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Model of Travel in London Phase 3: Frequency model estimation

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Preface

RAND Europe, working in collaboration with Jacobs and SYSTRA, has been commissioned by Transport for London (TfL) to deliver the third phase of work to develop a new strategic travel model for London, termed the Model of Travel in London (MoTiON). MoTiON will be used by TfL to develop strategic land use and transport policy scenarios to assist with prioritisation and to support the case for sustained investment of billions of pounds in London's transport systems.

Jacobs is the lead consultant managing the overall delivery of the project and is in charge of tasks associated with the implementation of the final model and the integration of TfL assignment models. SYSTRA was responsible for calibration and testing of the resulting model as well as delivering runtime improvements, and Mott MacDonald provided an ongoing peer review role. RAND Europe was responsible for tasks relating to the scoping and delivery of work to update and enhance the frequency and mode-destination models.

This report documents the development of frequency models for MoTiON Phase 3. While most of the model development work was undertaken during the earlier Phase 1, this report has been written to provide stand-alone documentation of the final frequency models. The primary audience for this report is TfL; however, it may be of wider interest for transport researchers and transport planners involved in demand forecasting and strategic planning. The report is aimed at audiences familiar with travel demand modelling.

One other RAND Europe report has been produced as part of MoTiON Phase 3, documenting the development of the mode and destination models.

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Summary

This report documents the development of the frequency models for TfL's Model of Travel in London (MoTiON).

Model development

The frequency models were originally estimated during the first phase of model development (Jahanshahi et.al, 2017). In Phase 3, the models were updated to reflect more recent data and a change in the definition of the travel day. The Phase 1 models were estimated from London Travel Diary Survey (LTDS) data collected in 2010–2012 and the frequency of travel was represented for an average weekday. In Phase 3 more recent LTDS data representing UK financial years 2015/16–2017/18 was used to estimate the models and the travel day definition was changed to an average weekday during school term time to better represent the peak levels of demand on London's highway and public transport networks.

The model structure remains unchanged since the Phase 1 work, using two linked sub-models: the first quantifies the probability of an individual making a tour[1] on a given day, and conditional on the individual making one tour the second model estimates the number of tours made.

Further analysis was undertaken to understand the impact of the two changes that were introduced in Phase 3. Moving to a school term day led to a substantial increase in tour rate for those travelling for primary education, secondary education and school escort purposes. We also observed a decline in the weekday school term time tour rate during the five-year period from Phase 1 to Phase 3 for the majority of purposes. The extent of decline is largest for shopping and is consistent across all population segments that influence shopping travel.

Model results

The model specifications remained largely unchanged from Phase 1. Where changes were introduced they were confined to the income segments so that they aligned with the income segmentations in the mode-destination models. Counter-intuitive or insignificant terms were also dropped from the model.

[1] A tour is a series of two trips: the first starts at home and the second ends at home.

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Abbreviations

FT	Full-time
FY	Financial Year
HB	Home-Based
HH	Households
LTDS	London Travel Diary Survey
MoTiON	Model of Travel in London
NTEM	National Trip End Model
NTS	National Travel Survey
NHB	Non-Home-Based
PD	Primary Destination
PT	Part-time
SD	Secondary Destination
TfL	Transport for London

Acknowledgements

We would like to acknowledge the input of Transport for London, who funded the model development work and have provided ongoing constructive feedback throughout Phase 3 of the project. We would also like to thank our collaborators in the development of MoTiON: Jacobs and SYSTRA. Finally, we are grateful for the quality assurance comments provided by Charlene Rohr and Dr Hui Lu of RAND Europe, Andrew Gordon of Andrew Gordon Consulting Limited and David Christie, Tim Price and Teye Collins of Transport for London. We emphasise, however, that any errors or omissions herein remain the responsibility of project team.

1. Introduction

1.1. MoTiON Phase 3

Transport for London (TfL) has developed a new transport demand model for London in partnership with a consortium led by Jacobs and supported by SYSTRA, Mott MacDonald and RAND Europe. The model is now called MoTiON (Model of Travel in London) and has been subject to demonstration testing.

In the third phase of work, referred to as MoTiON Phase 3, the consortium has worked to deliver a set of improvements to the model including quicker runtimes, updating its base year to 2016/17 and replacing the public transport assignment model (moving from Cube to the EMME-based Railplan model). A key feature of Phase 3 is the integration of work from the Estimating Demand from Mobile Network Data (EDMOND) Project recently completed by TfL.

The overall objective is to deliver an improved 2016/17 base year version of MoTiON in order to migrate TfL projects across from LTS and consolidate TfL's strategic demand modelling in MoTiON and public transport modelling in Railplan.

1.2. Development of frequency models

The frequency models were originally estimated during the Phase 1 development project work (Jahanshahi et al. 2017). Travel frequency is modelled through two linked sub-models that predict the total amount of travel an individual makes on an average weekday. The first sub-model predicts the probability that an individual makes any travel and the second sub-model predicts the amount of travel if the individual travels at all. The Phase 1 models were estimated using the disaggregate London Travel Diary Survey (LTDS) data of observed trip-making. In the Phase 3 estimation work, two enhancements were made:

1. The frequency models were re-estimated using more recent LTDS data covering UK financial years (FY) 2015/16–2017/18 (covering the period from April 2015 to March 2018), as opposed to LTDS data from calendar years 2010– 2012 used in Phase 1. The base year of Phase 3 estimation is 2016/17 and represents the mid-point of the three years of LTDS data used.
2. The definition of the travel day was changed: the Phase 1 models represented travel on an average weekday, whereas in Phase 3, to ensure better representation of travel at peak times, the definition was revised to represent an average school term time day.

This report summarises the development of the Phase 3 frequency models. Although the methodology and model specification used for developing the Phase 3 models remains largely unchanged from Phase 1, this report is structured as a stand-alone description of the Phase 3 frequency models. We provide a comparison against Phase 1 results where appropriate.

The remainder of this report is structured as follows:

Chapter 2 describes the specification of the frequency models. It defines the units that are modelled and then outlines the structure of the models. In particular, it highlights the special model structure that has been used to model the home–escort to school travel frequency to take account of the atypical travel frequency distribution associated with this travel purpose.

Chapter 3 presents an analysis of changes in the frequency rates as a result of moving to a school term time definition and using the latest LTDS data.

Chapters 4 and 5 summarise the model parameters for the home-based (HB) and non-home based (NHB) models, respectively.

Chapter 6 offers a summary of the Phase 3 frequency models and makes recommendations for further work.

2. Frequency model structure

This chapter provides an overview of the structure of the frequency models. The models were estimated using disaggregate information on individuals' choices to travel recorded in LTDS data[2] from financial years 2015/16–2017/18.

The chapter starts with a brief discussion of the types of travel that are represented in MoTiON, specifically tours and detours, and the travel purposes represented, before going on to describe the model structure that has been used to represent travel frequency.

2.1. Identification of home-based and non-home-based travel

2.1.1. Home-based travel

Home-based (HB) travel has been modelled using tours. A *home-based tour* is a series of linked trips that start and finish at the individual's home. When a traveller makes a direct trip from home to an out-of-home destination and back home again, determining the purpose of the tour is straightforward: the purpose is the activity at the destination. The majority of tours are of this type. However, if two or more out-of-home destinations are visited the purpose may not be clear. In such instances we identify a *primary destination* (PD) in order to define the main purpose of the tour.

To determine the PD, the following purpose hierarchy is employed:

1. Work
2. Employer's business
3. Education
4. Other purposes.

Thus, if a person makes a trip to work and then stops on the way home to do some shopping (an 'other purpose' trip), then the PD will be the work destination.

If there are ties after applying the purpose hierarchy, then the destination at which the longest time was spent is taken as the PD. For example, if a person makes a series of shopping trips to different destinations, the destination where they spent the most time will be the PD. If there were still ties after the purpose hierarchy and maximum time criteria were applied, then of the tied destinations the destination furthest

[2] For more information on the LTDS survey, see (as of 4 March 2020): https://tfl.gov.uk/corporate/about-tfl/how-we-work/planning-for-the-future/consultations-and-surveys#on-this-page-1

from the home was taken as the PD; if there were still ties after the purpose hierarchy, maximum time and maximum distance criteria were applied, then the first tied destination visited was taken as the PD (this only happened in a few cases).

A large number of trips observed in the LTDS data are considered *full tours*, which means that both an outward leg from the home to the PD, and a return leg from the PD back to the home, have been recorded. An *outward half tour* is where a movement from the home to the PD is recorded, but no corresponding return is observed (for example, an individual who leaves the home on the survey day to visit a friend and then stays overnight). Similarly a *return half tour* is a movement from the PD back to home where no corresponding outward leg is recorded (for example, a nightshift worker returning home after their shift). Only 1.7 per cent of trips are associated with half tours whereas 81.0 per cent are associated with full tours and 16.6 per cent are associated with non-home-based travel.

Half tours can occur for two reasons: because the full tour cannot be recorded within the survey day, and because of coding errors (where individuals have recorded only partial information about their trip chain).

To develop the mode-destination models, only full tours have been modelled. It was judged that modelling the small numbers of half tours was not justified given the higher levels of error associated with them. However, half tours are more important for frequency modelling, because if they are all excluded the frequency models will slightly under-predict total travel. Therefore, the approach that has been used for the frequency models is to include all full tours *and* outward half tours. Each outward half tour is treated as equivalent to a full tour, whereas return half tours are dropped, recognising that coding error is more likely to be prevalent in the return half tours[3].

Tour frequency models have been developed for ten different HB tour purposes:

- Commute
- Employer's business
- Primary education
- Secondary education
- Tertiary education for 17 and 18 year olds
- Tertiary education for those aged 19 and over
- Shopping
- School escort
- Other escort
- Other travel.

For return half-tours, the origin purpose of the first trip in a trip sequence (arranged chronologically) is not home. Though this may be a valid response but from our experience of analysing similar datasets, by correlating purpose with trip location, time etc., we observed that the instances of purpose misclassification to be very high.

Separate frequency models have been developed for escort to school tours and other escort travel because the structure of the data and factors that influence tour-making vary significantly between escort to school and other escort travel.

2.1.2. Non-home-based travel

Once the HB tours had been identified, the NHB travel associated with those HB tours was determined. Two types of NHB travel have been represented for travel made during full HB tours only:

- PD-based tours – a series of linked trips starting and finishing at the same PD location (for example, if an individual goes shopping at lunchtime during their work day).
- NHB detours made during the outward or return legs of HB tours – a single trip to or from the PD (for example, if an individual stops at the shops on the way back home).

These two cases are illustrated by the examples in the following figures. In Figure 2-1, trips (2) and (3) form the PD-based tour. In Figure 2-2, trip (2) forms the NHB detour.

Figure 2-1. PD-based tour example

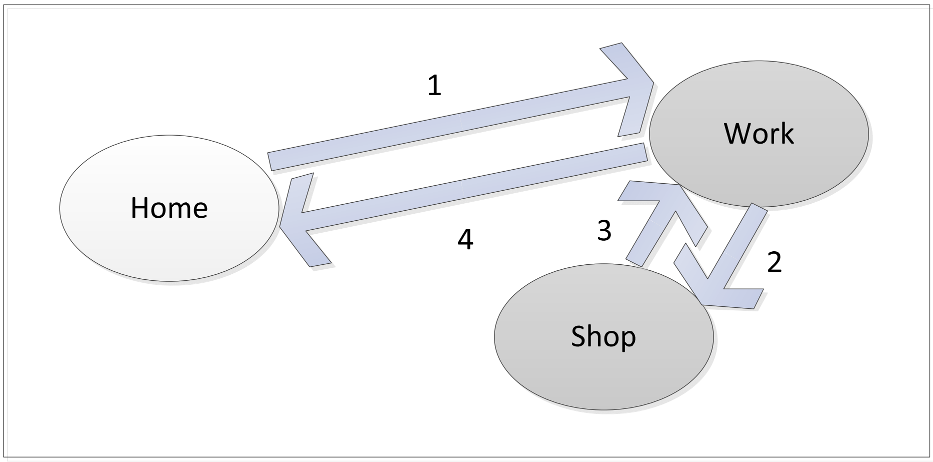
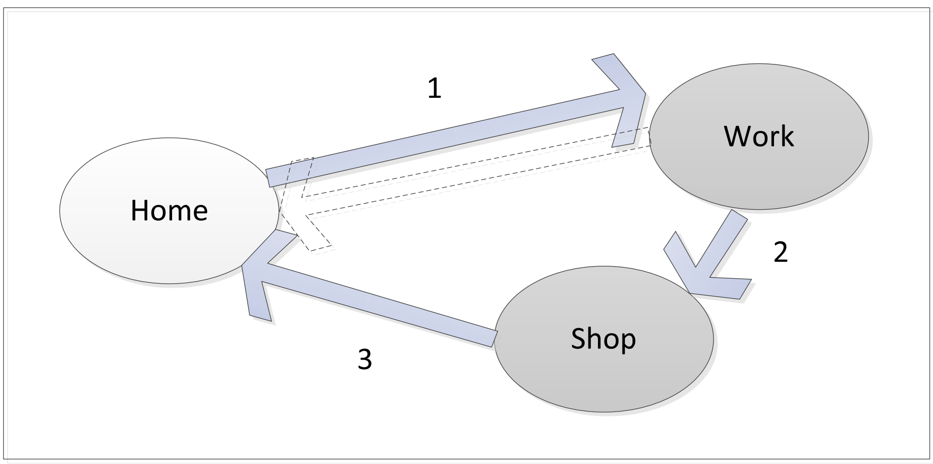


Figure 2-2. NHB detour example



If multiple destinations are visited during the PD-based tour, a single *secondary destination* (SD) is identified, and a direct return tour between the PD and SD is modelled. Similarly, if an individual makes detours to more than one destination during an outward or return HB tour leg, a single SD is identified in that direction, and a direct trip between the PD and the SD is modelled. In both cases, the SD is identified using the same set of rules used to determine the PD, with a purpose hierarchy applied first, and then subsequent tie-break rules are applied if required. The number of cases where individuals visit multiple SDs is low (0.5 per cent of total trips), and so the additional complexity that results from modelling multiple SD visits during a single tour separately is not justified.

