# MODELLING ESCORT TRAVEL IN THE WEST MIDLANDS REGION OF THE UK

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5,250 words plus 9 tables/figures

## ABSTRACT

Most tour-based models do not represent escort travel separately. However, escort travel can account for 10% of trips, a fraction that has been growing in recent years. This paper describes how escort travel can be reflected in a tour-based model; we illustrate this through an application in the updated PRISM model for the West Midlands region of the UK.

School escort and other escort travel were recorded separately in the household interviews used to develop the new model, and interviewers were carefully briefed to ensure escort travel was recorded properly. Analysis of the West Midlands data demonstrates that escort travel is dominated by school escort travel, and consequently most escort travel is made at the start and end of the school day. Adults in households with children are more likely to make two school escort tours on a given school day than one, and this needs to be taken into account when modelling school escort frequency. As well as tours made purely to escort another household member, escort movements made as a detour during another tour are important, with more than half of outward detours made to escort. Thus to model escort travel properly within a tour-based framework, both escort tours and escort detours should be represented.

The tour-based modelling approach describes in this paper could be improved further by moving fully to an activity-based approach. The paper reviews some of the literature in this area and describes how these approaches would be applied to modelling escort travel.

## 1. INTRODUCTION

Most transport models consider the individual travellers as the decision-makers. This is logical and convenient for most trip purposes. Even if travelling jointly, the assumption that all travellers travel for the same purpose is generally not unreasonable. When using public transport, it does not actually matter that much whether the travellers travel in a group, and for car travellers joint travel is handled naturally if, in mode choice, car drivers and car passengers are distinguished (rather than approximating this choice by assumptions about car occupancy).

An exception is when people travel purely to accompany others. Whereas the main traveller's purpose may be obvious and may be explained by activity needs and land use, the accompanying person's travel purpose is escort, and their trip generation, mode and destination choice depend virtually solely on the other person's personal status and travel needs. This causes problems in

traditional transport models, and these escort trips are generally ignored or combined with the main traveller's purpose. However, as Ho and Mulley describe for Sydney (*1*), joint household travel can account for more than half of all home-based tours.

Further evidence for the need to reflect escort travel in forecasting models is that this purpose has been growing fast: according to the Great British National Travel Survey (NTS) only 5.4 per cent of all trips in 1975-76 were described as 'escort', whereas in 1988-91 11.8 per cent of all trips had this description (*2*). In addition, between 1975/76 and 2001/04 the share of car as the mode of transport for very short escort trips (under 1 mile) has increased from under a quarter to more than a third, whereas it has stayed constant for the longer trip lengths (*2*).

According to the NTS, in both 2006 and 2011 escort travel (excluding escort to school) was estimated to comprise around 10% of trips and 7% of total mileage (all modes). Since 1995/97, cars taking children to school (escort education trips) have increased as a proportion of all car driver trips in the morning peak hour (8-9am) from 10% to 16%, with the 'school run' now accounting for nearly a quarter (24%) of car driver trips by residents of urban areas during term time (*3*). Of all escort education trips, 72% were followed by a trip to home, 8% were followed by a trip to work or business, 8% were followed by another escort trip and the remaining 12% were followed by a trip for education, shopping, personal business, visit friends or other leisure purposes (*4*). Thus the majority of escort trips are made by individuals who travel purely to escort, rather than by individuals who make a detour while travelling somewhere else. Females tend to make more escort education trips per year than males (66 compared to 27) (*3*).

Of course, joint travel (including escort trips) is described naturally in an activity-based framework. Vovsha *et al.* set a benchmark (*5*), referring to even earlier work by, for example, Fuji *et al.* (*6*) and Chandrasekharan and Goulias (*7*). Later work includes that by Bhat and Pendyala (*8*), Bradley and Vovsha (*9*), Ho and Mulley (*10*), Roorda *et al.* (*11*), Roorda *et al.* (*12*), Vovsha and Petersen (*13*), Yagi *et al.* (*14*) and Yarlagadda and Srinivasan (*15*). However, there are few examples where escort trips have been incorporated separately in an more traditional tour-based travel demand model that is operational.

Vovsha and Petersen (*13*) describe the development of a school escort model for Atlanta, Georgia for implementation within an activity-based framework. They divided school tours into outbound and inbound half tours, and then for each half tour modelled the choice between three different alternatives:

- Ridesharing with one of the household drivers who also makes a mandatory tour for work, university or school purposes.
- Pure escort by one of the household drivers who does not have any mandatory activity on the tour.
- No escort, where the child travels to or from school alone, or is escorted by someone who is not a member of the household.

The model is applied after mandatory activities have been generated, but before mode choice for mandatory activities, and also before generation, location and scheduling of non-mandatory activities. This structure allows the impact of escort duties on mode choice decisions to be represented, for example if a worker has to take a child to school this increases the probability that they will drive rather than use public transport.

PRISM is a tour-based model for the West Midlands region of the UK that was originally developed between 2002 and 2004 (*16*). PRISM in not a bespoke model. Instead it was developed drawing upon over two decades of experience that RAND Europe have in the development and application of large-scale disaggregate model systems, gained from studies in The Netherlands, Norway, Paris, Stockholm, Copenhagen and Sydney (*17*).

