Transport Model for Scotland 2014 (TMfS14)

Transport Scotland

TMfS14 National Demand Model Development Report

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TMFS14 DEMAND MODEL DEVELOPMENT

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1 INTRODUCTION

1.1 Background

Transport Scotland plays a key role in the assessment of proposed changes to land use and transport networks across Scotland. As part of the planning process, Transport Scotland offers the use of its strategic transport and land use appraisal tools to assess the social, economic, operational, and environmental impacts of different land use options and transport interventions.

These appraisal tools include National integrated land use and transport models which cover the whole of Scotland. These National models include both the Transport Model for Scotland (TMfS) and the Transport, Economic, and Land-use Model of Scotland (TELMoS) which are both developed and maintained under Transport Scotland's Land Use and Transport Integration in Scotland service (LATIS).

For more information regarding the LATIS service and the National Transport and Land Use Models, please visit the LATIS website: www.transportscotland.gov.uk/latis

Transport Scotland requested the development of TMfS14 which is calibrated to transport and land use conditions observed during 2014, with this model being an update of the previous TMfS12. The TMfS14 development was to consider:

> *During the development of TMfS12 a number of additional data sources became available or were identified as missing, technical challenges were encountered, enhancements proposed and other models developed.*
>
> *TMfS shall incorporate the new data, technical updates and potentially the proposed enhancements. This model shall also have the specific objective of being suitable for supporting the Outline Business Case for improvements on the Inverness to Aberdeen transport corridor.*

This model is to be used to prepare a single (baseline) Forecast Scenario for the future years; 2017 – 2037 at five year intervals.

1.2 Introduction

In summer 2012 SIAS Limited (SIAS) was appointed as a nominated consultant within the Multiple Framework Agreement (MFA) for the Transport Planning, Modelling and Audit Services, Lot 1: Commission for the Maintenance and Enhancement of TMfS, which encompasses the maintenance and enhancement of the existing LATIS models.

The Transport Model for Scotland (TMfS12) was a "light touch" refresh of TMfS07 to 2012 conditions undertaken by SIAS throughout the first half of 2013. TMfS12 and its associated primary forecasts were circulated to all LATIS Framework Participants in the summer of 2013 for use on various applications. The primary focus of TMfS12 was its future application on the A9 Dualling between Perth and Inverness and therefore any updates to the model will also apply to this corridor.

In December 2014 SIAS provided Transport Scotland with an updated programme for the development of TMfS12A, an updated version of TMfS12 utilising the 2011 census travel to work data which had become available from the National Records for Scotland. Following this, Transport Scotland agreed that the demand model structure needs to change to include the ports and other zone disaggregation opportunities would also be included to take advantage of this change to the demand model.

Further TMfS12A scoping discussions took place which concluded on 28 May 2015, where Transport Scotland (TS) requested that SIAS and Peter Davidson Consultancy Limited (PDC) update TMfS12 to create TMfS14. The scope of this commission contains the following elements *(SIAS Ref. 78104,TMfS14 Specification Note, June 2016)*:

- Updating TMfS12 to a 2014 base year, thus creating TMfS14
- Establishing TMfS14/TELMoS14 requirements and features
- Incorporating 2011 census travel to work data
- Data collection, collation and assimilation
- Homogenising the zone system between the demand and assignment models
- Establishing a range of forecast scenarios for TMfS14/TELMoS14
- Calibration, validation and realism testing of the demand model
- Calibration and validation of the road and PT assignment models
- Updating the TMfS14 Trip End Model
- Preparing a release version of TMfS114
- Engagement with the LATIS Lot 3 participant David Simmonds Consultancy (Development, Update and Application of the Transport Economic Land-Use Model of Scotland (TELMoS)
- Preparation of updated technical and support documentation

The key changes to the TMfS14 demand model were as shown as follows:

- Additional Park & Ride sites added to the model
- Updated base year trip ends, re-basing the trip end model to a 2014 base year
- Mode and destination choice models re-estimated using household travel survey data and the observed matrices
- Updated vehicle occupancy inputs for 2014
- New incremental matrices to compensate for differences between the validated matrices and the synthesized base matrices
- Elasticity calculations for realism testing

This Report covers work undertaken to update the demand model from 2012 to 2014 base year. References in this Report to the Demand Model and Model refer to the 2014 update. If the previous TMfS07 or TMfS12 models are referred to it will be made clear in the text.

This Report describes the development, calibration, and validation of the TMfS14 National Road Model and is one of a series of documents describing the development, calibration, and validation of the TMfS14 models, as follows:

- TMfS14 National Road Model Development Report
- TMfS14 National Public Transport Model Development Report
- TMfS14 Demand Model Development Report
- TMfS14 Forecasting Report

1.3 Structure of this Report

The structure of the remainder of this Report is as follows:

- Section 2 Key model dimensions
- Section 3 Model overview
- Section 4 Updating the base year demand model
- Section 5 Estimation of mode and destination choice coefficients
- Section 6 Other updates
- Section 7 Sensitivity tests
- Section 8 Further examination of model responses
- Section 9 Forecasting procedures
- Section 10 Conclusions and recommendations.

2 KEY MODEL DIMENSIONS

2.1 Introduction

The main inputs to the TMfS14 Demand Model were:

- Updated trip ends from the trip end model
- 2014 demographic data from TELMOS
- New base year generalised cost matrices for Road and public transport modes
- Road and public transport networks
- Park & ride site files
- Validated base year trip matrices for the three main car journey purposes described below and for goods vehicles
- Incremental matrices
- Model parameters

The TMfS14 Model has a revised zone system with 799 zones. The additional zones are created by splitting some of the old zones into two or more new zones, thus allowing a clear correspondence to be developed between the two. The new zone system, as shown in Table 2.1, consists of:

- 779 internal zones; Zones 1 – 708 and 713 – 783
- 4 airport zones (Aberdeen, Edinburgh, Glasgow and Prestwick); Zones 709 – 712
- 16 external zones covering England and Wales; Zones 784 – 799

This change provides additional spatial detail and also ensures that all but one zone contains no more than one rail station per zone.

Table 2.1 : TMfS14 Zone Definition

	TMfS12	TMfS14
Internal zones	708	779
Airport zones	4	4
External zones	8	16
Total	720	799

The TMfS14 zone system has been aggregated to a nine sector system to assist in analysing the model. This sector system is illustrated in Figure 2.1.