Only full PD-based tours can be observed because an individual has to return to the PD before travelling back home again; if they do not travel back to the PD before travelling home then the travel is classified a detour. Thus there is no need to consider PD-based half tours.

Three types of PD-based travel have been modelled:

- PD-based tours made from work-related PDs to work-related SDs
- PD-based tours made from work-related PDs to non-work-related SDs
- PD-based tours made from non-work-related PDs to non-work-related SDs.

There is no need for a PD-based tour from non-work-related PDs to work-related SDs, because if work was part of the tour it would have been defined as the PD.

Three further purposes have been defined to model NHB detours:

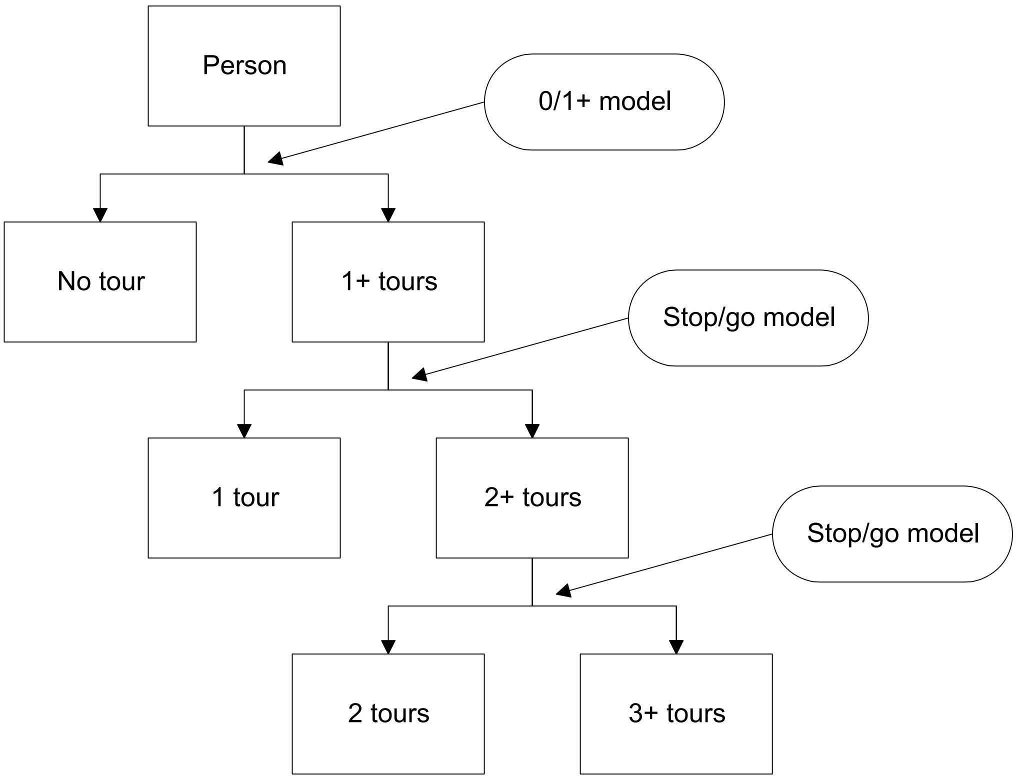
- Detours made during work-related PD tours to work-related SDs
- Detours made during work-related PD tours to non-work-related SDs
- Detours made during non-work-related PD tours to non-work-related SDs.

2.2. Tour model structure

The tour frequency model structure combines two sub-models: firstly, a sub-model to predict whether any tours will be made (zero/one-plus model) for a given purpose, and secondly, a sub-model to predict the extent to which additional tours are made, for a given purpose, given at least one tour is made on an average weekday (stop/go model). The two sub-models are estimated in a single model run for efficiency.

The model structure is illustrated in Figure 2-3. This model structure is used for all of the HB tour purposes, except escort to school, and for the three PD-based tour purposes. The structure was not used for escort to school travel because adults are as likely to make two escort to school tours per day as one; this issue is explained further in Section 2.2.1.

Figure 2-3. Tour frequency model structure



In the zero/one-plus model, utilities are defined for the 'no tours' alternative and therefore the model terms reflect the increased probability of *not* making a tour on an average weekday. **Therefore negative model terms imply an increased probability of making a tour**. The zero/one-plus model has two alternatives, an individual making 'no tours 'at all and the individual making at least one tour.

In the stop/go model, utilities are defined for the stop alternatives (one tour, two tours) and therefore in this model the model terms reflect the probability of *not* making additional tours. **This means that negative model terms imply an increased probability of making multiple tours**. In the example presented in Figure 2-3, no more than two tours are observed per individual on a given day and therefore the final stop/go choice represented is 2 versus 3+. For each model purpose, the structure for the stop/go model was tailored to reflect the maximum number of tours observed in the LTDS data. It is noted that the utility functions are identical on the 1 tour, 2 tours, etc., alternatives, as the probability of stopping is assumed to be constant for a given individual.[4] The choice set for stop/go model depends on the maximum number of observed tours. Figure 2-3 illustrates a structure where two tours were observed, and the stop/go model has two alternatives in the two nests, an individual stopping after making exactly 1 or 2 tours and the individual making more tours (2 or more or 3 or more).

The expected tour rate E(t) can be shown by a very simple formula (Daly and Miller, 2006 and Patruni et.al, 2018).

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[4] P(1|1+) = P(2|2+) = P(3|3+), etc.

$E(T) = P_{1+}/P_{stop}$;

where

P_{1+} is the probability of the individual making at least one tour and $P_{1+} = 1/(1+\exp(v_{none}))$

P_{stop} is the probability of individual stopping, and $P_{stop} = 1/(1+\exp(-V_{stop})$

In addition to constant terms, which ensure that the tour rates observed in the 2015–2017 LTDS data are reproduced, socio-economic terms were tested to represent differences in tour rates according to the personal and household-level characteristics of individuals. The socioeconomic segmentations were agreed during the Phase 1 model development with TfL and the wider project team, and the model specifications in Phase 3 remain largely unchanged since then. Changes made during Phase 3 were either:

a. Aimed at rationalising the income segment definitions in the model so that the definition in mode-destination and frequency models for a given purpose align.

b. Dropping insignificant terms because of the switch to a school term time definition or changes in the underlying data.

2.2.1. Escort model structure

For the escort to school frequency model, analysis of the number of tours made per adult demonstrated that the standard frequency model structure presented in Figure 2-3 was not appropriate because the observed frequency of making two tours was almost as high as that for one tour, as illustrated in Table 2-1.

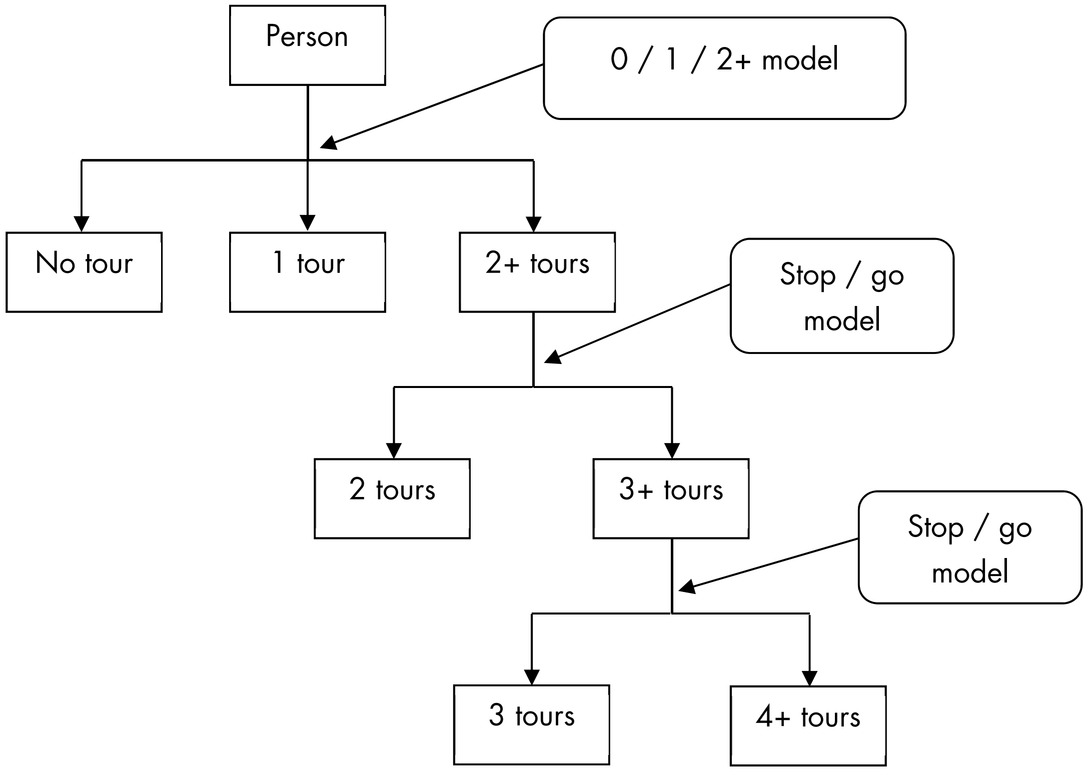
Table 2-1. Escort to school tours made per weekday

Number of tours	Frequency	Per cent
0	33,131	95.6%
1	759	2.2%
2	707	2.0%
3	66	0.2%
4	0	0.0%
Total	34,663	100.0%

Individuals are observed to make two escort to school tours relatively frequently, presumably because if a parent drops their child at school in the morning, in many cases the same parent picks them up in the afternoon. For all other HB purposes the percentage of individuals making two tours is much lower than the percentage making one tour. If parents have more than one child and the school times for their children vary, then one parent may make more than two escort to school tours, although as Table 2-1 illustrates the percentage of individuals observed to make more than two escort to school tours is very low.

To represent the similar frequencies for 1 and 2 tours in the LTDS data, a revised model structure was used. This model structure is illustrated in Figure 2-4.

Figure 2-4. Escort to school model structure



In the modified model structure, a multinomial logit model is used to model the choice between the no tour, 1 tour and 2+ tours alternatives, with utility terms placed on the no tour and 1 tour alternatives. Then a stop/go model is used to predict the probability of making two or more tours. By representing the three-way choice between the no tour, 1 tour and 2+ tour alternatives, the model can separately capture socio-economic segmentations that impact on the probabilities of choosing the 1 tour and 2+ tours alternatives.

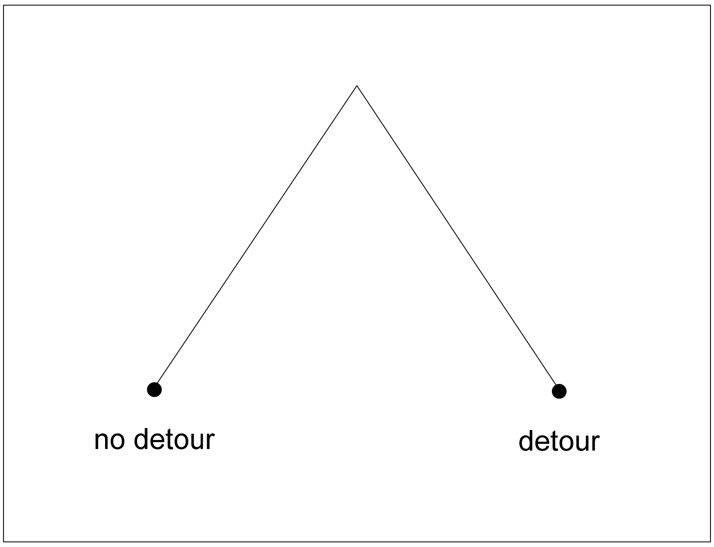
2.2.2. Detour model structure

The detour models predict the binary choice between the 'no detour' and 'detour' choices. The utility terms are placed on the 'no detour' alternative and **therefore a negative model term indicates that an individual is more likely to make a detour**.