The PRISM model is currently being extensively updated using new survey data. In the context of the growing importance of escort travel, it was decided when updating the PRISM demand model to record escort travel separately in the travel surveys so that a separate 'escort' purpose could be reflected in the tour frequency, mode and destination choice components. This paper describes the

data collection strategy, and the approach used to model escort trips as a separate purpose in the demand model. While the approach described is specific to the PRISM model, the insights provided about the nature of escort travel, and the socio-economic factors that impact upon it, are useful for the developers of other tour-based and/or activity-based model systems.

## 2. DATA COLLECTION

A survey of around 5,000 households was collected in the West Midlands. The sample was geographically stratified at ward level proportional to the number of households. Households were identified using the random walk method. From the outset and in design trip under-reporting bias was kept in mind - in particular any under-reporting of the 'escort to education' trips. Beside interviewers' skills and integrity in collecting accurate trip data, there were some further factors related to survey design and conduct leading to under-reporting and potentially erroneous trip data. Therefore both the interviewers and respondents were managed through a quality control mechanism that sought to minimise the propensities to under-report trip making, falsely categorise trips or erroneously record trip attributes.

The study team's experience is that unless the survey, as part of its design, classifies 'education escort' trips, 'escort other' trips and 'other' trip purposes separately, the survey will lose 'education escort' trips, collapsing them into the category of 'other'. 'Education escort' trips for children below and above the age of five require separate consideration, as in general travel made by children under five is not recorded in household surveys.

For example, where a parent escorts a child aged five and above by car to school en-route to his/her work destination, the interviewer has to record three trips, a trip by the child from home to school and for the parent a trip with escort for education purpose from home to school and a non-home-based trip from school to work. In addition, it is often the same parent or their partner who escorts the child back from school to home. In the case of a trip for a child aged five and above, the interviewer has to record again a separate trip for the child as a person with the mode of travel being 'car passenger'. Here the risk is that an interviewer would find it easier to record one trip for the parent; home to work by car and for the child home to education by mode 'walk'. Also the interviewer would tend to save time, and would not record the parent's return from work to education escort trip. Such rogue records result in two types of errors, firstly underreporting of trips and secondly the incorrect mode used for education trips.

In order to minimise such under-reporting of escort trip categories, in the PRISM household survey design, the escort trips were categorised separately by 'escort to education' and 'escort other' purposes. The 'escort to education' was then subdivided into two separate categories 'escort to school' and 'escort from school'. This subdivision in term helped to eradicate the interviewers' propensity to copy the outbound 'escort to education' trip to 'escort from education' trip. And of course it is known that in some cases the 'escort from education' to home is not made by the same mode or even person as the trip 'escort to education'.

The following section discusses the key quality control tools, survey instruments and protocols which were implemented to avoid trip under-reporting.

1. Extensive training of interviewers on the subject of transport planning and modelling.
2. Use of advanced technology in the conduct of the surveys.
3. Survey instruments (use of Memory Jogger).
4. Survey instruments (use of Family Travel Story Sheet).

*Interviewers' Training*

All interviewers received an extensive three day training course, focused on trip generation and demand forecasting modelling. In addition interviewers were also given training on the end-use of the data collected, to instil a full understanding of how inaccuracy in capturing trip information leads to problems downstream and ultimately unreliable models.

*Use of Advanced Technology*

The surveys were conducted using the CAPI method using handheld palmtop PDA (Personal Digital Assistant) devices. The survey software was designed with embedded logic control to accurately record the number of trips per person without missing any trip attribute information.

*Survey Instruments - Use of Memory Jogger*

Each household member was given a Memory Jogger with a pictorial illustration of a typical person's one day travel, as an example, which helped the respondent to understand the concept of a trip and the difference between a tour, a journey and a trip.

*Survey Instruments - Use of Family Travel Story Sheet*

After an initial briefing with the household, the interviewer established and input the family travel story for the previous weekday, ensuring at a coarse level how each family member travelled to and from activities, such as work, school, shopping, leisure and other places. This assisted the interviewer a) to obtain an accurate number of trips each person made and b) to establish accompanied and escort trips.

This process ensured that no trips were missed out and that the interviewer already understood and had recorded the travel story of the family before completing the more detailed and time-consuming travel diary section. The author's experience is that often trip under-reporting occurs because of fatigue during trip recording. The length of the survey and the perceived complexity of recording trip details can influence the current but also other, waiting household members to underreport trips, or in extreme cases withdraw from the survey. This is not possible with the Family Travel Story Sheet, as the overall number of trips by each family member has already been identified and logged.

In order to deal with the potential trip under reporting related to escorting children under five to education, the interviewer also determined up-front whether a child was at nursery or not.