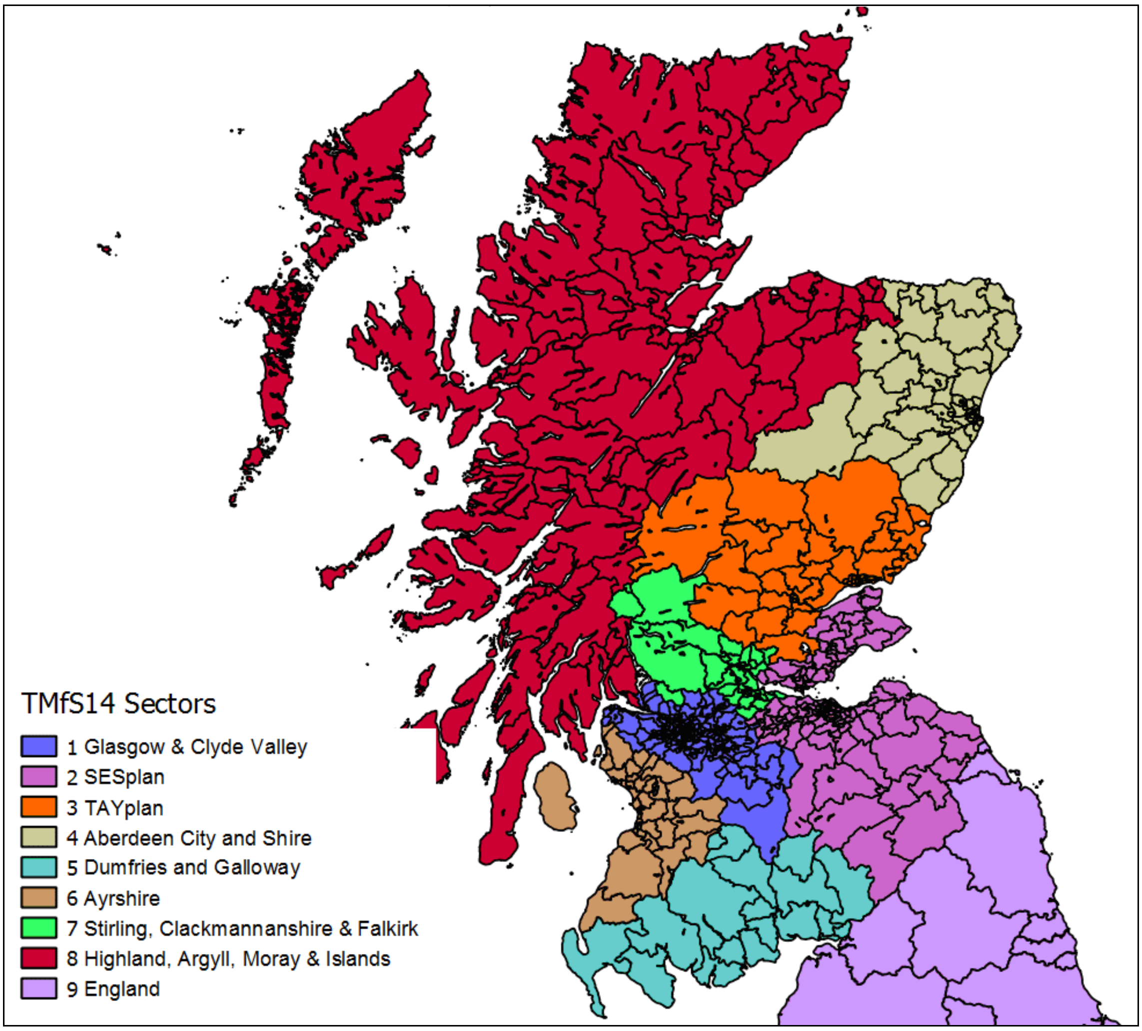


Figure 2.1 : TMfS14 Zone Sector Definition

The TMfS14 Demand Model consists of three main journey purposes with their definitions unchanged from TMfS12:

- Home-Based Work (HBW):
  Travelling 'From-Home' to work (and back again), a typical commuting journey Note: this travel purpose does not take place in employer's time
- Home-Based Other (HBO):
  Travelling 'From-Home' to a non-work-related location such as shopping or leisure (but excluding education)
- Home-Based Employer's Business (HBEB):
  Travelling 'From-Home' to a destination where you are in employer's time as soon as you leave the home

Three other journey purposes complement the above main purposes:

- Non-Home-Based Other (NHBO):
  Travelling between two Non-Home-Based locations (e.g. from work to shop)
- Non-Home-Based Employer's Business (NHBEB):
  Travelling during employer's time, such as travel from place of work to a business meeting, visiting customers, etc.
- Home-Based Education (HBS):
  Travelling 'From-Home' to an education destination (e.g. school, university, etc.).

These latter three purposes are not part of the main Demand Model, but are added separately after the mode and destination choice process, as part of the reverse factoring sub application.

Each journey purpose is segmented into four household types:

- C0
  Zero car households
  (everyone from these is considered to be captive to PT)
- C1/1
  1 car, 1 adult household
- C1/2+
  1 car, 2+adult household
- C2+
  2+ car household

Three main modes are considered in the Demand Model:

- Car
- Public transport (PT)
- Park & Ride

Separate demand models were developed for the morning peak (AM) and inter peak (IP) periods. Evening peak demand is extracted from the demand for the other time periods. The periods are defined as:

- AM Peak period 07:00 – 10:00
- AM peak hour (for assignment modelling) 08:00 – 09:00
- Inter peak period 10:00 – 16:00
- Inter peak hour (for assignment modelling) 1/6 of 10:00 – 16:00
- PM peak period 16:00 – 19:00
- PM peak hour (for assignment modelling) 17:00 – 18:00

Five user classes were used in the Road assignment supply model:

- Car in work time
- Car in commute time
- Cars in other time (shopping, leisure, etc.)
- Light goods vehicles (LGV)
- Heavy goods vehicles (HGV)

Each of these user classes has a separate set of weightings for distance and time, affecting the routeing that the Cube model calculates. These weightings also change across the modelled years.

The PT assignment assigns three user classes:

- PT in work time
- PT in commute time
- PT in other time (shopping, leisure, etc.)

Through the PT factor files (applied in route enumeration process) two different values of time are applied; one for travel in work time, and a separate, lower value for commute and other purposes.

2.2 Parking Charges

Parking charges are introduced by adding representative costs to the central area zones of:

- Aberdeen
- Dundee
- Dunfermline
- Edinburgh
- Glasgow
- Inverness
- Perth
- Stirling

Different costs are added in for different journey purposes. This is due to different types of journey having different average lengths of stay.