Separate detour models have been estimated for detours made during the outward and return legs of HB tours, because we observe that individuals are more likely to make detours during return legs. This reflects travel patterns such as individuals visiting the supermarket on their way home from work or participating in evening social activities near their workplace before returning home.

Figure 2-5 illustrates the detour frequency model structure. Note that only one detour per tour leg is modelled.

Figure 2-5. Detour frequency model structure



3. Analysis of tour rate changes

This chapter summarises changes to the tour rates as a result of the two enhancements introduced in the Phase 3 model: updating the travel day definition from an average workday to a school term day and using more recent LTDS data. We also present further analysis looking at the decline in tour rates for the purpose of shopping across different population segments to provide a more in-depth understanding of the changes.

3.1. Update to the travel day definition

Table 3-1 presents a comparison of the tour rate (per person day) across home-based purposes for an average weekday and an average school term day respectively.

As an average weekday definition includes school holidays, it is reasonable to anticipate higher tour rates for the education and escort to school travel purposes once school holidays are removed We observe an increase in tour-rate of about 28% for these purposes, and this increase is consistent with the number of holidays in a year[5].

We also observe a slight increase in work and business tour rates and a decrease in shopping and other travel tour rates. These changes are smaller than those observed for education purposes but are nonetheless consistent with the decision to drop travel in school holidays. For example, we would expect lower work and business tour rates during school holidays when working parents are more likely to be on leave, and therefore work and business tour rates would be expected to increase when school holiday records are dropped.

[5] Assuming 13 weeks of school holidays per year. a back of the envelope calculation suggests that education tour rates for average weekday should be about 75% of the average school term values, or alternatively tour rates for average school term day are 25% higher than average weekday.

Table 3-1. Tour rates by home-based purpose (LTDS, FY 2015/16–2017/18)

Purpose	Segment	Average weekday	Average school term day	Difference (school term-weekday tour rate)	% change
Commute	Workers and students aged 18 and over	0.44	0.46	0.02	4.5
Business	Workers and students aged 18 and over	0.14	0.15	0.01	7.1
Primary education	Aged between 5 and 11	0.70	0.90	0.20	28.5
Secondary education	Aged between 12 and 16	0.66	0.85	0.19	28.8
Tertiary education	Aged 17 and over	0.031	0.037	0.007	22.3
Shopping	Aged 5 and over	0.14	0.13	-0.01	-7.1
Escort to school	Aged 5 and over	0.066	0.086	0.019	29.2
Escort other	Aged 5 and over	0.04	0.04	0.00	0.0
Other travel	Aged 5 and over	0.26	0.24	-0.02	-7.6
All tours	Aged 5 and over	0.98	1.12	0.14	17.3

3.2. Change in tour rates over time

Table 3-2 shows a comparison of the average school term tour rates between the 2010–2012 LTDS data used for estimating the Phase 1 models and the FY 2015/16–2017/18 LTDS data used for the Phase 3 estimation. Declines in the tour rate are observed for the majority of purposes. The decline in the tour rate is less than 5 per cent for commute, business and escorting purposes, but greater than 20 per cent for tertiary education, shopping and other purposes. For business, a slight increase in the tour rate compared to the 2010–2012 LTDS data is observed. The decline in the tour rate for shopping, other and tertiary education purposes is substantial.

The tertiary education frequency model is applied for all persons aged 17 and over. The tour rate is very low and is susceptible to small changes in the underlying segments that impact tertiary education travel. To understand this variation across segments, a comparison of the tertiary education tour rates across different working status6 segments between the two LTDS datasets is presented in

Table 3-3. As expected, students have the highest tour rates and also account for more than 85 per cent of the total tertiary education tours in both datasets. The decline in the tour rate is 12.5 per cent for students, considerably lower than the overall decline of 28 per cent. For workers the decline is around 5 per cent, but we observe a significant decrease in the tour rate for non-workers (29 per cent). The overall decline in the tertiary education tour rate is primarily driven by decline in the tour rates for non-workers, as well as small differences in the fraction of students in the two datasets. The fraction of students in the Phase 1 dataset is 9.4 per cent compared to 7.6 per cent in the Phase 3 dataset, which has a substantial impact on the overall tour rate since students have a significantly higher tour rate than other segments.

Table 3-2. School term tour rate comparison between Phase 1 and Phase 3 LTDS data

Purpose	LTDS 2010–2012[7] (Phase 1)	LTDS FY 2015–2017 (Phase 3)	Difference (Phase 3 – Phase 1)	% change
Commute	0.49	0.46	-0.03	-4.6
Business	0.14	0.15	0.01	2.9
Primary education	0.92	0.90	-0.02	-3.2
Secondary education	0.84	0.85	0.01	1.3
Tertiary education	0.051	0.037	-0.014	-27.6
Shopping	0.17	0.13	-0.04	-22.3
Escort to school	0.089	0.086	0.003	-3.1
Escort other	0.038	0.037	0.001	-1.2
Other travel	0.28	0.24	-0.04	-15.1

[6] From Phase 1 models, the working status segment is observed to have the largest impact on tertiary education model.

[7] Please not for Phase 1 models, an average workday definition is used. The Phase 1

Table 3-3. Tertiary education tour rate by employment status

Segment	LTDS 2010–2012 (Phase 1)			LTDS FY 2015–2017 (Phase 3)			Tour rate difference (Phase 3 – Phase 1)	% change
	tour rate	tour distribution	population distribution	tour rate	tour distribution	population distribution		
Students	0.473	87.40%	9.40%	0.414	85.70%	7.63%	-0.059	-12.5
Workers	0.005	5.60%	54.30%	0.005	7.99%	59.36%	0	-5.5
Non-workers	0.010	7.00%	36.30%	0.007	6.28%	33.01%	-0.003	-28.8
Overall	0.051			0.037			-0.014	-27.6

3.3. Shopping tour rate analysis

Using the Phase 3 model, we observe a large decline in shopping tour rates. To understand these changes more, we undertook further analysis looking at the tour rate changes across detailed segments of the population recorded in the LTDS data that were found to impact on shopping-related travel during the Phase 1 work. This analysis was primarily intended to investigate whether the decline is driven by changes in specific segments in the population, or if the pattern is consistent across the entire population. For example, a greater use of online shopping services may reduce the need to travel for shopping, or the impact of a squeeze in income and increase in the cost of living may reduce the need to travel for discretionary purposes.

A comparison of shopping tour rates between the two datasets across age, household income, working status and household structure segments is shown in Figure 3-1 to Figure 3-4.

Figure 3-1 shows the variation of shopping tour rate by age band. Compared to the Phase 1 LTDS data, we observe a decrease in tour rates across all age groups, with the extent of decrease lowest for the youngest (under 16) and the oldest age groups (76 and over). We also observe a similar pattern of decrease in tour rates across all household income bands (gross annual income) except for individuals in households with gross annual income between £20k and £25k (Figure 3-2). The decrease in tour-rate is consistent across the rest of the income bands and is around 19% for individuals in bands less than £20k as well as for individuals in bands greater than £25k.

Figure 3-1. Variation of shopping tour rate by age band

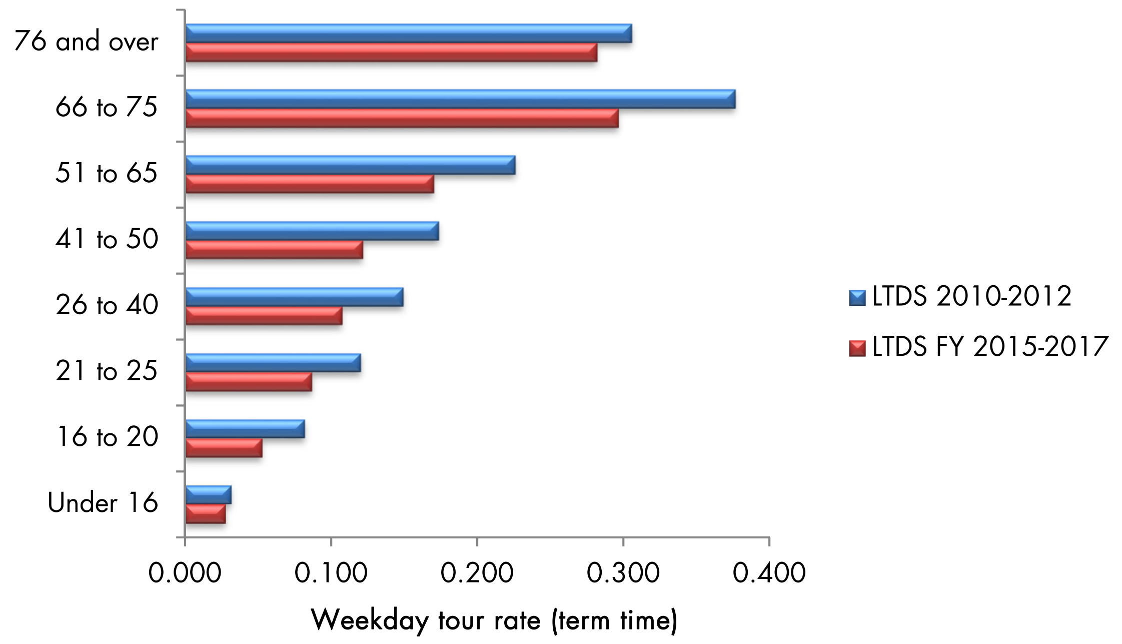


Figure 3-2. Variation of shopping tour rate by household income band

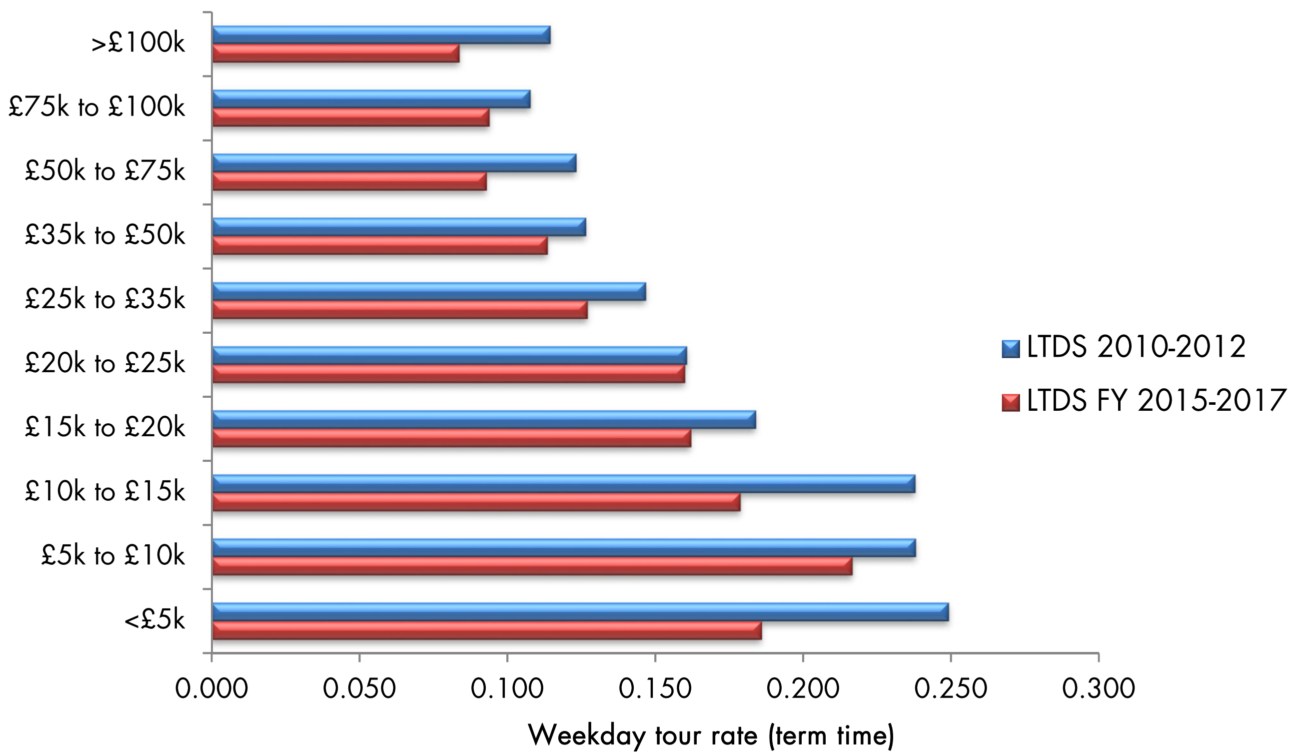
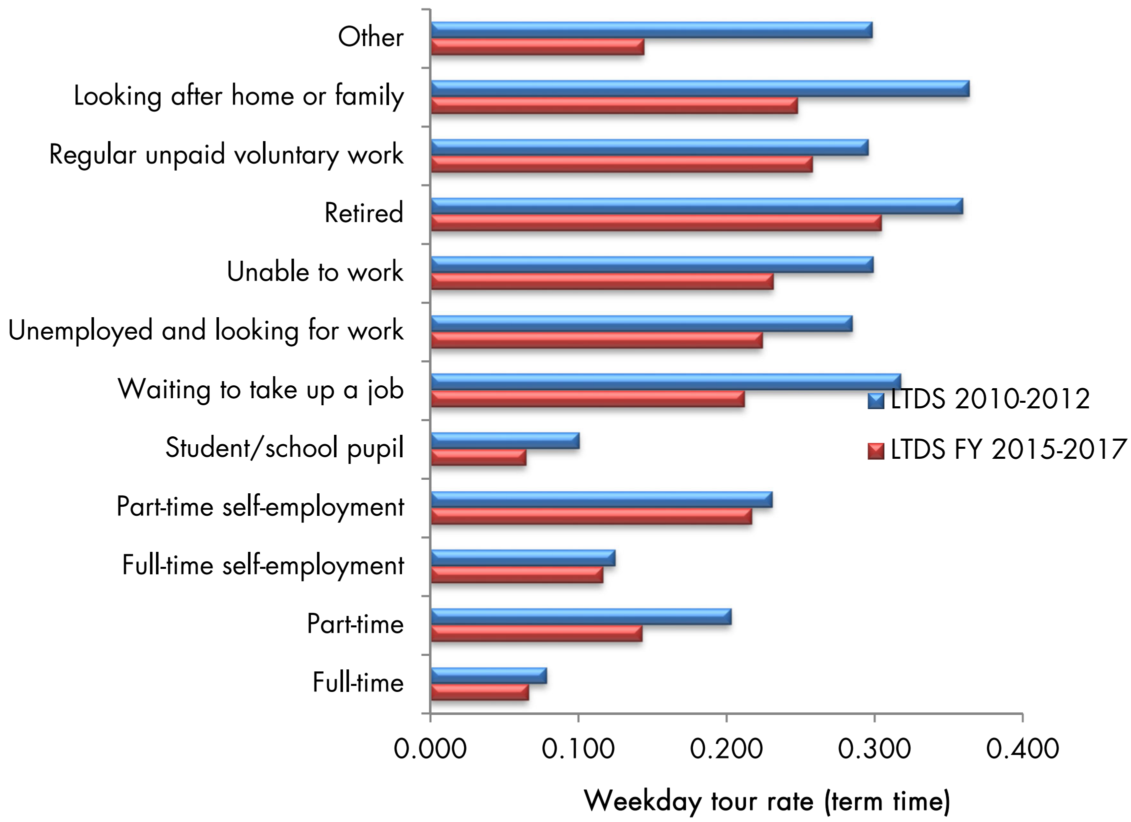


