areas, Not commute or business: 12 month users	-0.7793	-1.9
Monthly use, "Other" Areas, Not commute or business: 6-11 month users	0	n/a
Legal to advance stop line access relative to no stop lines	0	n/a
Lanes wide enough for filtering relative to not wide enough	0.1647	4.6
Congestion, Heavy relative to free flowing	-0.2235	-4.5
Congestion, Mild relative to free flowing	-0.0468	-1.6
Dummy (SP), London & Metropolitan	-2.0892	-4
Dummy (SP), Commute	-0.654	-2.1
Dummy (SP), Over 60 years old	-0.9382	-3.9
Dummy (SP), Smart dress required	-0.4398	-1.7
Dummy (SP), Perceive risk of Motorcycle accidents in peak period	-0.7371	-2.9
Dummy (SP), Engine size > 900cc	0.4374	2.3
Dummy (RP), Non-business & non-commute	-1.5806	-2
Terms on the Car Alternatives		
Journey Costs (pounds)	-0.1541	-7.2
Journey time (mins)	-0.012	-2.1
Unpredictable delays relative to no unpredictable delays	0	n/a
Journey distance (miles), Commute	0.0376	2.5
Journey distance (miles), Non-Commute	0.0728	3.4
Parking walk time (mins)	-0.0298	-2.5
Weather, Light rain relative to pleasant	1.3323	4.2
Weather, Heavy rain relative to pleasant	2.519	8.2
Weather, Gusty winds relative to pleasant	1.1868	4
ASC on Car (SP)	-2.475	-4.2
Dummy (SP), Own 2+ Motorcycle	-0.6935	-2
ASC on Car (RP)	-0.0073	0
Terms on the Public Transport Alternatives		
Journey Costs (pounds)	-0.1541	-7.2
Journey time (mins)	-0.0055	-1.1
Unpredictable delays relative to no unpredictable delays	0	n/a
Journey distance (miles)	0	n/a
Weather, Light rain relative to pleasant	0	n/a
Weather, Heavy rain relative to pleasant	0.5775	2.9
Weather, Gusty winds relative to pleasant	-0.4245	-1.6
ASC on Public Transport (SP)	-1.2961	-2.4
ASC on Public Transport (RP)	-1.3761	-1.4
Dummy (SP), "Other" Areas, not commute or business	1.4807	1.6
Terms on the Bicycle Alternatives		
Journey time (mins)	0	n/a
Journey distance (miles)	-0.0647	-3.5
Weather, Light or Heavy rain relative to pleasant	-0.2475	-1.5
Weather, Gusty winds relative to pleasant	0	n/a
ASC on Bicycle (SP)	-0.2772	-0.8
ASC on Bicycle (RP)	0.1392	0.3
Neither Alternative - Motorcycle within-mode SP		

ASC on neither	-0.7769	-4.9
Dummy, Web respondents	0.3558	3.3
Neither Alternative - Car between-mode SP		
ASC on neither	-4.7207	-9
Dummy, Car web respondents	2.1721	5.4
Journey Distance (per mile)	-0.0522	-2.9
Neither Alternative - Public Transport between-mode SP		
ASC on neither	-2.5523	-2.9
Dummy, Public Transport web respondents	1.2956	2.3
Journey Distance (per mile)	-0.0522	-2.9
Neither Alternative - Bicycle between-mode SP		
ASC on neither	-1.4218	-1.7
Journey Distance (per mile)	-0.0522	-2.9
Scaling Parameters		
SP within-mode data relative to SP between-mode data	4.5964	5.9
RP data relative to SP between-mode data	0.4693	2.1
Motorcycle-Car	1	n/a
Motorcycle-Public Transport relative to Motorcycle-Car	1.3163	3.9
Motorcycle-Cycle relative to Motorcycle-Car	2.6178	2.8
Observations	4459	
Final log(likelihood)	-2520.6	
Degrees of freedom	50	
Rho²(0)	0.47	

INSIGHTS INTO THE MODE-CHOICE BEHAVIOUR OF MOTORCYCLISTS

The initial journey time term of the motorcycle utility was positive, suggesting that respondents enjoy time spent on their motorcycle. This is relative to negative journey time terms for all other modes. This is in line with findings from previous work in Australia (1), which also suggest that motorcyclists have greater enjoyment of all driven modes than non-motorcyclists. This is also clear when reviewing the remarks made by the respondents, which in general indicated that people use their motorcycle mainly because they enjoy it and in many cases it is much more convenient than other transport modes. Further investigation of this journey time parameter revealed that the enjoyment of the time spent on a motorcycle decreased as the journey distance increased. The valuation of the journey time by motorcycle is therefore represented by a piecewise linear function, with increases in time up to 20 minutes being valued positively, and then after 20 minutes additional increase in time are valued negatively.

The time spent walking from the parking location to the final destination is only valued negatively when there are no specific security measures available at the parking location. If there are security measures, then the walking time has no impact on the utility.

The motorcycle utility is strongly dependent on the number of months per year that a person uses their bike. This is to be expected, since it is a good indicator whether a person is a real 'die-hard' or a 'fair weather' user of his motorcycle. 'Die-hard' users are more strongly inclined to use their motorcycle. The effect is strongest for commuting in London and other metropolitan areas.