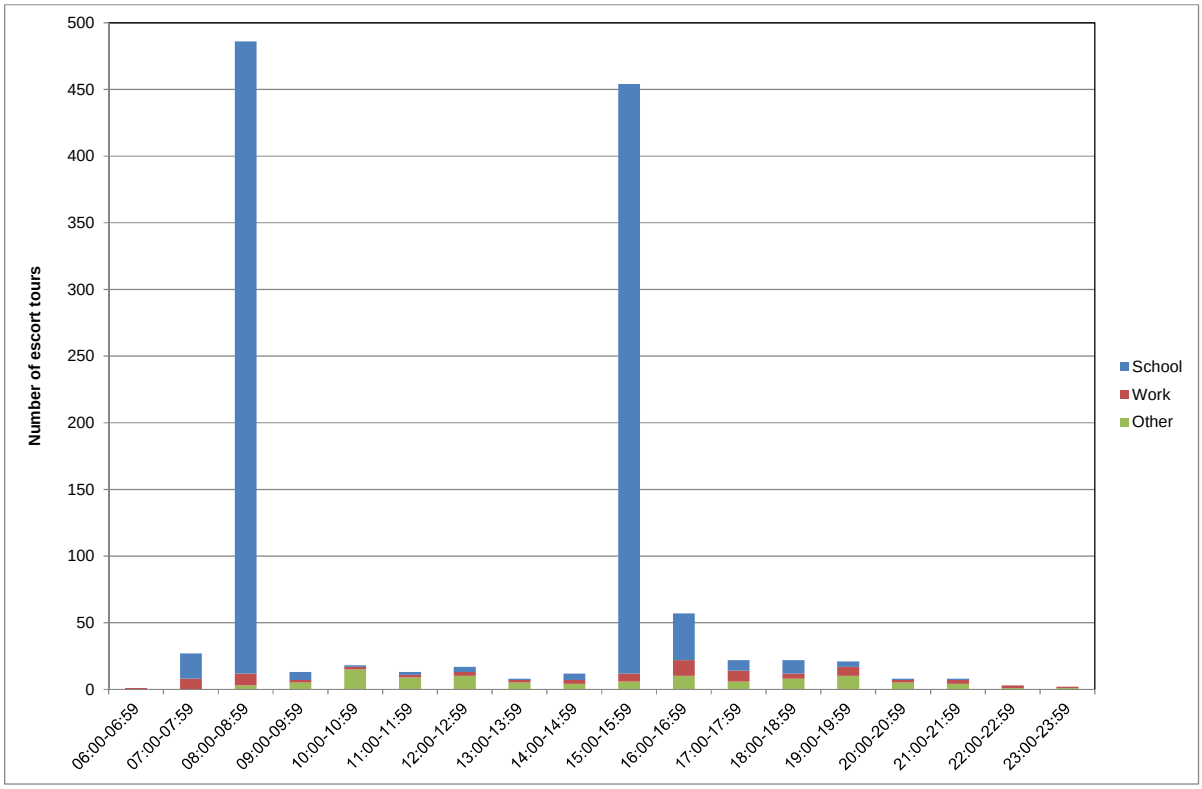
## 3. REPRESENTING ESCORT TRAVEL

### 3.1 Analysis of escort travel

Analysis was undertaken to examine the characteristics of the escort trips recorded in the HI data to inform the modelling approach. The travel recorded in the HI data has been built into *home-based tours*, which are series of linked trips starting and finishing at the individual's home. A total of 13,960 tours were observed in the HI data, of which 1,779 (12.7%) were escort tours.

Of the 1,779 escort tours recorded in the HI, 1,013 (56.9%) could be associated a tour made by another member of the same household with exactly the same trip timings, and for these tours this enabled the purpose of the tour being escorted to be determined. For these 1,013 tours FIGURE 1 plots the number of tours made by time of day and the purpose of the tour being escorted.

**FIGURE 1 Escort tours by time of day and purpose**




It is clear from FIGURE 1 that the great majority of escort tours are school escort tours, and consequently most escort tours are made between 08:00–08:59 and 15:00–15:59 when children are travelling to and from school. Escort tours for work and other purposes are more spread out during the day, but far fewer of these tours are made.

Given that the probability of an adult making a school escort tour will be strongly influenced by the presence of children in the household, it was decided to model escort travel frequency separately for school escort and other escort tours. TABLE 1 presents a summary of the number of escort tours made per weekday for adults in the HI sample.

**TABLE 1 Escort tours made per weekday**

| Number of tours | School escort tours, adults in households with at least one child | | Other escort tours, all adults | |
|---|---|---|---|---|
| 0 | 3,512 | 80.3% | 10,570 | 97.8% |
| 1 | 345 | 7.9% | 191 | 1.8% |
| 2 | 460 | 10.5% | 45 | 0.4% |
| 3 | 49 | 1.1% | 6 | 0.1% |
| 4 | 8 | 0.2% | 1 | 0.0% |
| Total | 4,374 | 100.0% | 10,813 | 100.0% |

The standard approach we adopt for modelling tour frequency is to estimate two linked models, a zero/one-plus model to model the decision to make at least one tour, which represents the decision to participate in an activity, and a stop/go model to model the probability of making multiple tours, which represents how that activity participation is organised (*18*). This structure assumes the probability of making two tours will be considerably lower than the probability of making one tour, the probability of making three tours will be considerably lower than making two tours, and so on. It

can be seen from TABLE 1 that this structure exists in the other escort data. However, for school escort travel adults are more likely to make 2 tours than 1 tour, reflecting the fact that if a parent drops off a child at school in the morning they are likely to pick them up in the afternoon as well. Therefore a modified structure was used to represent travel frequency for school escort tours, with one model representing the choice between zero, one and two-plus tours, and a second model used to represent the probability of making multiple tours given that at least two tours are made.