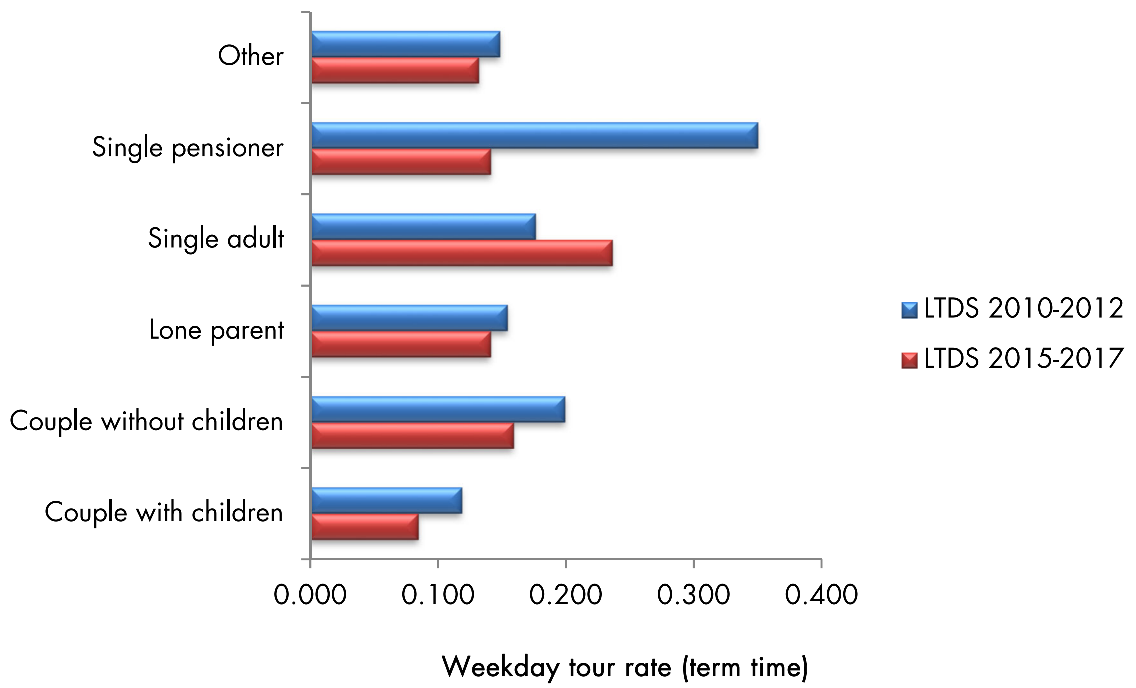
Figure 3-3 shows a comparison of tour rates by individuals' employment status. In the more recent dataset, we observe a decrease in tour rate across all groups. However, larger declines are noted for students, those looking after family, waiting to take up jobs and part-time workers. The decline in tour rate for all these groups is broadly consistent, ranging from 29 per cent to 33 per cent.

Figure 3-3. Variation of shopping tour rate by employment status



The variation of tour rate by household structure, presented in Figure 3-4, is slightly different from the rest of the other socio-economic variables. Compared to the LTDS 2010–2012 data, an increase in tour rate is observed for persons living in single-adult households and a decline in tour rate is observed for persons living in all other household types. The distribution of population across age, income and working status segments is consistent between the two LTDS datasets. However, a significant difference in the distribution of population across each household type is noted. Compared to the 2010–2012 data, a substantial decrease is noted in the distribution of population in 'other households': the fraction of people living in 'other households' was 17.5 per cent in the earlier data compared to 5.2 per cent in the 2015–2017 data. This pattern clearly points towards a difference in the definition of household types between the datasets.

Figure 3-4. Variation of shopping tour rate by household structure



Overall, from these results it is reasonable to conclude that a general structural decline in the shopping tour rate has occurred between 2010–2012 and 2015–2017. Except household structure a consistent decline in shopping tour rate is observed across other socio-economic segments. This consistent decline suggests that the reduction in trip-rate is not influenced by direct changes in socio-demographics but is more driven by changes in the underlying shopping behaviour that reduces the need to travel for shopping, for example switch to online shopping and things being delivered to home and a direct reduction in frequency of travel as a result of squeeze in real incomes[8]. Additional analysis is necessary to understand the extent of impact of these factors (online shopping and squeeze in income) on different socio-economic segments and how that influences the shopping behaviour.

An analysis of HB shopping productions for London from the National Trip End Model (NTEM[9]) shows a reduction in the shopping trip rate (HB shopping productions per person) by 6.8% between 2011 and 2016 for an average weekday. A similar analysis of National Travel Survey (NTS) data[10] between the period 2010/11 and 2015/16 also shows a reduction in average shopping trips per person by 15% in London. Therefore, we can conclude that there is a significant reduction in shopping trips in London. However, the

[8] An analysis of weekly pay for full-time worker shows that the real growth rate (1.7%) been relatively low in London compared to the rest of the UK (5.5%-9.03%) between the period 2011 and 2015. https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/bulletins/annualsurveyofhoursandearnings/2019, last accessed 02/09/2020.

[9] From TEMPRO 7.2.b, dataset 7.2.

[10] https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/821495/nts9906.ods), last accessed 02/09/2020. Also, it is important to note the NTS analysis includes both home-based and non-home based shopping trips.

extent of reduction in both cases is smaller than the reduction implied by the unweighted LTDS data. The unweighted results may be influenced by the difference in the distribution of sample across persons, household segment and spatial areas. Therefore, for precise quantification of the decline in LTDS, it would be necessary to run a weighted analysis. We also undertook a similar analysis looking at other travel and the pattern of decline is very similar to shopping except that the actual decline is lower.

3.4. Comparison of LTDS trips rates with NTEM

As a validation exercise a comparison of LTDS trip rates to the NTEM 2016 trip rates was undertaken. Table 3-4**Error! Reference source not found.** below summarises the results. It's important to note that the comparison is very broad as the tour/purpose classification[11] as well the survey definition is different between NTEM and LTDS. The NTEM trip rates represent an average weekday, whereas the LTDS trips rates represent an average day during the school term time.

Compared to NTEM, the overall commuting trip-rates are lower, and the business trip-rates are higher in LTDS sample. The purpose classification and the HB/NHB split in LTDS is derived differently compared to NTEM. The tour building procedure places commute and business purposes at the top of the purpose hierarchy as such identifies more home-based business tours than it is possible in a NTEM approach. However, it is interesting to note that when commute/business are summed together the overall volume of commute/business trip rates matches well with NTEM (0.3%). In terms of overall other purpose trip rate, LTDS is 10% higher than NTEM. The HB other trip rate is similar between NTEM and LTDS. However larger differences are seen for HB shopping, HB education and NHB other trips.

Despite the definitional differences, the NTEM and LTDS trip-rates validate well at an aggregate purpose level. The overall LTDS trip-rate per person is 7% higher than NTEM, and a higher trip rate for LTDS is consistent with the difference in the survey day definition.

[11] The NTEM purpose classification is simple and is done based on the origin and destination purpose of trip in question. Whereas, the LTDS tour building uses a set of complex rules for identifying tours and various tour related attributes.

Table 3-4. Comparison of LTDS trip rates to NTEM 2016

Purpose	**NTEM trips [12](2016)**	**Trip rate per person (weekday)**	**LTDS (FY-2015-17)**	**Trip rate per person (school term day)**	**Difference**
HB Commute	4,927,042	0.58	14,754	0.53	
NHB Commute	284,058	0.03	0[13]	0	
Total Commute	5,211,100	0.61	14,754	0.53	-13.2%
HB Business	623,396	0.07	4,744	0.17	
NHB Business	378,248	0.04	831	0.03	
Total Business	1,001,644	0.12	5,575	0.20	70.6%
Overall Commute/business	6,212,744	0.73	20,329	0.73	0.3%
HB Shopping	2,946,082	0.35	7,320	0.26	-23.8%
HB Other (includes escort other)	4,617,956	0.54	15,482	0.56	2.8%
HB Education (includes escort education)	3,529,168	0.41	14,524	0.52	26.2%
NHB other (shopping, other and education)	1,518,791	0.18	8,220	0.30	65.9%
Total other (shopping, other, education, NHB other)	12,611,997	1.48	45,546	1.64	10.7%
Overall	18,824,721	2.21	68,875	2.37	7.3%

[12] The HB trips from NTEM are estimated as 2 times the total number of productions.

[13] NHB commute trips are not possible in the tour-building procedure. Because of the purpose higher hierarchy, all possible works trips are classified as tours and those remaining (work to work trips) as treated as business trips.

4. Home-based frequency models

This chapter presents the frequency models for each of the ten HB frequency model purposes represented in the Phase 3 MoTiON models. The frequency model specifications were originally developed during Phase 1 (Jahanshahi et al. 2017), where an extensive specification search was undertaken by analysing travel frequency variations across a list of potential segments, and also drew upon RAND Europe's experience from developing travel frequency models for the West Midlands region and Sydney (Tsang et al. 2010; Fox et al. 2014). Figure 4-1 summarises the list of segments that were found to be significant in the Phase 1 models.

Figure 4-1. Summary of segments in Phase 1 by purpose

	Commute	Business	Education	Shopping	Escort	Other
Gender	✓	✓	✓	✓	✓	
HH income	✓		✓	✓	✓	
Age			✓	✓	✓	✓
HH structure	✓	✓		✓	✓	✓
Car availability	✓	✓			✓	✓
Disability	✓			✓		
Employment status	✓	✓	✓	✓	✓	✓
Pop. Density			✓		✓	

The focus of the Phase 3 frequency model development was to update the model parameters to reflect the availability of more recent LTDS data and a change of definition of the travel day.

The specification of the Phase 3 models remains largely unchanged from Phase 1. However, a few minor changes were made, specifically to drop some terms that are counterintuitive or insignificant[14] when

[14] Across purposes we observe that the tour-rates vary substantially with employment status, so we have retained employment status terms even if they are insignificant on the basis that it improves the forecasting ability of in case of changes in the future population distribution. With respect to other socio-economic terms (age, car-ownership, and gender) we have retained terms which were at a 85% level of significance (t-stat of about 1.4) on the basis that it helps h forecasting, given that a new specification search was beyond the scope of this study.

estimated with the more recent LTDS data, and to realign the income segment definitions in the model so that the definitions in the frequency models are consistent with the mode-destination model.