Appendix A describes how the parking charges have been included in the Model. It also describes the calculation of average parking charges in each city/town.

3 MODEL OVERVIEW

This section describes the model, based on reviewing the available documentation, Cube model, and code. Where appropriate, formulae have been included within the text and flow diagrams illustrating the processes have been presented in Appendix B.

3.1 Model structure

The TMfS14 Model is an extension of the conventional “four-stage” model, and incorporates the stages/choices listed as follows:

- Trip Generation Model
- Trip Frequency
- Macro Time of the Day Model
- Main Demand Module
- Assignment Models

The Macro time of the day and the Trip Frequency models are switched off by default in the TMfS07, TMfS12, and TMfS14 models. They have not been run in TMfS14, although the code has been checked to ensure that it is compatible with the updated model.

The Macro time of the day and the Trip Frequency models are turned off in the TMfS07, TMfS12, and TMfS14 models.

The Mode and Destination Choice Module forms the main choice mechanism within the TMfS14 model.

The Main Demand Module (shown in Appendix B, Figure 2) consists of the following sub-models:

- Mode and Destination Choice Module
- High Occupancy Vehicle (HOV) Choice Model
- Park & Ride Station Choice Model
- Long Distance Model
- Reverse Factoring and Non-Home-Based Module
- Assignment Preparation Module

The High Occupancy Vehicle Choice model is switched off by default and has not been tested in TMfS14. As with the Trip Frequency Model, the code has been checked to ensure that it is compatible with the updated model.

Appendix B, Figure 3 shows the structure of the Mode and Destination module and how the sub-models are connected. This module first executes the Initial Mode Choice Model (IMC) to produce initial trip ends by mode. The Destination Choice Model (DM) then distributes the trip ends for each mode to all available destination zones using a traditional gravity model. At this stage trip matrices for the three modes are produced.

For each mode and household type the composite cost of travel from each origin zone was calculated using a formulation similar to the traditional logsum.

$$\ln\left(\sum_i Trips_{ijmh}\right) - \ln\left(\sum_i \frac{Trips_{ijmh}}{\exp\left(\beta_{mh0} Intrazonal + \beta_{mh1}\ln\left(C_{ijmh}\right) + \beta_{mh2} C_{ijmh}\right)}\right)$$

These logsums are used to update the mode specific constants using the Mode Specific Parameters (MSP) module (on the first iteration). Finally, the modal share is updated using the Mode Choice (MC) model using the logsums and the mode specific constants as inputs. These updated mode shares are then used to update the trip matrices using the Distribution Model (DC), the logsums, and then the mode specific constants.

The resulting trip matrices by mode produced from the Mode & Destination choice module are ‘From-Home’ AM and IP trip matrices for the three main purposes (Home-Based Work, Home-Based Employers Business, and Home-Based Other). At this stage, if the HOV model had been turned on, it would have split the trips between each origin-destination pair for each mode and time period into High Occupancy Vehicle (HOV) trips and Single Occupancy Vehicle (SOV) trips. The Park & Ride trip matrices are then used as input by the Park & Ride Station Choice model to produce parking demand at each parking site.

The next stage produces evening peak (PM) ‘From-Home’ matrices from the IP ‘From-Home’ matrices using observed PM to IP factors. The resulting AM, IP, and PM ‘From-Home’ matrices are then used to create ‘To-Home’ AM, IP, and PM matrices. Finally, Non-Home-Based trip ends and trip matrices are derived from these matrices. All these processes are created by the Reverse Factoring module.

The final stage of the demand model involves preparing matrices for Road assignment using the Assignment Prep Module. At this stage external, long distance, and Education matrices, together with vehicle occupancy factors and period to hour factors are added to create five different user classes for Road assignment, and three user classes for PT assignment:

Road user classes:

- Car in work time
- Car in commute time
- Car in other time
- Light Goods Vehicles (LGV)
- Heavy Goods Vehicles (HGV)

PT user classes:

- PT in work time
- PT in commute time
- PT in other time

The final synthesised matrices, by Car user and PT user classes, are then ‘corrected’ with respect to the difference between the synthetic and validated (observed) base-year matrices using incremental matrices before assigning them.

The assignments generate a new set of cost matrices which go through the Generalised Cost Calculations module and are then fed back into the demand model to produce a new set of matrices. This demand-supply loop continues until convergence or a pre-defined number of iterations has been performed.

3.2 Initial modal share

The first time round the main demand-supply loop, the model uses a starting mode split between car and PT which comes in through the trip ends from the trip end model. The Park & Ride trips are then split out from the PT trip ends using a set of factors files. Later in this first iteration, and in subsequent iterations, the mode share will be recalculated as a function of the generalised costs and the mode specific parameters.

3.3 Destination choice model

The destination choice model for ‘From-Home’ purposes, uses the following inputs:

- Trip productions for car and public transport by each car availability segment
- Trip attractions/attraction factors for all modes and car availability types combined
- Generalised costs of travel by car and by Public Transport

These inputs are used to create matrices of person trips, separately by time period and trip purpose, for ‘From-Home’ trips. This process is carried out at a zonal level.

The process is a traditional gravity model process applied in a doubly constrained manner for ‘From-Home’ commute trips, and singly constrained for other ‘From-Home’ purposes. There are separate sensitivity parameters for each trip purpose/mode/household-type combination.

The spread parameters are β1, and β2. There are also Intra-Zonal factors β0, which affect the number of intra-zonal trips produced.

The outputs of this process are person trip matrices by time period, trip purpose/mode/car availability.

The estimated number of trips between each origin-destination pair is expressed as:

$$T_{ij} = P_i A_j \exp\left(\beta_0 I + \beta_i \ln\left(GC_{ij}\right) + \beta_2 GC_{ij}\right)$$

Where

P_i	Total number of trips generated by origin zone *i*
A_j	Total number of trips attracted to destination zone *j*
GC_{ij}	The generalised cost of travelling between zone *i* and *j*
I	Identity matrix whose cell value is 1 if *i* and *j* are in the same zone and zero otherwise

3.4 Composite cost calculation

This process follows the distribution model processes and calculates the logsum used in the mode choice process.

The matrices generated by the destination choice model along with the generalised costs by mode, as used in the destination choice model, are used to calculate a trip weighted composite cost for each origin zone.

The process was conducted separately for each 'From-Home' trip purpose and Car Available segment. For the Non-Car Available segments there is no mode choice, but the utilities are still calculated and input to the time of day choice and trip frequency choice processes. In the case of Car Available, the output utilities are used as input to the mode choice, time of day choice, and trip frequency choice processes.