In an activity-based approach, joint travel is typically represented explicitly taking account of timing and car availability constraints, whereas in the tour-based approach escort tours are modelled independently from the tours that are being escorted. Thus moving to a fully activity-based approach would give an improved representation of escort travel frequency.

TABLE 2 presents analysis showing the mode shares for school escort and other escort tours. It can be seen that for school escort tours, walk has the largest share, whereas the clear majority of other escort tours are made by car driver.

**TABLE 2 Escort tour mode shares**

| Mode | School escort tours | | Other escort tours | |
|---|---|---|---|---|
| Car driver | 544 | 36.8% | 248 | 82.7% |
| Car passenger | 34 | 2.3% | 18 | 6.0% |
| Bus | 62 | 4.2% | 4 | 1.3% |
| Cycle | 4 | 0.3% | 0 | 0.0% |
| Walk | 833 | 56.3% | 27 | 9.0% |
| Other | 2 | 0.1% | 3 | 1.0% |
| Total | 1,479 | 100.0% | 300 | 100.0% |

In addition to tours where the purpose is escort, a significant number of escort trips are made as detours as part of another tour, for example where a parent drops a child off at school on their way to work. TABLE 3 presents a cross-tabulation between the home-based tour purpose and the detour purpose for detours made during the outward legs of home-based tours.

**TABLE 3 Detours made during the outward legs of home-based tours**

| | | Detour purpose | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Work | Not usual workplace | Bus. | Educ. | Shop | Escort | Other | Total |
| Tour purpose | Work | 14<br>3.6% | 14<br>3.6% | 9<br>2.3% | 6<br>1.5% | 9<br>2.3% | 284<br>72.1% | 58<br>14.7% | 394<br>100.0% |
| | Not usual workplace | 0<br>0.0% | 25<br>61.0% | 0<br>0.0% | 0<br>0.0% | 1<br>2.4% | 11<br>26.8% | 4<br>9.8% | 41<br>100.0% |
| | Bus. | 0<br>0.0% | 0<br>0.0% | 7<br>53.8% | 0<br>0.0% | 1<br>7.7% | 3<br>23.1% | 2<br>15.4% | 13<br>100.0% |
| | Educ. | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 12<br>16.0% | 3<br>4.0% | 39<br>52.0% | 21<br>28.0% | 75<br>100.0% |
| | Shop | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 35<br>23.3% | 65<br>43.3% | 50<br>33.3% | 150<br>100.0% |
| | Escort | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 5<br>7.6% | 51<br>77.3% | 10<br>15.2% | 66<br>100.0% |
| | Other | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 0<br>0.0% | 62<br>26.3% | 60<br>25.4% | 114<br>48.3% | 236<br>100.0% |
| | Total | 14<br>1.4% | 39<br>4.0% | 16<br>1.6% | 18<br>1.8% | 116<br>11.9% | 513<br>52.6% | 259<br>26.6% | 975<br>100.0% |

Overall, more than half (52.6%) of outward detours are made to escort someone, and for commute tours nearly three-quarters (72.1%) of outward detours are made to escort someone. Thus a

significant fraction of the detours modelled in the new version of PRISM are escort detours and there is no reason to suspect this is different elsewhere.

### 3.2 Modelling escort travel

As discussed in Section 3.1, separate frequency models were developed for school escort and other escort tours, and a different model structure was used in the school escort model to take account of the fact that adults in households with children are more likely to make two school escort tours than one.

Two school escort frequency submodels were developed. The first submodel predicts the multinomial choice between zero tours, one tour and two-plus tours alternatives with two-plus tours specified as the base alternative with a utility of zero. The second submodel predicts the binary choice between 'stop and 'go' alternatives to represent whether an individual makes 2, 3 or 4 tours, with utility terms placed on the 'stop' alternative. The model structure is illustrated in FIGURE 2.