It should be noted that in the zero/one-plus model, the utility terms are placed on the zero tour alternative, and in the stop/go models the utility terms are placed on the stop alternatives. Therefore, negative model parameters are associated with *higher* rates of tour-making because individuals are less likely to choose 1+ tours in the 0/1+ model and the 'go' alternative in the stop/go sub-model.

4.1. Commute

The commute model was estimated from the sample of workers and students aged 16 and over.[15] Students were included because some students were observed to make commute tours, as illustrated by Table 4-1, although their tour rate is much lower than workers.

Table 4-1. Variation in commute tour frequency by employment status

Employment status	Persons	Tours	Tour rate
full-time employee	9,482	6,112	0.645
part-time employee	1,744	774	0.444
full-time self-employed	2,238	425	0.190
part-time self-employed	626	59	0.094
student	1,811	7	0.004
Total	15,901	7,377	0.464

As expected, full-time employees have higher tour frequency rates than part-time employees, and self-employed workers have noticeably lower commute tour frequency rates than other workers.

The frequency of commute tour-making is summarised in Table 4-2.

Table 4-2. Commute tours made per school weekday by workers and students

Number of tours	Frequency	Per cent	Tours
0	8,631	54.28%	0
1	7,166	45.07%	7,166
2	101	0.64%	202
3	3	0.02%	9
Total	15,901	100.00%	7,377
Tour rate	*0.464*		

[15] Specifically, employment status groups 1 to 5: full-time workers, part-time workers, the self-employed, full-time students and part-time students.

The commute travel frequency model results are summarised in Table 4-3. Here and in the tables that follow below, changes to the model specification from Phase 1 are indicated by shading: the terms shaded in pink are no longer significant in the model and were dropped, and those shaded in green are new terms added to the model to align the income segmentation with the mode-destination models. The relative strength of the different segmentation terms can be assessed by examining the magnitudes of the individual parameter estimates.

Table 4-3. Commute frequency model

Sub-model	Segmentation	Parameter name	Definition	Parameter value and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	-0.52	-18.6	constant to ensure overall fraction of individuals making at least one tour is replicated
	gender	zero_fem	female	-0.14	-3.8	females more likely to make commuting tours than males
	household income	zero_Inc05	HH income <£5k p.a.	0.00	n/a	this term is no longer significant in the new model
	household structure	zero_HH2wC	couples with children in HH	0.00	n/a	single parents make fewer commuting tours compared to adults in other household types
		zero_HH1Ad	single-adult households	0.00	n/a	
		zero_HH1Pa	single-parent households	0.12	2.0	
	population density	zero_dens	origin population density (persons per square km)	0.00	n/a	population density is no longer significant in the new model
	disability	zero_Dis	person with disability	0.41	2.7	persons with a disability impacting their mobility are less likely to make commuting tours
	employment status	zero_FTSE	full-time self-employed	2.03	34.5	all four groups are less likely to make commute tours than full-time workers; working students are much less likely to make tours than the other four employment status groups
		zero_PTSE	part-time self-employed	2.87	20.4	
		zero_PT	part-time employees	0.89	16.4	
		zero_st	students	6.12	16.2	
stop/go	*all segments*	stop	constant	4.52	36.3	constant to ensure observed rate of multiple tour-making is replicated
	employment status	stop_FTSE	full-time self-employed	-0.98	-3.1	the self-employed and part-time workers make more multiple tours than full-time workers and working students
		stop_PTSE	part-time self-employed[16]	-1.17	-1.7	
		stop_PT	part-time employees	-1.20	-5.0	

[16] The part-time self-employed term though not significant is still retained as it gives a better fit to tour rates by category as per Table 4-1, therefore would be better for forecasting when the population split between categories will change.

As expected, employment status is the strongest predictor of commute tours: full-time workers are more likely to make a commute tour, and self-employed and part-time workers are more likely to make multiple tours, subject to them making at least one tour. The specification largely remains unchanged from Phase 1, except that the terms for single-adult household, couple with children household type, population density and household income are no longer significant.

4.2. Home–business

A tabulation of mean tour rate by working status is presented in Table 4-4. Similarly to commute, the business model is also estimated from the sample of workers and students aged 16 and over. We do observe business tour-making among students, therefore students were retained for estimation.

Table 4-4. Variation in business tour rate with working status

Employment status	Persons	Tours	Tour rate
full-time employees	9,482	1,100	0.116
part-time employees	1,744	177	0.101
full-time self-employed	2,238	861	0.385
part-time self-employed	626	150	0.240
student	1,811	84	0.046
Total	15,901	2,372	0.149

The pattern of business tour-making is along expected lines, with self-employed persons having noticeably higher tour rates than other types of employees. It may be that a number of self-employed workers often do not visit their main workplace on a given day because they are visiting one or more business locations. Table 4-5 shows the distribution of business tours.

Table 4-5. Business tours made per weekday for adults in employment status groups 1 to 5

Number of tours	Frequency	Per cent	Tours
0	13,640	86.79%	0
1	2,162	13.60%	2,162
2	90	0.57%	180
3	7	0.04%	21
4	1	0.01%	4
5	1	0.01%	5
Total	15,901	100%	2,372

Almost 87 per cent of workers and students aged 16 and above made no business tours on the survey day, and less than 1 per cent of people in the survey made two or more tours. The average tour frequency rate is 0.149 business tours per weekday, which is considerably lower than the commute tour frequency rate of 0.464.

Table 4-6 presents the results from the final specification of the new business tour frequency model.

Table 4-6. Home–business frequency model results

Model	Segmentation	Parameter name	Definition	Parameter value and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	1.987	48.7	constant to ensure overall fraction of individuals making at least one tour is replicated
	gender	zero_fem	females	0.429	8.7	females less likely to make business tours than males
	household structure	zero_HH1Ad	1 adult households	0.000	n/a	this term is no longer significant in the model
	car availability	zero_CAFC	free car use	-0.261	-5.2	individuals from free car use households more likely to make business tours
	employment status	zero_FTSE	full-time self-employed	-1.430	-26.0	compared to full-time and part-time employees, the self-employed are more likely to make business tours whereas students are less likely to make business tours
		zero_PTSE	part-time self-employed	0.429	8.7	
		zero_St	students	0.846	7.2	
stop / go	*all segments*	stop	constant	3.178	19.4	constant to ensure observed rate of multiple tour-making is replicated
		stop_PT	part-time employees	-0.251	-0.7[17]	
	employment status	stop_FTSE	full-time self-employed	-0.350	-1.5	compared to full-time employees, students make fewer multiple tours whereas all other employment status groups make more multiple tours
		stop_PTSE	part-time self-employed	-0.539	-1.6	
		stop_ST	working students	11.021	55.9	

[17] The stop terms for employment status are not significant at a 95 per cent level of confidence but are still retained in the model as they gives a better fit to tour rates by adult status (category as per Table 4-4), and therefore would be better for forecasting when the population split between categories will change.

Similarly to commute, employment status is a significant driver for business travel and, compared to other types of workers, self-employed workers are more likely to make business tours and are also more likely to make multiple business tours in a given day. We also observe that females are less likely to make business tours compared to males and people who have free access to a car in their household are more likely to make business tours.

4.3. Home–primary education

The primary education models are estimated from the LTDS sample for children aged between 5 and 11. A summary of the observed number of primary tours is provided in Table 4-7 below.

Table 4-7. Primary education tours made per child aged 5–11

Number of tours	Frequency	Per cent	Tours
0	295	10.9%	0
1	2,395	88.3%	2,395
2	21	0.8%	42
Total	2,711	100.0%	2,437
Tour rate	*0.899*		

Over 88 per cent of primary-aged children were observed to make at least one school tour on the survey day. Just 0.8 per cent of children made more than one primary school tour, indicating that few pupils return home for doctors' appointments, lunch etc. during the school day. The overall tour frequency rate is 0.899 primary education tours per weekday. As shown earlier in Chapter 3, moving to a school term time weekday definition has a significant impact on the primary education tour rate. We observe that 11 per cent of primary school-aged children make zero tours on a given school term day.

Table 4-8 summarises the frequency model results. The primary education model is now a constants only model, i.e. there are no other terms that explain the variation in primary education tour behaviour because the population density term, which was found to be significant in the Phase 1 model, is no longer significant.

Table 4-8. Home–primary education model results

Model	Segmentation	Parameter name	Definition	Parameter value and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	-2.103	-11.1	constant to ensure overall fraction of individuals making at least one tour is replicated
	population density	zero_dens	population density in the home zone	0.000	n/a	this term is no longer significant in the new model
stop / go	*all segments*	stop	constant	4.745	21.9	constant to ensure observed rate of multiple tour-making is replicated

4.4. Home–secondary education

The secondary education models are estimated from the LTDS sample for children aged between 12 and 16. A summary of the observed number of secondary education tours is provided in Table 4-9 below.

Table 4-9. Secondary education tours made per child aged 12–16

Number of tours	Frequency	Per cent	Tours
0	265	16.3%	0
1	1,343	82.7%	1343
2	16	0.1%	32
Total	1,624	100.0%	1,375
Tour rate	***0.847***		

The pattern of tour-making among secondary education students is very similar to that of primary education students. Over 82 per cent of secondary-aged children were observed to make at least one school tour on the survey day. Just 0.1 per cent of children made more than one secondary school tour, indicating that few pupils return doctors' appointments, lunch etc. for lunch during the school day. The overall tour frequency rate is 0.847 secondary education tours per weekday.

Table 4-10 summarises the frequency model results. In addition to the constants, we found that secondary students aged 15 and 16 are more likely to make fewer tours compared to those aged between 12 and 14.

Table 4-10. Home–secondary education model results

Model	Segmentation	Parameter name	Definition	Parameter value and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	-1.858	-19.9	constant to ensure overall fraction of individuals making at least one tour is replicated
	age	zero_a15	aged 15 or 16	0.508	3.8	individuals aged 15 and 16 make fewer tours than those aged 12–14
stop / go	*all segments*	stop	constant	4.442	17.9	constant to ensure observed rate of multiple tour-making is replicated

4.5. Home–tertiary education

Two frequency models were estimated for home–tertiary education for two different age groups. The first model captures the tour rates for persons aged 17 and 18, as all the tours within this age band are made by students, and the second model captures the tour-making behaviour for persons aged 19 and over, where in addition to students, persons with non-student employment status are also observed to make tours. This age-specific segmentation of tertiary frequency model is consistent with the Phase 1 model.

4.5.1. Tertiary education model for people aged 17 and 18

A summary of the observed number of education tours for people aged 17 and 18 is shown in Table 4-11.

Table 4-11. Tertiary education tours made per person aged 17–18

Number of tours	Frequency	Per cent	Tours
0	292	48.7%	0
1	308	51.3%	308
2	0	0.0%	0
Total	600	100.0%	308
Tour rate	*0.513*		

The model results are shown in Table 4-12. As no multiple tours are observed, the stop constant in the stop/go model is highly positive and indicates that individuals stop after making a tour as opposed to making another tour. In addition to the constants, there is an age term that captures the difference in tour rate between those aged 17 and 18. Persons aged 17 are more likely to make a tertiary education tour compared to those aged 18.

Table 4-12. Home–tertiary education model results, persons aged 17–18

Model	Segmentation	Parameter name	Definition	Parameter value and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	0.680	6.8	constant to ensure overall fraction of individuals making at least one tour is replicated
	age	zero_a17	aged 17	-0.778	-5.6	individuals aged 17 make more tours than those aged 18
stop / go	*all segments*	stop	constant	15.200	0.1	constant to ensure observed rate of multiple tour-making is replicated

4.5.2. Tertiary education model for people aged 19 and above

A summary of the observed number of tours for people aged 19 and above is shown in Table 4-13.

Table 4-13. Tertiary education tours made per adult aged 19 and over

Number of tours	Frequency	Per cent	Tours
0	22,288	97.7%	0
1	533	2.3%	533
2	1	0.0%	2
Total	22,822	100.0%	535
Tour rate	*0.023*		

The model results are shown in Table 4-14. The specification of the model is similar to Phase 1 with two important changes:

1. The term capturing the tour rate for unemployed individuals is no longer significant and is dropped (shaded in pink).
2. The income terms in the Phase 1 model (shaded in pink) were redefined based on the segmentation in the mode-destination model (<£25k, £25k to £50k and >£50k). A significant effect is observed for individuals in households with income greater than £25k p.a. Individuals from higher-income households (>£25k) are less likely to make tertiary education tours compared to individuals from lower-income households(<£25k).

The rest of the effects are similar to Phase 1 models. Students have much higher tour rate than other groups and women have higher tour rates than men even after accounting for differences in tour-making by employment status groups and by income.