The parameters β1, β2 and β0 shown in the formula below are the same parameters that were used to calculate the trips in the Destination Choice model:

$$Logsum_i = \ln T_i - \sum_j \frac{T_{ij}}{\exp\left(\beta_0 I + \beta_1 \ln\left(GC_{ij}\right) + \beta_2 GC_{ij}\right)}$$

Where

T_i The synthesised tripends for zone *i*

3.5 Mode Specific Parameters (MSP)

The forecast trip ends provided by the trip end model are the forecast trip ends based on base year costs, in other words they forecast future travel demand by zone and by mode based on demographic changes but assuming no change in travel costs from the base year.

When the model is run for future years, the demand model includes a process that calculates the MSPs so that they reproduce the forecast trip ends with base year costs. When the model is run for future years, the model initially creates the reference case Road and PT matrices for the year in question. These reference case matrices reflect expected land-use and car ownership changes (through the outputs provided by the trip end model) but take no account of cost changes.

As per TAG unit M2 2.5.12, which describes the reference case forecast as follows:

> *The construction of the reference case forecast requires reference case growth factors/assumptions and will involve the adjustment of the row and column of the base P/A matrix at an all-day all-modes level to reflect expected land-use and car ownership changes (taking no account of cost changes). As a default, these should be based on NTEM.*

The MSPs are calculated to ensure that when the demand model produces its first set of matrices (which use the base year costs), these matrices reproduce the mode shares given by the future year trip ends that came out of the trip end model. The mode split is then allowed to vary according to the changing generalised costs in the future year scenario.

So, the mode specific constants, (or K,) are calculated for each zone using the formulae given. This calculation is only carried out on the first iteration of the supply-demand loop and uses the generalised costs from the base year.

These matrices are then assigned to the future year Road and PT networks, and the generalised costs are calculated. The costs are then fed back in to the demand model for the second and subsequent iterations of the outer supply-demand loop and the modelled responses will then change on the basis of the differences between base year costs and forecast year costs.

Subsequent iterations, which will return a new set of generalised costs, will then use these MSP together with the new generalised costs to calculate the mode split in the mode choice model.

$$K_{i(Car)} = Lsum_{i(PnR)} - Lsum_{i(Car)} + \frac{1}{\theta}\ln\left(\frac{P_{i(Car)}}{P_{i(PnR)}}\right)$$

$$K_{i(PT)} = Lsum_{i(PnR)} - Lsum_{i(PT)} + \frac{1}{\theta}\ln\left(\frac{P_{i(PT)}}{P_{i(PnR)}}\right)$$

Where

$P_{i(Car)}$	Proportion of car trips generated from zone *i* in the base year
θ	Mode choice scaling factor
$Lsum$	Logsum or composite utility

These formulae were derived from the mode split formulation and are calculated for each journey purpose.

Note that they are relative to the Park & Ride Mode Constant ,which is set to zero.

3.6 Mode choice (MC) model

Mode Choice is undertaken at the trip end level. It uses the following inputs:

- Person trip productions by time period and household car-ownership level for 'From-Home' purposes
- Logsum composite utilities calculated from the destination choice model

The process is carried out for Car Available persons only; people from Non-Car Available households are assumed to be captive to public transport. The calculations are carried out separately for each purpose.

There are two types of parameter input:

- The scaling factors θ, which control the sensitivity of the mode choice process
- The mode specific parameters K, which ensure that the mode choice proportions in the model (when run with the base year reference costs) match the input trip end data at a zonal level

There are separate scaling parameters for each combination of mode, trip purpose, and household car ownership level.

The outputs of the process are vectors of trip productions by mode that are then taken back into the inner loop (that which iterates between the destination choice and mode choice processes) and input to the destination choice process, shown in Figure 3 of Appendix B.

$$U_{i(Car)} = \theta\left(Lsum_{i(Car)} + K_{i(Car)}\right)$$

$$P_{i(Car)} = \frac{\exp\left(U_{i(Car)}\right)}{\exp\left(U_{i(Car)}\right) + \exp\left(U_{i(PT)}\right) + \exp\left(U_{i(PnR)}\right)}$$

$$T_{i(Car)} = T_i * P_{i(Car)}$$

Where

$U_{i(Car)}, P_{i(Car)}$	Utility and probability of using car from zone i
$T_{i(Car)}, T_i$	Car trips and total trips originating from zone I respectively
θ	Mode choice scaling factor
$Lsum$	Logsum or composite utility

3.7 High Occupancy Vehicle choice model

If switched on, this model is executed after the mode and destination loop. The High Occupancy Vehicle (HOV) choice Model allows trips to move between single occupancy vehicles and multiple occupancy vehicles.

Note that the HOV choice is 'off' by default, so will not split the trips into single and high occupancy trip matrices at the time of writing.

The Module sits after the Inner Loops procedure, which loops over mode choice and destination choice within the Model structure, before the Park & Ride (P&R) station choice and reverse factoring applications. It works on the Home-Based Work, Home-Based Employers Business trips, and Home-Based Other trips for the household segments C1/1, C1/2+ and C2+.

The occupancy choice takes the form of a logit model using different generalised costs for Single Occupancy and High Occupancy trips. The person trip proportion of low occupancy for a particular ij pair will be:

$$P_{SO} = \frac{\exp(\beta GC_{SO})}{\exp(\beta GC_{SO}) + \exp(\beta GC_{HO} + \partial)}$$

Where

GC_{SO}, GC_{HO} Generalised cost for low and high occupancy respectively

∂ Is a high occupancy penalty for representing additional travel and difficulty in arranging passengers

β Is a sensitivity parameter of the logit model

The output of this is 'From-Home' matrices by purpose and segment for High Occupancy and Single Occupancy. These are then passed through the reverse trip process and converted into vehicle OD matrices using occupancy factors.

Finally, Road Assignment and Public Transport Assignment are undertaken. If there are specific High Occupancy Vehicle lanes, they need to be coded into the Model as a separate link type (the Road Model has link types for HOV only and HOV and HGV). The High Occupancy and Single Occupancy costs are then skimmed separately to be put back into the Demand Model.

3.8 Park & Ride station choice (SC) model

The Park & Ride Station Choice model follows the High Occupancy Vehicle Choice Model. It is applied to 'Car Available' trips 'From-Home' (produced by the Destination Choice Model) in the AM Peak Period only. The corresponding return trips are assumed to take place during the PM Peak period.