**FIGURE 2 School escort frequency model structure**

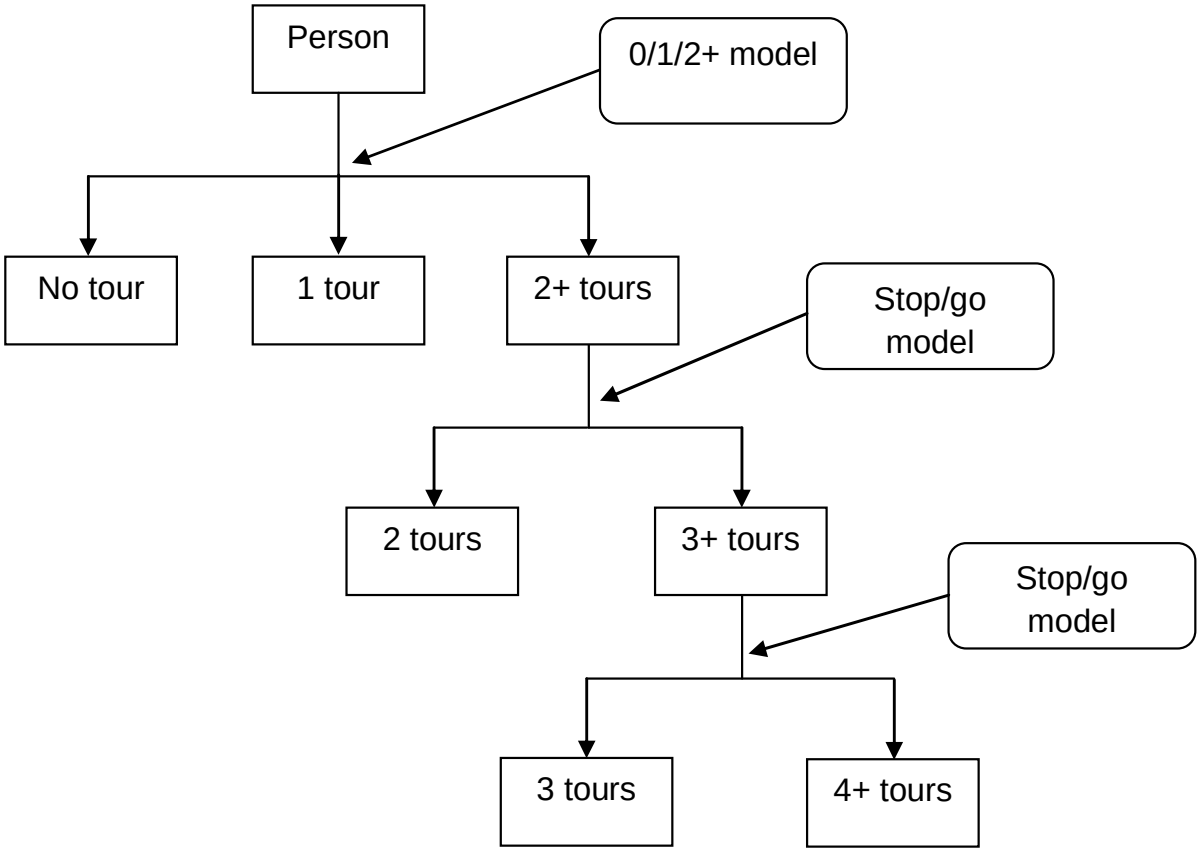



TABLE 4 summarises the model parameters identified in the final model. The signs in TABLE 4 indicate whether the parameter implies the alternative is more likely to be chosen (positive) or less likely to be chosen (negative), and the t-ratios of the parameter estimates are given in parentheses. A t-ratio of 1.96 and above indicates that the parameter is statistically significant at a 95% confidence level.

The accessibility term uses a logsum from the escort mode-destination model. The logsums capture variation in accessibility between different home zones, and between different mode-destination segments, specifically car availability and presence of children in the household.

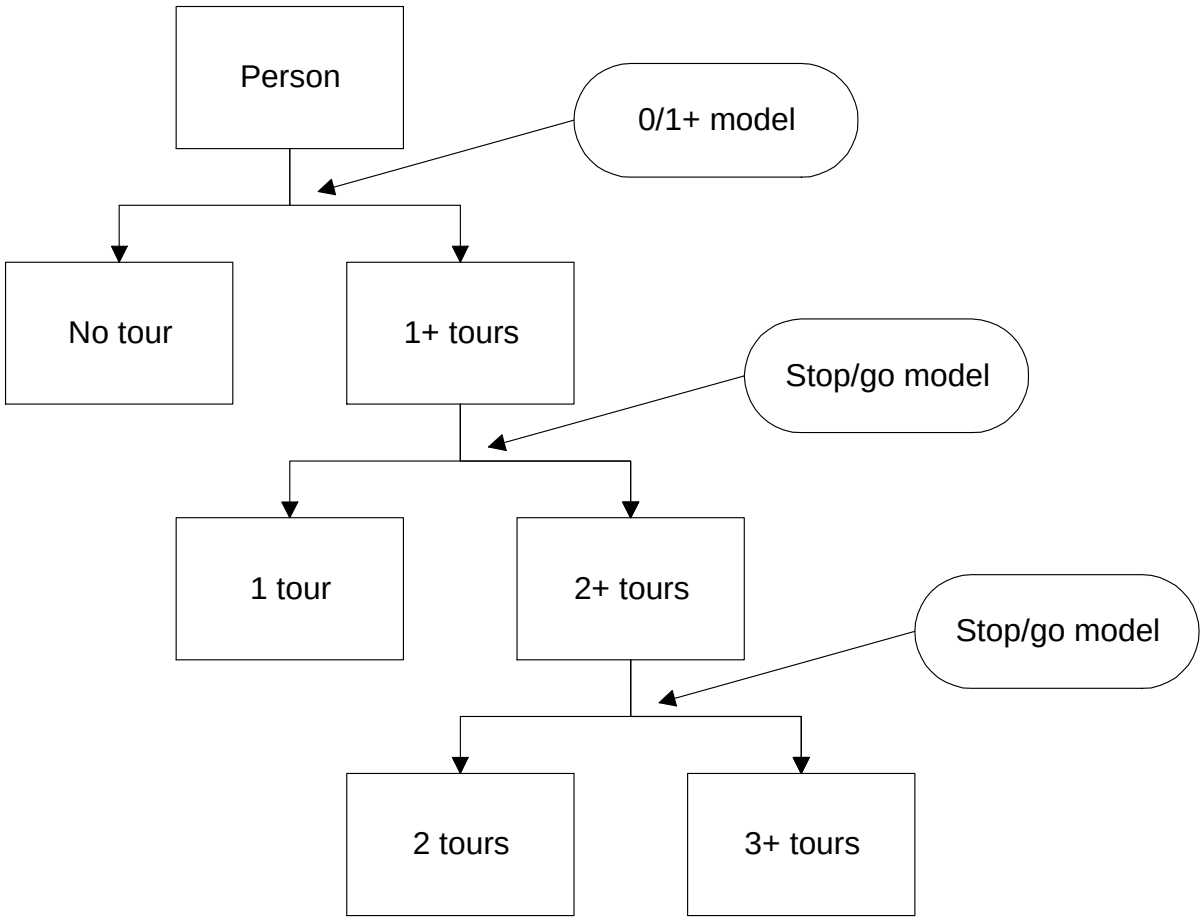
Unsurprisingly the terms that have the strongest impact on the school escort frequency model are the number of children in household terms which is therefore key to predicting school escort travel frequency.