Table 4-14. Home–tertiary education model results, adults aged 19 and above

Model	Segmentation	Parameter name	Definition	Parameter value	and t-ratio	Description
zero / one-plus	*all segments*	zero	constant	4.407	25.2	constant to ensure overall fraction of individuals making at least one tour is replicated
	employment status	zero_W	workers	0.756	3.6	captures differences in tour rates relative to persons waiting to take up a job, those unable to work due to sickness or disability, voluntary workers, those looking after the home and other groups
		zero_St	students	-4.140	-23.9	
		zero_Un	unemployed	0.000	n/a	
		zero_Ret	retired	1.580	4.6	
	income	zero_Inc05	income <£5k p.a.	0.000	n/a	revised income banding is used in the new model, these terms no longer apply
		zero_I515	income £5–15k p.a.	0.000	n/a	
		zero_I100p	income > £100k p.a.	0.000	n/a	
		zero_I25p	income > £25k p.a.	0.449	4.0	lower tour rates for individuals in households with income greater than £25k p.a. compared to households with income less than £25k p.a.
	gender	zero_fem	females	-0.197	-1.8	females are more likely to make tertiary education tours
stop / go	*all segments*	zero	constant	6.271	6.3	constant to ensure observed rate of multiple tour-making is replicated

4.6. Home–shopping

As both children and adults were observed to make shopping tours, the home–shopping model was estimated using all individuals in the LTDS data interviewed on the travel day. The observed distribution of shopping tours is shown in Table 4-15.

Table 4-15. Shopping tours made by persons aged 5 and above

Number of tours	Frequency	Per cent	Tours
0	24,295	82.7%	0
1	3,279	16.3%	3,279
2	171	0.9%	342
3	13	0.1%	39
4	0	0.0%	0
Total	27,758	100.0%	3,660
Tour rate	*0.132*		

A large number of model parameters have been identified in the shopping frequency model, representing significant variation in tour-making behaviour across age band, employment status, household income, household structure, car availability, pass holding and gender segments. A more detailed analysis of variation of shopping tour rates across different segments is presented in Chapter 3.

The estimated model parameters are presented in Table 4-16. The likelihood of making shopping tours increases with age up to 75 years, and compared to full-time workers others have higher shopping tour rates, more so for non-workers compared to other non-full-time work status groups. The specification of the model is similar to Phase 1 with two important changes:

1. The income segments were revised to align with the definition of mode-destination segments. With an increase in income, a decrease in tour rate is observed. This pattern is as expected since individuals in higher-income households may have less time to undertake a shopping tour on a school term day.
2. The term for two-plus cars in households is not significant in the new model and is dropped.

Table 4-16. Shopping frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
zero / one-plus	*all segments*	zero	constant	2.548	41.8	constant to ensure overall fraction of individuals making at least one tour is replicated
	age	zero_aL16	aged under 16	0.966	9.0	overall the likelihood of making shopping tours increases with age, except for those aged 76 and over – the reference group is those aged 26–40 *and* those aged 76 and over
		zero_a1620	aged 16–20	0.647	4.2	
		zero_a2125	aged 21–25	0.149	1.6	
		zero_a4150	aged 41–50	-0.091	-1.5	
		zero_a5165	aged 51–65	-0.190	-3.6	
		zero_a6675	aged 66–75	-0.112	-1.7	
	employment status	zero_PT	part-time employee	-0 .537	-6.5	shopping tour rates vary significantly with employment status, with the lowest rates for the reference group of full-time workers
		zero_St	school pupil or student	-0.218	-1.6	
		zero_FTSE	full-time self-employed	-0.39	-4.9	
		zero_PTSE	part-time self-employed	-0.939	-8.5	
		zero_fam	looking after family	-1.097	-16.3	
		zero_WnJ	waiting to start job	-1.105	-4.5	
		zero_Oth	unemployed and other	-1.244	-16.6	
	household income	zero_I3550	HH income £35–50k p.a.	0.000	n/a	revised income banding is used in the new model, these terms no longer apply
		zero_I5075	HH income £50–75k p.a.	0.000	n/a	
		zero_I7510	HH income £75–100k p.a.	0.000	n/a	
		zero_I100p	HH income £100k-plus p.a.	0.000	n/a	
		zero_I2550	HH income £25–£50k p.a.	0.131	2.7	compared to the reference group <£25k p.a., shopping tour rates decrease with increase in income
		Zero_I50p	HH income £50k-plus p.a.	0.264	5.2	
	car availability	zero_1cFC	1 car in HH, free car use	-0.290	-5.4	single car free car use individuals make more tours that other car availability groups
		zero_2pC	2-plus cars in HH	0.000	n/a	
	Freedom Pass	zero_FPass	Freedom Pass holders	-0.416	-6.7	Freedom Pass holders are more likely to make shopping tours
	gender	zero_fem	females	-0.145	-3.6	females make more shopping tours than males
stop / go	*all segments*	stop	constant	2.867	38.8	constant to ensure overall fraction of individuals making multiple tours is replicated

4.7. Home–escort travel

For home–escort travel, owing to differences in the patterns of travel between those accompanying children to school and those escorting for other purposes, two separate frequency models were estimated. Escort for other purposes includes escorting people to work and escorting people to social activities (for example, dropping or picking up a child from their friend's house). Table 4-17 and Table 4-18 show the distribution of escort to school and other escort tours made on a term-time day by persons aged 5 and above. It is clear from the tables that the pattern of tours between the two purposes is very different. The instances of persons making two tours a day comprise a significant fraction for school escort, an expected pattern since some people who drop off their children at school will also pick-them up again later in the day. Therefore, a modified frequency structure that has an additional choice between zero and one tour is used for modelling school escort, and the stop-go model is applied for instances of two or more tours. Please refer to Chapter 2 for details on the escort to school frequency model structure.

Table 4-17. Distribution of escort to school tours made by persons aged 5 and above

Number of tours	Frequency	Per cent	Tours
0	26,246	94.55 %	0
1	737	2.66 %	737
2	736	2.65 %	1.472
3	38	0.14 %	114
4	1	0.00%	4
Total	27,758	100.00 %	2,327
Tour rate	*0.084*		

Table 4-18. Distribution of other escort tours made by persons aged 5 and above

Number of tours	Frequency	Per cent	Tours
0	26,923	96.99%	0
1	657	2.37%	657
2	159	0.57%	318
3	15	0.05%	45
4	4	0.01%	16
Total	27,758	100.00%	1,036
Tour rate	*0.037*		

The school escort travel results are presented in Table 4-19 and other escort travel results are presented in Table 4-20.

Table 4-19. School escort tour frequency model parameters

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
zero tours	*all segments*	Zero	constant	8.196	29.5	constant to capture fraction making zero tours
	gender	zero_fem	females	-0.950	-13.1	females make more tours than males
	car availability	zero_0CAL	no licence, car in household	0.903	9.5	those with access to a free car and people with one car in household with competition are more likely to make escort tours, relative to other categories
		zero_1CPC	1 car, car competition	-0.855	-9.1	
		zero_1CFC	1 car, free car use	-1.08	-9.7	
		zero_2CPC	2+cars, car competition	0.000	n/a	
		zero_2CFC	2+cars, free car use	-0.917	-9.0	
	household structure	zero_1kid	one child in the household	-3.839	-13.9	those with more children in the household are much more likely to make escort to school tours than those without children
		zero_2pkid	two plus children in the household	-4.720	-17.3	
	employment status	zero_FT	full-time employed workers	0.269	2.8	the self-employed, part-time employees and those who are looking after home or family members are more likely to make escort to school tours than others
		zero_FTSE	FT self-employed workers	-0.399	-3.2	
		zero_PTSE	PT self-employed workers	-1.093	-6.9	
		zero_Fam	looking after home or family	-2.003	-20.0	
	income	zero_Inc05	below £5k p.a.	0.000	n/a	revised income banding is used in the new model, these terms no longer apply
		zero_I515	£5–15k p.a.	0.000	n/a	
		zero_I100p	£100k plus	0.000	n/a	
		zero_I50p	£50k plus	0.162	2.4	people in households with income greater than £50k are less likely to make escort tours compared to others
	population density	zero_dens	continuous population density	0.000	n/a	this term is no longer significant in the new model
one tour	*all segments*	One	constant	1.871	6.2	constants to capture fraction making one tour
	gender	one_fem	females	0.000	n/a	females more likely to make one tour than males
	employment status	one_FTNoSE	full time workers	0.000	n/a	those looking after home or family are more likely to make multiple escort tours compared to people with other employment status
		one_Fam	looking after home or family	-0.935	-8.1	
	income	one_I100p	income above £100k	0.000	n/a	this term is no longer significant in the new model

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
	household structure	one_Hkid	having children in the household	-1.496	-5.0	those with children in the household are less likely to make only one escort to school tour
	population density	one_dens	continuous population density	-2.35E-05	-2.7	residents in denser areas are more likely to make more than one escort to school tour
stop/ go	*all segments*	Stop	Constant	2.963	18.7	constant to ensure overall fraction of individuals making multiple tours is replicated
	employment status	stop_fam	looking after home or family	0.000	n/a	this term is no longer significant in the new model

The presence of children in the household, employment status, car availability and gender have a strong impact on school escort tours. People in households with children are much more likely to make escort tours compared to households without children. Also, people in households with two or more children have a slightly higher escort tour rate compared those in households with a single child. People looking after family are more likely to make escort tours compared to others with different working status and are also more likely to make multiple escort tours. People in households with access to a free car are also more likely to make escort tours and males are less likely to make escort tours compared to females. However, compared to Phase 1 models, there are a few changes to the specification:

1. On the zero tour alternative, the car competition term for two or more cars and the population density terms are no longer significant
2. On the one tour alternative, the gender and full-time worker terms are no longer significant
3. The employment status term for people looking after home or family on the stop alternative is no longer significant
4. People in high-income households (>£50k) are less likely to make escort tours compared to the rest.

Table 4-20. Other escort tour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
zero/ one-plus	*all segments*	zero	constant	4.144	29.2	constant to ensure overall fraction of individuals making at least one tour is replicated
	Age	zero_aL20	aged under 20	1.349	6.7	young people make the fewest escort other tours, and individuals aged 50 and over make the most, relative to other age bands
		zero_a4150	aged 41 to 50	0.000	n/a	
		zero_a5165	aged 51 to 65	0.000	n/a	
		zero_a66p	aged 66 and over	0.000	n/a	
		zero_a51p	aged 51 and over	-0.235	-2.6	
	car availability	zero_1CPC	one car, car competition	-1.344	-12.0	individuals with higher car availability make more other escort tours
		zero_1CFC	one car, free car use	-1.476	-11.9	
		zero_2CPC	two-plus cars, car competition	-0.923	-4.7	
		zero_2cFC	two-plus cars, free car use	-1.501	-13.0	
	household structure	zero_HH1Ad	single-adult households	1.364	4.7	single-adult households are less likely and those in two-adult households (with and without children) more likely to make escort other tours
		zero_HH1pe	one pensioner households	0.362	2.4	
		zero_HH2m	two-adult households with children	-0.719	-8.1	
	employment status	zero_FT	full-time workers	0.665	7.5	FT employed and disabled people are less likely, and those looking after family are more likely, to make escort other tours compared to others
		zero_Dis	disability that impacts mobility	0.412	2.5	
		zero_Fam	looking after family member	-0.364	-2.9	
	income	zero_I50p	income above £50k	-0.242	-3.1	those with incomes above £50k are more likely to make escort other tours
	population density	zero_dens	continuous population density	2.32E-05	2.9	those residing in areas with higher population density are less likely to make escort other tours
stop/go	*all segments*	stop	Constant	1.818	10.0	constant to ensure overall fraction of individuals making multiple tours is replicated
	car availability	stop_0CAL	no licence, but car in household	0.000	n/a	individuals from one- and two-plus car households make more tours than zero car households
		stop_1CPC	one car, car competition	-0.422	-2.0	
		stop_1CFC	one car, free car use	-0.472	-1.9	
		stop_2CPC	two-plus cars, car competition	-0.566	-1.6	
		stop_2cFC	two-plus cars, free car use	-0.360	-1.6	
	employment status	stop_Fam	looking after family member	-0.364	-2.9	those who look after the home or family are more likely to make multiple escort other tours

Car availability is a strong factor influencing the escort other frequency rates. Those residents in households with access to a car have the highest tour frequency rates, compared to households with no access to a car. The household structure terms reflect high tour rates for those household types where there are children in the household, who may need escorting to participate in out-of-home activities or to visit friends. We also observe slightly higher tour rates for those who are looking after home or family, and people in households with income greater than £50k. Compared to Phase 1 we observe one minor change to the specification. The age-specific terms for those aged between 41–50, 51–65 and 66 and over are no longer significant in the new model. However, we identified an age-related effect for people aged 51 and over, who are more likely to make other escort tours.