The inputs to the Station Choice model were:

- Park & Ride generalised cost.
- Park & Ride trip matrices.
  (From the Mode & Destination Choice models)
- Park & Ride Sites and their attributes.
  The attributes included Car Park charge (if any), the number of 'official' car parking spaces, and transfer times.

A single parameter, the calibrated transfer time attribute of each car park, aims to reflect a variety of attributes of the Park & Ride site (e.g. cleanliness, ease of transfer, and security) and was used as a calibration tool. This parameter does not vary with car occupancy, however, there is also an element of cost which does vary according to the demand for the site, also referred to as the transfer time.

The model operates in an iterative fashion. The process initially split the Park & Ride trips between each Origin-Destination pair across the available car parks using generalised cost; car park cost and the calibrated transfer time.

Sites that are over capacity have their associated transfer times increased as a function of the modelled demand and capacity at that site. This is to represent the increasing search and/or walk time associated with using the non 'official' car parking spaces.

The generalised costs were calculated from combinations of the Road and PT costs. Park & Ride cost matrices are the best path cost matrices. They are built by finding the minimum path from each origin to each Park & Ride site by car and then from there to each destination.

Park & Ride trips calculated from the Mode and Destination choice models are assigned to the Park & Ride sites using the logit formula:

$$U_{ij(S)} = \lambda(GC_{ij(S)} + TT_{ij(S)} + PC_{(S)})$$

$$P_{ij(s)} = \frac{\exp(U_{ij(s)})}{\sum_{s \in S} \exp(U_{ij(s)})}$$

$$T_{ij(s)} = T_{ij} * P_{ij(s)}$$

$$T_s = \sum_{i,j} T_{ij(s)}$$

Where

$GC_{ij(s)}$	Generalised cost of using car park s between each OD pair
$TT_{ij(s)}$	Transfer time of using car park s between each OD pair
PC_s	Parking cost for car park s
λ	Spread parameter for the park and ride station choice

The Park & Ride model works separately for each of the three main purposes. It calculates the Home-Based Work, Home-Based Employers Business and Home-Based Other trips simultaneously. The output is by site for each of the above purposes.

External trips (i.e. trips from England and Wales) do not have the choice of using Park & Ride as they are not included in the mode choice calculations. The Park & Ride model outputs AM ‘From-Home’ and PM ‘To-Home’ matrices by purpose and mode. These were added into the Road and PT assignment matrices before assignment.

3.9 Reverse and non-Home-Based trips model

This module is executed after the Park & Ride Station Choice model and the HOV Choice model. Although it does not interact with the Park & Ride model, it is included within the Park & Ride Model loop so that one of the cluster nodes runs the process in parallel with the Park & Ride Model. At this stage 'From-Home' AM and IP trips are produced for each of the three Home-Based purposes (Home-Based Work, Home-Based Employers Business and Home-Based Other), along with both 'From-Home' and 'To-Home' PM peak trip matrices.

Non-Home-Based AM, IP, and PM matrices are then created in the Non Home-Based Destination Choice section. The starting matrix is calculated from the generalised costs and then a fratar process is applied, in other words their destination choice is applied in the same manner as the Home-Based Work demand segment.

Creating 'To-Home' Trip matrices – 'From Home'

i For the 'From-Home' situation there were three time periods – AM Peak, Inter-Peak and Evening Peak, three Home-Based purposes – work (HBW), employer's business (HBEB) and other (HBO), and two modes, each by four Car Availability segments.

ii The 'To-Home' trips were calculated from the 'From-Home' trips as follows:

$$T_{ij(to)}^{TMP} = \sum_{t,p,m} (\alpha_{TPM}^{tpm} * T_{ji(from)}^{tpm})$$

Where

$T_{ij(to)}^{TMP}$	'To-Home' person trips from origin i to destination *j* in time period *T* for Home-Based purpose *P* by Mode *M*
$T_{ji(from)}^{tpm}$	'From-Home' person trips from origin *i* to destination *j* in time period *T* for Home-Based purpose *p* by Mode *m*
α_{TPM}^{tpm}	Factors by 'From-Home' time period *t*, 'From-Home' mode *m*, 'To-Home' time period *T* and 'From-Home' mode *M*

iii The parameters α_{TPM}^{tpm} were calculated from the results of the tabulations from the Scottish Household Survey. The details of return journeys for each 'From-Home' trip made by the sample adult were tabulated so that for each $T_{ji(from)}^{tpm}$ the return trips $T_{ij(to)}^{TMP}$ were included.

Creating 'To-Home' Trip matrices - 'Non-Home-Based'

i For Non-Home-Based trips, the origins and destinations for the two Non-Home-Based purposes (In-Work and Non-Work) were calculated based on the destinations of 'From-Home' trips and the origins of 'To-Home' trips. The Non-Home-Based, trip ends were calculated separately by time period

ii The Non-Home-Based origin trip ends were derived as follows:

$$O_i^n = \sum_{pt} \left(\beta_{j(to)}^{ntpm} * D_{j(to)}^{tpm} \right)$$

Where

n is the Non Home-Based purpose (i.e. Employers business and Other)

Note that the factors β are zero for time periods later than the Non-Home-Based origins/destinations

iii It is unlikely that the total origins would equal the total destinations when applying this process, so the totals were constrained to an average of the two. Matrices of Non-Home-Based trips by mode and time period were created by applying the trip ends to a distribution model using appropriate inter-zonal costs

iv The total trips by mode were calculated simply by adding the origin destination matrices together for Public Transport, and weighting by vehicle occupancy for car trips.

v Once the trip ends for the Non-Home-Based purposes were computed they were distributed to the available destination zones using the 'Fratar' method.

3.10 Assignment prep module

This module combines the matrices produced by the demand model with add-in matrices (such as education, long distance, and external trip matrices) and factors such as occupancy factors, period to hour factors, etc. to produce five user classes for Road assignment:

- Cars in work time
- Cars in commute time
- Cars in other time (e.g. shopping and leisure)
- Light Goods vehicles (LGV)
- Heavy goods vehicles (HGV)

The module also produces three user classes for PT assignment:

- PT in work-time
- PT in commute-time
- PT in other-time

The resulting matrices are then 'pivoted' using the incremental matrices before assignment.

3.11 Other choice models

These include the Trip Frequency Model, and the Macro Time of Day Model. They form part of the demand model and can be switched on or off by the user. They are switched off by default in TMfS07, TMfS12, and the current TMfS14.

3.12 Trip Frequency Model

The trip frequency model has not been reviewed or revised as part of this update., however, the description of this module from the TMfS12 update report has been retained for completeness.