**TABLE 4 School escort frequency model terms**

| Zero/one/two-plus tours model | | | | Stop/go model | | Definition |
|---|---|---|---|---|---|---|
| Zero tours alternative | | One tour alternative | | Stop alternative | | |
| 1.438 | (9.3) | | | | | Full-time workers more likely to make zero tours than other adult status groups |
| -0.671 | (-4.7) | | | | | Unemployed persons make more tours than any other adult status group except looking after family |
| 1.147 | (3.1) | | | | | Retired persons make fewer tours than any other status group except full-time workers |
| -0.929 | (-6.9) | | | | | Persons looking after the family are more likely to make tours than any other adult status group |
| -0.761 | (-7.3) | | | | | Females make more tours than males |
| -0.973 | (-9.1) | | | -2.389 | (-2.3) | Individuals in households with 2 children make more tours than those in households with 1 child |
| -1.456 | (-11.4) | | | -2.671 | (-2.6) | Individuals in households with 3 children make more tours than those in households with 1 or 2 children |
| -1.691 | (-10.2) | | | -3.283 | (-3.2) | Individuals in households with 4-plus children make more tours than those in households with 1, 2 or 3 children |
| 1.576 | (8.5) | | | | | Individuals aged 17-24 make fewer tours than those aged 25 and above |
| -0.639 | (-2.5) | | | | | Individuals aged 30-39 make more tours than those aged 25-29 and 40-plus |
| -0.395 | (-4.3) | | | | | Individuals from households with incomes under £25k p.a. make more tours than those from households with incomes of £25k p.a. and above |
| -0.351 | (-3.9) | | | -0.639 | (-2.5) | Individuals with higher accessibility more likely to make tours |
| 5.796 | (7.9) | | | | | Constant on zero tours alternative |
| | | 0.691 | (3.7) | | | Full-time workers make more single tours than other status groups, e.g. they drop off the child in the morning but do not pick them up again in the afternoon |
| | | -0.729 | (-4.4) | | | Persons looking after the family are less likely to make one escort tour than other adult status groups, most likely because they can make escort tours in both the morning and afternoon |
| | | -0.315 | (-3.1) | | | Constant on one tour alternative |
| | | | | 9.520 | (4.3) | Constant on stop alternative |

The first other escort frequency submodel predicts the binary choice between zero tours and one tour alternatives with the zero tours alternative specified as the base alternative with a utility of zero. The second submodel predicts the choice between ‘stop and ‘go’ alternatives to represent whether an individual makes 2, 3 or 4 tours, with utility terms placed on the ‘stop’ alternative. The model structure is illustrated in FIGURE 3.

**FIGURE 3 Other escort frequency model structure**




It is noted that there is an additional branch in the stop/go model for the 3 versus 4+ tours choice because as highlighted in TABLE 1 one individual was observed to make 4 other escort tours on the survey day.

TABLE 5 summarises the parameters in the other escort frequency model. Again the signs indicate whether the term implies the alternative is more likely to be chosen (positive) or less likely to be chosen (negative) and t-ratios are given in parentheses.