4.8. Home–other travel

The home–other travel purpose covers a range of activity types including personal business, visiting friends, recreation and leisure – any activity where the purpose is not work, business, education, shopping or escort. Home–other travel is observed across all age groups including children and therefore all individuals in the LTDS data on the travel day have been included in the analysis. Table 4-21 summarises the final other travel frequency estimation sample.

Table 4-21. Other travel tours made per weekday for persons aged 5 and above

Number of tours	Frequency	Per cent	Tours
0	21,900	73.23 %	0
1	5,131	23.01 %	5,131
2	626	3.24 %	1,252
3	88	0.43 %	264
4	8	0.08 %	32
5	4	0.01 %	20
6	1	0.00 %	6
Total	27,758	100.00 %	6,705
Tour rate	*0.241*		

The model parameters are presented in Table 4-22.

Table 4-22. Other travel frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate	t-ratio	Description
zero/ one-plus	*all segments*	zero	constant	1.096	26.5	constant to capture fraction making zero tours
	age	zero_aL16	aged under 16	1.205	18.4	children and those aged 76 and over make the least other travel tours, those aged 16 to 25 make the most
		zero_a1620	aged 16 to 20	0.000	n/a	
		zero_a2125	aged 21 to 25	0.000	n/a	
		zero_a1625	aged 16 to 25	-0.125	-2.0	
		zero_a76p	aged 76 and over	0.296	4.8	
	free bus pass	zero_Fpass	free bus pass holder	-0.573	-12.9	free bus pass holders are more likely to make tours
	car ownership	zero_1CPC	one car, car competition	-0.386	-8.5	individuals with higher car availability levels make more tours than zero-car households
		zero_1CFC	one car, free car use	-0.420	-8.5	
		zero_2pC	two-plus car households	-0.346	-8.7	
	household structure	zero_HH1Ad	single-adult households	-0.145	-2.4	single-adult households are more likely to make other tours, single pensioners are less likely to make other tours compared to other household types
		zero_HH1Pe	single pensioner households	0.114	2.4	
	employment status	zero_FT	full-time workers	1.071	22.9	those in employment and studying are less likely, and the unemployed are more likely, to make tours than other status groups
		zero_PT	part-time workers	0.462	7.0	
		zero_FTSE	FT workers, self-employed	0.529	8.4	
		zero_Un	unemployed	-0.349	-4.1	
		zero_St	school pupils and students	0.608	7.0	
stop/ go	*all segments*	stop	constant	2.422	33.1	constant to ensure overall fraction of individuals making multiple tours is replicated
	car availability	stop_1CPC	one car, car competition	-0.749	-7.1	individuals from car-owning households are more likely to make multiple other tours than zero-car households
		stop_1CFC	one car, free car use	-0.744	-6.5	
		stop_2pC	two-plus car households	-0.745	-7.6	

The status parameters show that worker and students groups make fewer other travel tours than other status groups, whereas the unemployed make more. These differences seem plausible given that these models are predicting tour rates on an average weekday in school term time and as such many workers will be at work during the day, reducing the time they have available to make other travel. Compared to Phase 1, there is one minor specification change to the age terms: we could not separately identify terms for those aged 16–20 and 21–25, and therefore these are replaced by a single term capturing those aged 16–25.

5. Non-home-based frequency model results

As described in Chapter 2, NHB travel is linked to the primary destination (PD) of associated HB travel, either as PD-based tours or detours to or from the PD. The PD of the HB tour is the production end of the NHB tour, and the frequency rate of NHB tours is estimated relative to the number of HB tours, unlike HB tours where the tour rates are defined relative to the total number of individuals available for the purpose in question. NHB travel associated with an HB tour[18] on a school term time day is modelled in the Phase 3 estimation work. The specification of the NHB frequency models remains unchanged compared to Phase 1 (although some insignificant or wrongly signed terms were dropped in the Phase 3 estimation).

The sub-sections below summarise the frequency model results for the NHB models.

5.1. PD-based tour frequency model results

Frequency models were estimated for three PD-based tour purposes, listed below (please refer to Fox & Patruni (2020)) for more details on NHB purpose aggregations):

1. Work-related PD to Work-related SD
2. Work-related PD to non-work-related SD
3. Non-work-related PD to non-work-related SD.

5.1.1. Work-related PD to work-related SD tours

The work-related PD to work-related SD frequency model is estimated from the combined sample of home-based work and home-based business tours. Table 5-1 below tabulates the observed frequency of PD-based tours made per work-related HB tour. The travel associated with this purpose will be business travel.

[18] Full home-based tours are only used, as the primary destination is unclear in case of half-tours.

Table 5-1. Work-related to work-related PD-based tours

Number of tours	Frequency	Per cent	Tours
0	9,367	98.5%	0
1	126	1.3%	126
2	13	0.2%	26
Total	9,506	100.0%	152
Tour rate	*0.016*		

Table 5-2 shows the model results. Household income, mode of travel used for accessing the primary destination, occupation and working status impact the frequency of work–work PD-based travel. Individuals who drive to their work-related PDs are more likely to make work-related NHB tours, compared to others. Working individuals with household income greater than £75k are also more likely to make NHB tours. Those individuals in blue collar and clerical/intermediate occupations are less likely to make work–work PD-based tours compared to those in managerial/professional occupations. Full-time workers are more likely to make work–work PD-based tours compared to part-time workers or students. Compared to Phase 1, terms for females and those in households with income between £50k and £75k are dropped, since we no longer observe significant impact on the frequency of work–work PD-based tours.

Table 5-2. Work-related to work-related tour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
0/1+ tours	*all segments*	zero	constant	4.287	29.8	constant to ensure fraction choosing zero tours is replicated
	gender	zero_fem	females	0.000	n/a	this term is no longer significant in the new model
	household income	zero_I5075	household income £50–75k	0.000	n/a	individuals from high-income households make more work-related tours
		zero_Igt75	household incomes of £75k and above	-0.438	-2.5	
	employment status	zero_PT	part-time workers and students	0.883	2.2	part-time workers and students make fewer tours compared to full-time workers
	occupation	zero_OInt	clerical and intermediate occupations	1.015	2.4	clerical and intermediate occupation types make the fewest tours, 'blue collar' occupation types make fewer tours than managerial and professional occupation types
		zero_blu	technical and craft occupations, semi-routine manual and service occupations, routine manual and service occupations	0.658	2.9	
	HB mode	zero_CarDr	choose car driver for HB tour	-0.660	-3.8	individuals who drive on their HB tour are more likely to make work-related PD-based tours
stop/ go	all segments	stop	constant	2.271	7.8	constant to ensure observed rate of multiple tour-making is replicated

5.1.2. Work-related PD to non-work-related SD tours

The PD-based work-related to non-work-related SD frequency model is also estimated from the combined sample of home-based work and home-based business tours. Table 5-3 tabulates the observed frequency of PD-based tours made per work-related HB tour.

Table 5-3. Work-related to non-work-related PD-based tours

Number of tours	Frequency	Per cent	Tours
0	8,852	93.1%	0
1	638	6.7%	638
2	14	0.2%	28
3	2	0%	6
Total	9,506	100.0%	662
Tour rate	*0.069*		

Table 5-4 summarises the model parameters. Household structure, the mode used for the corresponding HB tour, occupation and employment status impact the non-work tour rates made by individuals in the course of a work-related tour. HB tours made by those in single-person households generate more work-related NHB tours compared to those in other households.

Table 5-4. Work-related to non-work-related tour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
0/1+ tours	*all segments*	zero	constant	2.270	28.1	constant to ensure fraction choosing zero tours is replicated
	household income	zero_I75k	household income £75k-plus	0.000	n/a	income terms are no longer significant in the new model
	employment status	zero_PT	part-time workers and students	0.805	4.5	part-time workers and students make fewer tours
	occupation type	zero_OInt	clerical and intermediate occupations	0.000	n/a	
		zero_blu	technical and craft occupations, semi-routine manual and service occupations, routine manual and service occupations	1.363	9.8	'blue collar' occupation types make fewer tours than 'white collar' occupation types
	household structure	zero_1adlt	single-adult households	-0.638	-4.4	single-adult households make more tours
	HB mode	zero_CarD	choose car driver for HB tour	0.724	5.4	individuals who drive to their work related destination are less likely to make PD-based non-work related tours
		zero_Rail	choose rail for HB tour	-0.188	-2.0	individuals who take the train to their work destination PD more likely to make tours
stop/ go	all segments	stop	constant	3.593	13.9	constant to ensure observed rate of multiple tour-making is replicated

5.1.3. Non-work-related to non-work-related tours

The non-work-related frequency model is estimated from a sample of HB tours that are not work or business related. Table 5-5 below tabulates the observed frequency of PD-based tours made per non-work-related HB tour.

Table 5-5. Work to non-work PD-based tours

Number of tours	Frequency	Per cent	Tours
0	18,160	99.2%	0
1	139	0.76%	139
2	7	0.04%	14
Total	18,306	100.0%	153
Tour rate	*0.008*		

Compared to the PD-based tours made in course of work-related tours, the numbers of tours made on a non-work-related tour is considerably lower. Given the low sample size there are fewer explanatory variables than the other two PD-based purposes.

Table 5-6 summarises the model parameters. Compared to other age groups, we observe that people aged 16–20 are more likely to make more non-work-related PD-based tours, and those whose choice of mode of travel for the corresponding HB tour is car driver or rail are more likely to make a non-work-related PD-based tour than others.

Table 5-6. Non-work-related to non-work-related tour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
0/1+ tours	*all segments*	zero	constant	5.050	45.2	constant to ensure fraction choosing zero tours is replicated
	household income	zero_I515	household income under £15k p.a.	0.000	n/a	no longer significant in the new model
	employment status	zero_fam	looking after home or family	0.000	n/a	no longer significant in the new model
	age	zero_a1620	aged 16 to 20	-1.088	-4.3	those aged 16 to 20 make more tours than other groups
	HB mode	zero_CarDr	choose car driver for HB tour	-0.410	-2.1	individuals who drive or choose rail for their HB tour make more tours
		zero_Rail	choose rail for HB tour	-0.372	-1.4	
stop/ go	all segments	stop	constant	3.038	8.2	constant to ensure observed rate of multiple tour-making is replicated

5.2. Detour frequency model results

The detour frequency models are also estimated for the three purposes that are defined based on the purpose of the primary and secondary destinations respectively. However, unlike PD-based tours, detours can be made either on the outward leg (from SD to PD) or return leg (from PD to SD) of the corresponding full tour. We observe that the detour frequency rates are higher for return legs compared to outward legs, therefore for each purpose separate detour frequency models were estimated by tour leg. The six detour frequency models estimated were:

a. Work-related to work-related detours
   1) Work-related SD to work-related PD (outward tour leg)
   2) Work-related PD to work-related SD (return tour leg)
b. Work-related to non-work-related detours
   3) Non-work-related SD to work-related PD (outward tour leg)
   4) Work-related PD to non-work-related SD (return tour leg)
c. Non-work-related to non-work-related detours
   5) Non-work-related SD to non-work-related PD (outward tour leg)
   6) Non-work-related PD to non-work-related SD (return tour leg).

The sub-sections below summarise the model results.

5.2.1. Work-related to work-related detours

The work-related to work-related detour frequency models are estimated from the samples of commute and HB business tours. Table 5-7 tabulates the number of detours by outward and return HB tour legs. We observe a higher frequency rate for return detours compared to outward detours.

Table 5-7. Work-related outward and return detours made per HB work-related tour

	Outward: work-related SD to work-related PD		Return: work-related PD to work-related SD	
no detour	9,278	97.6%	9,207	96.2%
detour	228	2.4%	299	3.8%
Total	9,506	100.0%	9,506	100.0%
detour rate	0.024		0.031	

Table 5-8 and Table 5-9 summarise the model parameters for the outward and return work-related to work-related detour frequency models respectively.

Table 5-8. Work-related to work-related outward detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
detour / no detour	*all segments*	zero	constant	4.065	42.4	constant to ensure fraction choosing not to detour is replicated
	employment status	zero_PTSE	part-time self-employed	-0.974	-3.0	self-employed individuals make significantly more detours than employees and students
		zero_FTSE	full-time self-employed	-0.843	-5.4	
	occupation	Zero_OInt	clerical and intermediate occupations	0.597	1.9	clerical and intermediate occupations make significantly fewer detours than other occupation groups
	HB mode	zero_CarDr	choose car driver for HB tour	-0.786	-5.7	individuals who drive on their HB tour are more likely to detour compared to other modes except taxi
		zero_Taxi	choose taxi for HB tour	-1.070	-2.2	individuals who use taxi for their HB tour are more likely to detour compared to other HB modes

Table 5-9. Work-related to work-related return detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
detour / no detour	*all segments*	zero	constant	3.825	42.5	constant to ensure fraction choosing not to detour is replicated
	employment status	zero_PTSE	part-time self-employed	-0.874	-2.9	self-employed individuals make significantly more detours than employees and students
		zero_FTSE	full-time self-employed	-0.939	-6.8	
	occupation	Zero_OInt	clerical and intermediate occupations	0.598	2.1	clerical and intermediate occupations make significantly fewer detours
	age	age2125	aged 21 to 25	0.655	2.3	persons aged 21–25 less likely to detour
	HB mode	zero_CarDr	choose car driver for HB tour	-0.729	-6.0	individuals who drive on their HB tour are more likely to detour compared to other HB tour modes

Employment status, occupation and the mode used for the corresponding HB tour impact both detour frequency models. In both models, we observe that self-employed persons are much more likely to detour for a work-related activity than other worker types or students. This pattern is intuitive as self-employed workers are likely to access more than one workplace during a day. We also observe that those in clerical and intermediate occupations are less likely to detour compared to people in other occupation types.