Note that by default the trip frequency model is switched off.

The trip frequency module within the model is a simple elasticity model, with parameters based on a level of sensitivity to travel cost by purpose.

The trip frequency choice process adjusts the trip ends created by the trip end models according to whether the zonal level generalised cost of travel in the forecast is higher or lower than in the base year.

The inputs to the process are:

- Logsum composite utility for all modes and purposes for the base year, by zone
- Logsum composite utility for all modes and purposes for the forecast year, by zone
- Trip productions for all modes in persons

The trip productions are adjusted using a straightforward elasticity model, trip attractions are unaffected:

$$T_i^1 = T_i * \exp\left(\lambda(U_i - U_i^1)\right)$$

Where

T_i^1, T_i Tripends for the current and previous iteration resp.

U_i, U_i^1 The logsums for the previous and current iteration resp.

λ Is the sensitivity parameter of the logit model

And the logsums are calculated as:

$$U_i^1 = \log\left(\exp\left(\theta\left(U_{i(Car)}^1 + K_{i(Car)}^{1`}\right)\right) + \exp\left(\theta\left(U_{i(PT)}^1 + K_{i(PT)}^1\right)\right) + \exp\left(\theta\left(U_{i(PR)}^1 + K_{i(PR)}^1\right)\right)\right)$$

The parameters θ for each purpose within the demand model are all zero

The process is applied separately for each 'From-Home' trip purpose. The outputs of the process are person trip productions by time period for all modes for Car Available people. These form the inputs to the time period choice/mode choice.

3.13 Macro Time of Day Choice Model

The Macro Time of Day Choice Model has not been reviewed or revised as part of this update, however, the description of this module from the TMfS12 update report has been retained for completeness.

The Macro Time of Day Choice is applied to the AM 'From-Home' Trip Ends.

Note that it is switched off by default.

The time of day choice module takes as inputs logsum composite costs and trip ends (as amended by the trip frequency module if it is turned on). It is an incremental logit model, which compares the base and the forecast logsum utilities to amend the proportions of travellers in each time period.

Time of Day choice outputs are trip ends by each Car Availability segment, which then go into the main demand model.

$$T^1_{i(AM)} = T_{i(AM+IP+PM)} \frac{1}{\left(1 + A\exp\left(\beta\left(U^1_{i(IP)} - U^1_{i(AM)}\right)\right) + B\exp\left(\beta\left(U^1_{i(PRE)} + K^1_{i(AM)}\right)\right)\right)}$$

Where

T^1_i, T_i Tripends for the current and previous iteration respectively

U^1_i, U_i The logsums for the current and previous iteration respectively

β Is the sensitivity parameter of the logit model

And

$$A = \frac{T_{i(IP)}}{T_{i(AM)}}, B = \frac{T_{i(PRE)}}{T_{i(AM)}}$$

PRE' in a subscript in the equations above refers to the pre-peak period.

4 UPDATING THE BASE YEAR DEMAND MODEL

4.1 Introduction

Several updates were carried out within the changes for TMfS14. Among these: the model zone system was updated from 720 to 799 zones, the P&R model was updated to include additional sites, the base year trip end model was rebased to 2014 and adjusted to work with new data formats, mode and destination choice models were re-estimated and the incremental matrices were updated.

Further detail on the trip end model, mode and destination choice re-estimation and incremental matrices is provided as follows. This Report then goes on to describe the realism testing that was carried out with the updated model.

The Park & Ride was found not to converge and the base transfer time parameters and other aspects were adjusted to improve this.

4.2 Updating the trip end model base year

The trip end model was rebased to 2014. With the zone system extended from 720 zones in TMfS12 to 799 zones in TMfS14, the trip end model was also updated to use inputs and produce outputs with 799 zones.

The trip rates applied were also updated to use the NTEM 6.2 dataset and were applied by area type, although it was found that in practice the specific elements extracted from the NTEM dataset for use in TMfS14 had not changed from those applied in TMfS12.

Previous versions of TMfS applied the NTEM trip rates for a single area type to all model zones. TMfS14 applied the different rates according to the NTEM area types for model zones. This means that rather than assuming that all of the modelled zones related to one of NTEM's area types, each zone was assigned a different area type which allowed the trip end model to reflect differences in trip making between suburban and rural zones. Future year forecasts assume that the area types remain the same as in the base. Further details are provided in Appendix C.

New annual airport growth factors based on Department for Transport aviation forecasts *(UK Aviation Forecasts, DfT August 2011 www.gov.uk/government/uploads/system/uploads/attachment_data/file/4503/uk-aviation-forecasts.pdf*) were added which are summarised in the Table 4.1.

Table 4.1 : Airport Growth Factors

Zone	Airport	Growth
709	Edinburgh	5.588%
710	Prestwick	0.0%
711	Glasgow	2.371%
712	Aberdeen	1.213%

The trip end model used data derived from the base and future year land use model outputs to factor up the base year trip ends. A set of base year trip ends split by purpose and time period was produced from the 2014 observed matrices. The trip ends needed to be split by household car availability, which was not available in the observed matrices, so the household car availability split in the TMfS12 base year trip ends was applied to the 2014 trip ends.

The trip end model was updated with additional changes to handle the change in the format of the demographic input files from TELMOS, to take account of the increased number of zones and to aggregate over income bands. While the TMfS14 demand model is not currently disaggregated by income band this update could facilitate any future demand model update of this nature.

The 2014 land use data was then used in both the base and scenario inputs for the base year trip end model run as an initial test. The resulting output trip ends were identical to the inputs. Additional checks were then carried out using TELMOS data for a 2037 forecast year, confirming that the trip end model was working correctly.

5 ESTIMATION OF NEW MODE AND DESTINATION CHOICE COEFFICIENTS

5.1 Scope of update

The remit of the update was to re-estimate and update the coefficients rather than changing the model structure, which effectively has mode choice above destination choice in the hierarchy of responses.

It is, however, worth noting at this point that the estimations carried out appeared generally to support the view that destination choice is more sensitive than mode choice and should, thus, be beneath mode choice in the hierarchy. They therefore support the existing model structure and is consistent with WebTAG.

5.2 Methodology

Using the revealed preference information contained in the base year validated Road and PT trip matrices and network skims, the Visual Choice software package allowed the estimation of various model coefficients via discrete choice methodology.