**TABLE 5 Other escort frequency model terms**

| Zero/one-plus model | | Stop/go model | | Definition |
|---|---|---|---|---|
| Zero tour alternative | | Stop alternative | | |
| 1.328 | (1.8) | | | Full-time students make fewer tours than other status groups |
| -0.837 | (-3.5) | | | Persons looking after the home make more tours than other status groups |
| 0.650 | (4.4) | | | Females make fewer tours than males |
| -0.959 | (-5.3) | | | Individuals aged 40 to 49 make more tours than individuals aged under 40 |
| -1.117 | (-6.3) | | | Individuals aged 50 and above more tours than individuals aged under 50 |
| -0.389 | (-5.9) | -0.191 | (-1.2) | Individuals with higher accessibility more likely to make tours |
| 6.912 | (13.4) | | | Constant on zero tours alternative |
| | | 2.783 | (2.4) | Constant on stop alternative |

The variation in other escort frequency with the number of children in the household was investigated, but no significant terms were identified. It is interesting to contrast the terms in the model with those in the school escort model presented in TABLE 4. Females make more school escort tours, but fewer other escort tours, relative to males. For school escort travel, the highest frequency rates are observed for adults aged 30-39, the age at which adults are most likely to have children of school age. However, for other escort travel the highest tour frequency rates are observed for persons aged 50 and above, most likely because a fraction of these individuals will be fully or semi-retired and so will have more time available to escort other household members.

A single mode-destination model was developed to model both school escort and other escort tours. Four modes were represented: car driver (CD), car passenger (CP), bus (BS) and walk (WK). To take account of the different destinations that escort tours serve, multiple size variables were used to represent the attractiveness of different destination locations, with total employment used to provide a measure of attractiveness for escort work tours, primary and secondary enrolments used to provide a measure of attractiveness for escort education tours, and population used to provide a measure of attractiveness for escort other tours. The model parameters are summarised in TABLE 6, t-ratios are also given.

**TABLE 6 Escort travel mode-destination model**

| Coefficent | Description | Modes | Value | t-ratio |
|---|---|---|---|---|
| *Cost parameters:* | | | | |
| GCost | Gamma cost parameter | CD, BS | -0.014 | -8.0 |
| *Level of service parameters:* | | | | |
| CarTime | Car time | CD, CP | -0.076 | -10.4 |
| BsGTime | Generalised bus time | BS | -0.034 | -7.7 |
| WalkDist | Walk distance | WK | -0.515 | -26.4 |
| *Socio-economic parameters:* | | | | |
| OneCarComp | Competition for car, 1 car in HH | CD | -1.833 | -4.4 |
| PassOpt | Passenger opportunity term | CP | 1.527 | 1.8 |
| BusNoCar | No car constant on bus | BS | 3.501 | 3.9 |
| BusFemale | Female constant on bus | BS | 2.891 | 2.7 |
| HHchild | Constant on walk for HHs with children | WK | 5.276 | 4.6 |
| *Mode constants:* | | | | |
| CarP | Car passenger (relative to car driver) | CP | -6.400 | -5.5 |
| Bus | Bus (relative to car driver) | BS | -4.018 | -3.0 |
| Walk | Walk (relative to car driver) | WK | -1.114 | -1.2 |
| *Time period constants for car driver:* | | | | |
| TP_11 | Out AM peak, return AM peak | CD | 3.456 | 5.9 |
| TP_12 | Out AM peak, return inter-peak | CD | -3.357 | -3.7 |
| TP_13 | Out AM peak, return PM peak | CD | -6.085 | -3.8 |
| TP_14 | Out AM peak, return off-peak | CD | 0.000 | n/a |
| TP_22 | Out inter-peak, return inter-peak | CD | 2.355 | 5.0 |
| TP_23 | Out inter-peak, return PM peak | CD | 1.456 | 3.6 |
| TP_24 | Out inter-peak, return off-peak | CD | -6.221 | -3.9 |
| TP_33 | Out PM peak, return PM peak | CD | 1.809 | 4.3 |
| TP_34 | Out PM peak, return off-peak | CD | -2.279 | -3.4 |
| TP_41 | Out off-peak, return AM peak | CD | -7.044 | -3.7 |
| TP_42 | Out off-peak, return inter-peak (never chosen) | CD | 0.000 | n/a |
| TP_43 | Out off-peak, return PM peak (never chosen) | CD | 0.000 | n/a |
| TP_44 | Out off-peak, return off-peak (base combin.) | CD | 0.000 | n/a |
| *Destination constants:* | | | | |
| CarPIZ | Car passenger intrazonal constant | CP | 2.205 | 5.1 |
| WalkIZ | Walk intrazonal constant | WK | 0.915 | 8.2 |
| CBDDest | CBD destination constant | all | 0.188 | 2.1 |
| CBDBus | CBD bus constant | BS | -0.869 | -2.1 |
| *Attraction variable:* | | | | |
| L_S_M | Log-size multiplier | all | 1.000 | n/a |
| Size_Pop | Population size parameter | all | 0.255 | n/a |
| Size_Prim | Primary enrolments size parameter | all | 29.639 | n/a |
| Size_Sec | Secondary enrolments size parameter | all | 7.121 | n/a |
| *Structural parameters:* | | | | |
| TR_M_TP | Relative sensitivity of modes and time periods | n/a | 1.000 | n/a |
| TR_TP_D | Relative sensitivity of time periods and dest.s | n/a | 0.471 | 7.1 |

The cost parameter in the model uses a 'gamma cost' formulation. This formulation is used to achieve acceptable elasticity values and model fit. Our experience is that a pure log-cost formulation typically gives a better fit to the data than a pure linear-cost formulation, but a log-cost formulation results in unacceptably low destination choice elasticities. The gamma cost form introduces a weighted mixture of linear and log-cost effects to give more realistic destination choice elasticities (*19*).