In the outward detour frequency model, HB tours with taxi and car driver as the main mode choice are likely to generate more detours compared to other modes, and in the return detour model, we observe a similar effect on detour generation by HB car driver tours but no effect is identified for taxi tours. We also observe that those aged 21–25 are less likely to detour on the return leg for a work-related activity compared to other age groups. The specification of these models remains unchanged from Phase 1.

5.2.2. Work-related to non-work-related detours

The work-related to non-work-related detour frequency models are also estimated from the sample HB commute and HB business tours. Table 5-10 tabulates the number of detours by outward and return HB tour legs. Compared to work-related to work-related detours, we observe a higher frequency of making non-work-related detours to or from a work-related location. We also observe substantially more return detours than outward detours.

Table 5-10. Non-work-related outward and return detours made per HB work-related tour

	Outward: non-work-related SD to work-related PD		Return: work-related PD to non-work-related SD	
no detour	8,773	92.3%	8,165	85.9%
detour	733	7.7%	1,341	14.1%
Total	9,506	100.0%	9,506	100.0%
detour rate	0.077		0.141	

In Table 5-11 and Table 5-12 we summarise the frequency model parameters for the outward and return models. The model specification and the corresponding effects are similar between the outward and return detour models. In both models, we observe that females are more likely than males to detour for non-work-related purposes, part-time workers are more likely to detour than other worker types/students, and those in households with children are more likely to detour than other households. These results are plausible and could be associated, for example, with dropping children at school in the morning and travelling on to work or picking them up on the way back from work.

The impact of HB mode is different between the outward and return detour models. HB car driver tours are likely to generate more outward detours compared to HB tours by other modes. In the return detour model we do not observe this pattern, but we find that HB walk tours are less likely to generate return detours compared to HB tours by other modes. Compared to the Phase 1 model there are no changes in specification for the outward frequency model. However, we no longer find any effect on return detour-making by senior managers and those who used rail or car driver as the main mode for their corresponding HB tour, and as such these terms are dropped in the Phase 3 model.

Table 5-11. Work-related to non-work-related outward detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
detour / no detour	*all segments*	zero	constant	3.839	37.4	constant to ensure fraction choosing not to detour is replicated
	gender	zero_fem	females	-0.560	-6.4	females make more detours
	employment status	zero_PT	part-time workers	-0.694	-6.7	part-time workers make more detours
	occupation	Zero_Ble	technical and craft occupations, semi-routine manual and service occupations, routine manual and service occupations	0.470	4.8	'blue collar' occupation types make fewer detours
	household structure	zero_HH1Pa	single-parent households	-0.599	-3.9	single-parent and couple with children households more likely to detour
		zero_HH2wC	couple with children households	-1.672	-17.7	
	HB mode	zero_CarDr	choose car driver for HB tour	-0.710	-8.6	individuals who drive on their HB tour are more likely to detour

Table 5-12. Work-related to non-work-related return detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
detour / no detour	*all segments*	zero	constant	1.909	37.1	constant to ensure fraction choosing not to detour is replicated
	gender	zero_fem	females	-0.380	-6.1	females make more detours than males
	employment status	zero_PT	part-time workers	-0.362	-4.4	part-time workers make more detours compared to other worker types and students
	occupation	zero_Ble	technical and craft occupations, semi-routine manual and service occupations, routine manual and service occupations	0.705	9.3	'blue collar' occupation types make fewer detours, compared to those with 'white collar' occupation type
		zero_smgr	senior managers or administrators	0.000	n/a	
	household structure	zero_HH1Pa	single-parent households	-0.416	-4.7	single-parent households more likely to detour compared to other household types
	HB mode	zero_CarDr	choose car driver for HB tour	0.000	n/a	individuals who walk for their HB tour are less likely to make detours compared to those using other modes for their HB tour
		zero_rail	choose rail for HB tour	0.000	n/a	
		zero_walk	choose walk for HB tour	0.556	3.3	

5.2.3. Non-work-related to non-work-related detours

The non-work-related to non-work-related detour frequency models are also estimated from the sample of all HB tours, except commute and business. Table 5-10 tabulates the number of detours by outward and return HB tour legs. Compared to detours made from/to work-related locations, we observe a higher frequency of making non-work-related detours from/to non-work-related locations. Consistent with the other two purposes, we observe more return detours than outward detours.

Table 5-13. Non-work-related outward and return detours made per HB work-related tour

	Outward: non-work-related SD to non-work-related PD		Return: non-work-related PD to non-work-related SD	
no detour	16,201	88.5%	15,895	86.8%
detour	2,105	11.5%	2,411	13.2%
Total	18,306	100.0%	18,306	100.0%
detour rate	0.115		0.132	

The frequency model results for non-work-related tours associated with non-work-related HB tours is summarised in Table 5-14 and Table 5-15 for outward and return detours respectively. In both frequency models we find that females are more likely to detour than males, and those who are retired or not working are more likely to make detours compared to workers or students.

The impact of HB tour mode is different in the two models: those using car driver, car passenger and bus as their main HB tour mode are more likely to detour on the return leg compared to those using other HB modes, and those using car driver, cycle or walk are less likely to detour on the outward leg.

Compared to the Phase 1 model, we do not observe any effect for part-time self-employed workers or those living in single-parent households in the outward detour frequency model, and we do not find any effect for part-time self-employed workers and those living in households with greater than £75k income in the return detour model. These terms have therefore been dropped in the Phase 3 models.

Table 5-14. Non-work-related to non-work-related outward detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate and t-ratio		Description
detour / no detour	*all segments*	zero	constant	1.734	26.2	constant to ensure fraction choosing not to detour is replicated
	gender	zero_fem	females	-0.239	-4.8	females make more detours
	age	zero_aL16	aged 16 or under	0.888	10.7	children make more detours
	employment status	zero_PTSE	part-time self-employed	0.000	n/a	compared to workers, students make fewer detours, retired and other non-workers make more detours
		zero_st	students	0.747	6.5	
		zero_ret	retired persons	-0.310	-4.8	
		zero_oth	other non-worker groups	-0.176	-2.7	
	household structure	zero_nchld	couple without children	0.165	2.8	couple without children household less likely to detour
		zero_1prt	single parent	0.000	n/a	
	HB mode	zero_CarDr	choose car driver for HB tour	0.120	2.0	those using car driver, cycle and walk to access their PD are less likely to detour compared to those using other modes
		zero_CarP	choose car passenger for HB tour	0.000	n/a	
		zero_cycle	choose cycle for HB tour	0.538	2.7	
		zero_walk	choose walk for HB tour	0.914	14.9	

Table 5-15. Non-work-related to non-work-related return detour frequency model results

Model	Segmentation	Parameter name	Definition	Parameter estimate	and t-ratio	Description
detour / no detour	*all segments*	zero	constant	2.314	36.3	constant to ensure fraction choosing not to detour is replicated
	gender	zero_fem	females	-0.283	-6.2	females make more detours
	household income	zero_75kp	household income £75k-plus	0.000	n/a	no longer significant in the new model
	employment status	zero_PTSE	part-time self-employed	0.000	n/a	compared to workers, retired and non-working people are more likely to make detours and students are less likely to make detours
		zero_st	students	0.342	3.6	
		zero_ret	retired persons	-0.385	-6.1	
		zero_oth	other non-worker groups	-0.261	-3.1	
	household structure	zero_hwnc	couple with children	0.128	2.2	couple households make fewer detours
		zero_hwc	couple without children	0.067	1.1	
	HB mode	zero_CarDr	choose car driver for HB tour	-0.359	-6.3	car and bus users most likely to detour
		zero_CarP	choose car passenger for HB tour	-0.505	-7.6	
		zero_Bus	choose bus for HB tour	-0.507	-8.4	

6. Summary and Recommendations

This report summarises the development of the MoTiON Phase 3 frequency models. The Phase 3 models were estimated from FY 2015–2017 LTDS data and represent travel during an average weekday in school term time. Using the latest LTDS data and the update to the travel day definition represent an enhancement compared to the Phase 1 models, where LTDS data for calendar years 2010 to 2012 was used and the frequency models represented an average weekday across the year.

Frequency models were estimated for ten HB tour purposes: commute, employer's business, primary education, secondary education, tertiary education for 17 and 18 year olds, tertiary education for persons aged 19 and over, shopping, school escort, other escort, and other travel purposes. In all cases additional segmentation terms were incorporated to reflect better the structure of travel frequency observed in the LTDS data, and in the case of school escort a different model structure was represented to reflect better the observed pattern of travel frequency. The segmentation by purpose in the HB frequency models largely remains unchanged from Phase 1.

As expected, moving to an average school term day definition led to a substantial increase in the tour rate for the education and school escort purposes but had a smaller impact on other purposes. The tour rate analysis between the Phase 1 and Phase 3 LTDS datasets showed a general decline in tour rate across the majority of segments that influence shopping and other travel. A substantial decline in the tour rate was also observed for tertiary education travel but that decline is primarily driven by the decrease in the fraction of full-time students in the new LTDS data and a decline in the tour rate for non-students/workers in the sample, and these two factors in combination impacted the overall tour rate.

A detailed comparison against NTEM and LTDS trip-rates shows that despite the definitional differences, the NTEM and LTDS trip-rates validate well at an aggregate purpose level. However, we observe some differences at a detailed purpose level particularly for HB business, HB shopping and NHB other trips. The overall LTDS trip-rates is higher than NTEM by 7%, and a higher trip rate in LTDS is consistent with the survey definition, an average weekday during school term time for LTDS as opposed to an average weekday for NTEM.

The HB models capture the variation in tour frequency across a wide range of segmentation variables. There was little change in model specifications since Phase 1. The changes that were made in Phase 3 related to either dropping terms that were insignificant or counter-intuitive and revising the income band definitions to be consistent with the mode-destination models. The variables that were found to be important in explaining observed tour frequency varied by purpose, including gender, car availability, working status, disability, household income and household structure. For commute and business travel, working status was the most important segmentation variable; whereas for shopping, escort other and other travel, age, working status and car availability were important in explaining observed variation in travel frequency. For school escort travel the most important segmentation was the presence of children, although working status was also an important factor.

The NHB models are segmented according to the purpose of both the HB travel with which the travel is associated and the purpose of the NHB travel. For both NHB tours and NHB detours three purposes were distinguished: NHB travel that is work-related made during work-related HB tours, NHB travel that is non-work-related made during work-related HB tours, and NHB travel that is non-work-related made during non-work-related HB tours. Separate frequency models were developed for outward and return detours to reflect the higher frequencies of return detours. The purpose definitions remain unchanged since Phase 1.

As per the HB models, the segmentations found to be important in explaining NHB travel frequency varied by purpose. Gender, working status, occupation type, age, household income, household structure and mode used for the associated HB tour were found to explain NHB travel frequency. In particular, individuals who use car driver for their HB tour mode make more NHB travel.

To conclude the frequency models have been refreshed and now represent the observed travel behaviour of London residents on an average weekday during school term time. Moving to a school term day definition had led to an increase in the tour-rates for education and escort education purposes, as expected. We observe a slight decrease in the commute tours and a substantial decrease in the discretionary tour rates compared to Phase 1. However, the focus of the Phase 3 estimation was an update to the model considering the availability of new data and a change in the definition of travel day, as such a specification search was not undertaken. If the estimation of trip frequency model is revisited in future using latest LTDS data we recommend that the model specifications are revisited:

a. Test the impact of accessibility improvements on the frequency response via the mode-destination logsum.

b. Include existing LTDS variables that capture individual's behaviour with respect to items such as food, groceries, clothing, etc., being delivered to their home/work location. The frequency of deliveries would provide a greater insight into the decline of the shopping tour rate and may also provide quantification for the decline (or continued decline) in the shopping tour rate.

c. Undertake an analysis of the home–other sub-purposes[19] and revisit the specification adding sub-purposes to the frequency model, if necessary. It may be the case that the decline in home–other tour rate is not uniform across sub-purposes; for example, we may observe greater decline in entertainment/recreation tours compared to personal business tours, etc.

[19] Home-other travel includes personal business, leisure trip, holiday, visiting friends/relatives at home, entertainment/recreation, etc.

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