There is a negative impact on the motorcycle utility for travellers living in London and other metropolitan areas, relative to the "other" areas. It is possible (though not further investigated) that this is because of the higher risk of theft in these areas. This effect needs to be assessed in combination with the previous effect, since they cancel each other out in some cases.

Other terms show that people aged 60 and over are less likely to use their motorcycle, as are those that are commuting and people whose work dress code is smart. Those who perceive a higher accident risk in the morning peak than on the rest of the day are less likely to choose a motorcycle. Motorcycle owners with large motorcycles (>900cc) are more likely to choose to use the motorcycle alternative for the peak period journeys than those owning smaller motorcycles. In determining these effects a range of different model specifications were examined in order to determine the model specification that gave the best fit to the mode choice data available.

The RP data revealed a negative value attributed to a trip that was made for purposes other than commuting or business. This suggests that once all other effects have been accounted for, motorcycle is viewed less favourably for these purposes. These non-commuting and non-business trips will include journeys such as shopping and taking children to their place of education, so it is not entirely surprising that motorcycle is seen as less appropriate in such cases.

Journey time unreliability was presented only on the non-motorcycle alternative in the SP experiments so does not appear in the motorcycle utility. In the between-mode models it was not possible to estimate statistically significant terms for unreliability of car and public transport journey time. Congestion also affects motorcyclists (though less than car users), so they will also perceive unreliability as a consequence of increased congestion. This is quantified in the within-mode experiment where the traffic in the general motor vehicle lanes was described as "free flowing", "subject to mild congestion", and "subject to long stopped periods". We also see a positive coefficient on wide lanes that allow motorcyclists to filter, indicating both motorcycles become a more attractive proposition when the road layout makes this possible, and that motorcyclists are reluctant to filter when space is inadequate.

The weather coefficients have been applied to the non-motorcycle utilities. In the case of car, the coefficients clearly show that when the weather gets worse, the car becomes more attractive, as is to be expected. There is a striking difference between the weather coefficients for car and public transport. Light rain does not influence the choice between using a motorcycle and public transport. With gusty winds, motorcycles seem to be preferred over public transport (although this has a low level of significance): it may imply dissatisfaction for waiting for public transport during windy conditions. Only with heavy rain is public transport clearly preferred.

All of the bicycle utility terms are low in significance. This is due to the low number of respondents in this experiment. Those choosing between bicycle and motorcycle do not distinguish a difference between light and heavy rain: in both conditions motorcycle is deemed to be more attractive which may be related to the ability to wear weather resistant clothing on a motorcycle without any impairment of movement. Gusty winds are not found to be an important factor in Motorcycle-cycle choice, possibly as both modes are susceptible to gusty conditions and there may be no difference in benefit from using either of the two modes under consideration in such circumstances.

The scales relating to the SP within-mode data and the RP data act to control for differences in variance from the SP between-mode data. These demonstrate that the SP within-mode data has less variance than the SP between-mode data, and the RP data has more variance than the SP between-mode data. The scales relating to different mode combinations within the model indicate that the motorcycle-cycle utilities have less variance than the motorcycle-public transport ones, which in turn have less variance than the motorcycle-car ones. This suggests that there is greater cross-elasticity between motorcycle and bicycle than motorcycle and public transport, and greater cross-elasticity between motorcycle and public transport than motorcycle and car. These are both significant policy insights.

EXTENSIONS AND FURTHER RESEARCH

This study is limited to investigating the propensity of existing motorcycle owners to change their travel behaviour. Mode-switching to motorcycle by those that are not currently motorcyclists would require an ownership model that included travel quality variables as well as demographic variables.

In the ownership models, there is currently no linkage between motorcycle ownership and travel quality variables, such as increased congestion. It was not possible to easily obtain information on usual congestion levels for journeys made by travellers in the NTS or FES samples, and ideally the model would benefit from network accessibility information. It may be possible to investigate such a linkage in London where there may be enough motorcycle owning persons and where detailed information on journeys made is collected, such that travel conditions could be approximated. It would also be interesting to analyse the impact of the introduction of the London Congestion Charge on motorcycle ownership levels in the Greater London area.

Additional benefits may be obtained from incorporating retail prices into the motorcycle ownership models, rather than manufacturing prices. An attempt was made in this study, but the data did not become available during the project.

In the mode-choice component, the RP models currently rely on self-reported level of service information for the modes in the model. This was a practical approach as a survey was already being used to collect the SP data, however, practical restrictions make it difficult to collect data on more than two modes within such an instrument. Whilst the data collected has allowed RP information to be incorporated within the model and allows binary choice models for motorcycle against the next best mode, there could be potential benefits from estimating a model using network level of service (LOS) data. This would lift the practical restrictions of the existing survey and allow more modes to be considered. Combined with availability information, this would provide the basis for a simultaneous mode choice model covering all available modes. This would require a sample of respondents who used motorcycle for an AM peak period journey for whom the LOS for a range of available modes, including motorcycle, could be obtained.

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