The car competition term for one car households reflects the fact that car driver is less likely to be chosen in households where there are two or more licence holders but only one car. The passenger opportunity term reflects the fact that car passenger is more likely to be chosen if the household owns a car and contains at least one other licence holder so that the individual can be driven by another household member. Finally a constant for bus accounts for higher use of bus for escorting in zero car households.

To take account of the significantly higher use of walk for school escort tours highlighted in TABLE 2, the positive 'HHchild' constant was added to the walk mode that is applied for adults from households with at least one child.

The size parameters are shown in the 'attraction variable' section. Total employment is the base size variable, and the attractiveness of the other size variables is defined relative to the base size variable. The parameter values demonstrate that the enrolment variables have the strongest effect by far, consistent with the dominance of school escort tours illustrated in FIGURE 1. Primary enrolments have a greater impact than secondary enrolments, reflecting that primary aged children are more likely to be escorted to and/or from school.

The structural parameters indicate the relative sensitivity of the three choices represented in the model, namely modes, time periods for car drivers only, and destinations. In the final model structure modes and time period alternatives are represented together at the upper level (less sensitive), whereas destinations are represented at the lower level (more sensitive).

The constants for car driver time period choice have large positive values for combinations where the outward and return time period is equal. This is because escort tours are short compared to other tour types, for example if an individual escorts their child to school and travels out in the AM peak it is likely that they will return home in the AM peak as well.

In contrast to the frequency models, the mode-destination models are similar to the models used in activity-based approaches to model mode and destination choice. Modelling escort travel separately represents a significant improvement relative to the previous version of PRISM, where escort travel was not recorded separately in the survey data, and was therefore modelled as part of the other travel purposes. However, there are a number of ways in which the modelling of escort travel could be improved further.

In PRISM, tours made by different individuals in a household are modelled independently, and, for a given individual, tours made by different travel purposes are also modelled independently. As discussed, the escort frequency models that have been developed take account of the fact that the probability that an adult makes a school escort tour increases as the number of children in the household increases, but there is no explicit linkage that identifies that a child needs escorting to school, and one of the adults in the household needs to make an escort tour. Similarly, there is no representation of the impact of escorting responsibilities on mode choice for other tours. If an activity-based model were to be developed, then these interactions would be explicitly represented by modelling the choice of activity pattern. For households where all adults are workers, these activity patterns could include alternatives where one adult escorts the child to school in the morning and another adults picks them up again in the afternoon. The models Vovsha and Petersen developed for Atlanta, Georgia (*13*) allow activity patterns of this type to be developed.

## 4. SUMMARY AND RECOMMENDATIONS

Escort travel can account for more than 10% of tours, and more than half of detours made in the course of a tour to another location, and the percentage of trips that are made for escort has increased in recent years. However, in most tour-based models, escort travel is not represented separately and so these important contributions to travel demand are not modelled properly.

To better model escort travel, a carefully designed survey is required which records escort travel separately, and distinguishes between school escort and other escort travel. It is also important to brief interviewers carefully so that they understand the importance of recording escort travel, particularly when it is made as a detour during a journey to another destination.

Analysis of the escort travel made in the West Midlands region in the UK demonstrates that it is dominated by escort of children to and from school. In the morning, most escort to school travel takes place between 08:00 and 09:00 which coincides with the peak for travel to work, and therefore represented escort travel separately allows a more accurate representation of travel demand in the peak periods.

The frequency of school escort tour making has a distinct pattern, with adults in households with children more likely to make two school escort tours on a given school day than one. It is important to take account of this pattern when modelling the frequency of school escort tour making. Unsurprisingly the key driver of school escort travel making is the number of children in the household and school escort travel models should be segmented accordingly.

In addition to tours made purely to escort another household member, significant volumes of escort travel take place as detours during tours made to another location. More than half of detours made on the outward legs of home-based tours are made to escort another household member, and for home-work tours where the outward leg is often made at the same time as children are travelling to school three-quarters of detours are made for escort purposes. Thus as well as modelling a separate escort tour purpose, detours made during other home-based tours should be represented to model escort travel properly.

The approach described in this paper shows how escort travel can be incorporated naturally in a tour-based model, when allowing for determining variables such as household structure and the presence of children. Of course, it could be improved further by moving to a fully activity-based approach where activity patterns and joint travel would be explicitly modelled taking account of timing constraints of different household members. A valuable research exercise would be to develop an activity based approach to tour and detour frequency using the PRISM household interview data, and combine this with the existing PRISM mode-destination models. This would allow investigation of the benefits that activity-based models offer relative to an advanced tour-based model such as PRISM.

## ACKNOWLEDGEMENTS

The PRISM West Midlands model is owned by the seven West Midlands Metropolitan Local Authorities, the Highways Agency and CENTRO. It is developed, maintained and operated by Mott MacDonald and RAND Europe. We are grateful to the PRISM Management Group for their permission to publish this paper. We are also grateful for comments on the paper from Roger Himlin of the UK Highways Agency. The authors take full responsibility for any errors or omissions.

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