There were various approaches available for estimation, and a number of constraints which needed to be taken into account. For example, use of a multinomial logit structure in the estimations would have been computationally quicker and easier than estimating a nested logit, but would not have produced scaling coefficients to apply to the mode choice. For the TMfS14 estimations a nested logit structure was used (with destination choice under mode choice) in order to obtain scaling coefficients, cost, log-cost, and intra-zonal coefficients. Nested choice models can be estimated by estimating each nest individually as multinomial logit, calculating the logsums and passing them up to the next level up in the hierarchy, however, it is much better , more robust, more rigorous, more theoretically sound and can give different answers if both nest levels are estimated simultaneously. We estimated both nest levels simultaneously, which is more difficult with unknown convergence and run times.

TMfS incorporates distinct coefficients for different household types which have different car-ownership levels, however, the estimation dataset, being based on the observed matrices, was not split by car availability level so separate estimations for 1 car, 2 car households, etc. could not be carried out. Instead the data was grouped to an all car available level and the estimations had to be carried out at this aggregate level.

We calculated zonal ASCs by hand for all zones in an iterative process. Firstly coefficients were be estimated based on no Alternative-Specific Constants (ASCs fixed at zero), these were run through the Cube demand model, then a set of ASCs were calculated to ‘correct’ the modelled share across destinations and modes predicted by the model. These were then input as fixed ASCs to a new estimation and the process repeated until the estimations are satisfactorily stable or converged.

With the nested logit structure and large number of zones, estimation run times were found to be very long. In order to allow overnight runs we adopted a sampling approach, working with just one part of the dataset at a time. The estimations were initially run with external (i.e. outside of the estimation software) calculation of 9 ASCs, one for each sector, however, under this approach the estimation process was not converging and the number of ASCs had to be increased to 32 based on division of the zones across local authority boundaries.

It was also found that the Park & Ride was not converging and so action was taken to try and address that problem and make the model converge (see Section 3.1). The Park & Ride non-convergence exacerbated the problems with run times, and with the non-convergence of the ASCs.

Each of these samples were still substantial sized datasets, and in combination with the sector-level ASCs allowed overnight estimations and 24hr turnarounds for a full iteration of estimation, running the demand model in Cube and calculating a new set of ASCs ready for the next estimation run. Iterations 2 and 3 of the 32 sector ASCs appeared to give the best overall set of ASCs, so iteration 3 was used.

5.3 Sample selection

Samples of the order of about 1,000 records were used, and a set of 10 estimations were made from 10 different sets of data for each trip purpose. The resulting coefficients were then averaged across the sampled subsets.

The samples were selected at random according to the following approach for each purpose:

1. The master set of all trip records for the purpose in question was created
2. The proportion of this dataset required to provide a sample of approximately 1,000 records was determined, i.e. 1 in every n records (e.g. 1 in 40 records)
3. Random starting point x within the first n records determined
4. Records x, x+n, x+2n, x+3n… selected to form the sample
5. The process was repeated to get all ten sets of trip records, ensuring that no record was used twice

5.4 Utility specification

The parameters included in the estimations were Road generalised cost, the PT generalised cost, two cost damping ln(GeneralisedCost) parameters (one for Road and one for PT), and an intrazonal factor. These are equivalent to the parameters that were using in the destination choice model in TMfS12 so the essential structure is unchanged. In order to improve the estimation of the above coefficients, Alternative Specific Constants (ASCs) were also estimated for each destination sector.

As described earlier, in the initial stages ASCs were calculated for each of the 9 model sectors. Following difficulty achieving convergence with this configuration an alternative set of 32 sub-sectors, based on local authority areas, was used.

Hence the utility functions used were as follows:

$$U_{j.Hwy} = \beta_0 Intra + \beta_1 \ln\left(C_{ij.Hwy}\right) + \beta_2 C_{ij.Hwy} + ASC_{j.Hwy}$$

and

$$U_{j.PT} = \beta_0 Intra + \beta_1 \ln\left(C_{ij.PT}\right) + \beta_2 C_{ij.PT} + ASC_{j.PT}$$

The model was estimated as a simultaneous nested logit, with mode choice above destination choice, producing structural parameters (scalar coefficients applied to each branch of the nest) for Road and public transport. These structural parameters are equivalent to the mode choice θ 'spread parameter' described in the *Transport Model for Scotland 2012 (TMfS12), TMfS12 Demand Model Development Report (SIAS Ref. 76888, February 2015).*

5.5 Resulting coefficients

The AM coefficients and their t-statistics are shown below in Table 5.1. The coefficients for the log of generalised cost for employer's business trips by car and for Home-Based Work and Home-Based Other by Public Transport were found to be positive and/or not statistically significant,
so these were removed from the utility equations and the estimations rerun.

Positive coefficients for elements of cost are somewhat counterintuitive and might lead to the model producing unreasonable outputs under certain circumstances, so it is best practice to remove the parameter from the utility equation and re-estimate.

The corresponding log cost coefficients in the TMfS14 Cube input files have thus been set to zero for these purposes.

Table 5.1 : AM Mode and Destination Choice Coefficients

AM Coefficients	HBW	HBW t-stat	HBEB	HBEB t-stat	HBO	HBO t-stat
β_0 intrazonal						
C0	0.03261	5	0.71662	3	2.33999	17
C11	0.69826	5	0.11701	3	1.67004	17
C12	0.73214	5	0.09935	3	1.50256	17
C2	0.77836	5	0.41808	3	1.10969	17
β_1 ln (cost)						
C11C	-0.24344	5	0	0	-0.23042	2
C12C	-0.24445	5	0	0	-0.07941	2
C2C	-0.21956	5	0	0	-0.06029	2
C11P	0	0	-0.12707	21	0	0
C12P	0	0	-0.13654	21	0	0
C2P	0	0	-0.46044	21	0	0
C0P	0	0	-0.12985	21	0	0
β_2 cost						
C11C	-0.06413	27	-0.04777	42	-0.05579	25
C12C	-0.0533	27	-0.04492	42	-0.05932	25
C2C	-0.05164	27	-0.9933	42	-0.05694	25
C11P	-0.02762	29	-0.02416	21	-0.03655	37
C12P	-0.02494	29	-0.02202	21	-0.0178	37
C2P	-0.02179	29	-0.00881	21	-0.02415	37
C0P	-0.03415	29	-0.05581	21	-0.03639	37
θ spread						
C11	0.63783708	28	0.875399	34	0.311254	11
C12	0.66539099	28	0.860596	34	0.207813	11
C2	0.65658193	28	0.230564	34	0.220133	11

5.6 Calculation of the Final AM Coefficients

5.6.1 Home-Based Other AM Coefficients

The calculation of the Home-Based Other AM coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.2. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.1.

The new coefficients that are in TMfS14 are in the column headed B-2c-v2 with their 't' statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS14 'All' value to the TMfS07 'All' value. The TMfS07 'All' value is the average of the coefficients split by car availability.

Table 5.2 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its 't' statistic.

Table 5.2 : Calculation of HBO AM Mode and Destination Choice Coefficients by Car Availability

HBO_AM	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Car Cost													
All	-0.06970	-0.621	20	-0.05868	21	-0.05900	21	-0.05893	21	-0.05735	25	-0.05936	21
C11	-0.06780	-0.06041	7%	-0.05708	8%	-0.05739	8%	-0.05732	-8%	-0.05579	-5%	-0.05774	-8%
C12	-0.07210	-0.06424	+0.0076	-0.0607	+0.0034	-0.06103	-0.0003	-0.06096	-0.0002	-0.05932	+0.0016	-0.614	-0.0004
C2	-0.06920	-0.06166	-11%	-0.05826	-6%	-0.05857	+1%	-0.0585	+0%	-0.05694	-3%	-0.05893	+1%
Car log cost													
All	-0.18007	-0.2182	1%	-0.18316	2	-0.16222	2	-0.16327	2	-0.12337	2	-0.14504	2
C11	-0.33630	-0.40752	73%	-0.34208	16%	-0.30298	20.00%	-0.30492	20%	-0.23042	52%	-0.27088	23%
C12	-0.11590	-0.14044	-0.0381	-0.11789	+0.035	-0.10442	+0.0209	-0.10509	+0.0199	-0.07941	+0.0399	-0.09335	+0.0182
C2	-0.08800	-0.10664	+0.21	-0.08951	-16%	-0.07928	-11%	-0.07979	-11%	-0.06029	-24%	-0.07088	-11%
PT cost													
All	-0.01808	-0.02998	30	-0.02971	29	-0.03027	30	-0.03006	30	-0.02872	37	-0.03051	30
C0	-0.02290	-0.03798	7%	-0.03764	7%	-0.03835	7%	-0.03808	7%	-0.03639	4%	-0.03866	7%
C11	-0.02300	-0.03814	-0.0119	-0.03780	+0.0003	-0.03852	-0.0006	-0.03825	-0.0004	-0.03655	+0.0013	-0.03882	-0.0005
C12	-0.01120	-0.01857	+0.66	-0.01841	-1%	-0.01876	+2%	-0.01862	+1%	-0.01780	-4%	-0.01891	+2%
C2	-0.01520	-0.02521		-0.02498		-0.02545		-0.02528		-0.02415		-0.02566	
PT log cost													
All	-1.61480	-0.05607	1	-0.03343	1	-0.01736	0	0	0	0	0	0	0
C0	-1.00000	-0.03472	63%	-0.02070	37%	-0.01075	93%	0	0%	0	0%	0	0%
C11	-1.47070	-0.05107	+1.5587	-0.03045	+0.0226	-0.01581	+0.0161	0	+0.0334	0	+0.0000	0	+0.0000
C12	-1.98950	-0.06908	-97%	-0.04119	-40%	-0.02139	-48%	0	-100%	0	0	0	0
C2	-1.99900	-0.06941		-0.04138		-0.02149		0		0		0	
Intrazonal													
All	-0.24020	1.59404	15	1.66625	16	1.69990	16	1.698782	16	1.65557	17	1.73180	16
C0	-0.3395	2.25308	9%	2.35508	9%	2.40265	9%	2.401067	9%	2.33999	7%	2.44773	9%
C11	-0.2423	1.60798	+1.8342	1.68081	+0.0722	1.71477	+0.0337	1.713634	+0.0325	1.67004	-0.0432	1.74694	+0.033
C12	-0.218	1.44672	-764%	1.51225	+5%	1.54279	+2%	1.541775	+2%	1.50256	-3%	1.57174	+2%
C2	-0.161	1.06845		1.11684		1.1394		1.13865		1.10969		1.16078	
Structural parameter													
All	0.31800	0.28042	12	0.28999	12	0.27162	12	0.28413	12	0.24640	11	0.27456	12
C11	0.4017	0.35423	7%	0.36632	5%	0.34311	6%	0.35892	5%	0.31125	11%	0.34683	5%
C12	0.2682	0.23651	-0.0376	0.24458	+0.0096	0.22908	-0.0184	0.23963	-0.0059	0.20781	-0.0377	0.23156	-0.0096
C2	0.2841	0.25053	-12%	0.25908	+3%	0.24266	-6%	0.25384	-2%	0.22013	-13%	0.24529	-3%
Iterations				8		7		8		9			
N		1198.3		1198		1198		1198		1198		1198	
Null LL		-8119.52		-8120		-8120		-8120		-8120		-8120	
Model LL		-5572.61		-5521		-5542		-5526		-5524		-5547	
Rho^2		0.31023		0.32		0.31		0.32		0.32		0.31	

Each coefficient has four values in the 't' statistic column. The first two, in blue, are the 't' statistic and the coefficient's standard deviation divided by the coefficient and expressed as a percentage. The final two, in black, are the change from the previous calculated value of the coefficient and this change as a percentage of the previous coefficient.

The ‘t’ statistic for each coefficient is the value in the final cell on the ‘All’ row and is expressed below this as a percentage. The value below this is the difference between the coefficient and the value obtained on the previous estimation run, again expressed in the cell below it as a percentage.

As explained earlier, the PT log cost coefficient was not estimated in the later runs as the earlier runs gave statistically insignificant values. The coefficients in Table 5.2 that are in TMfS14, the values in the B-2c-v2 column, were calculated from the average of ten runs as shown in Table 5.3 to Table 5.5. Each run is shown with its ‘t’ statistic.

Table 5.3 : Calculation of average AM Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 1-4)

HBO_AM-lnPT	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.05706	23.1	-0.05645	30.7	-0.05382	33.1	-0.0567	22.6
CarlnGenCost	-0.05764	1.2	-0.01868	0.4	-0.1472	3.6	0.01068	0.2
PTGenCost	-0.02803	36.4	-0.02983	35.0	-0.02699	36.0	-0.02981	33.7
PTlnGenCost								
Intrazonal	1.579827	16.1	1.60056	15.7	1.625197	16.4	1.82944	18.4
Structural 1	0.256	10.7	0.2229	10.4	0.2814	11.6	0.2215	9.9
Structural 2	0.256	10.7	0.2229	10.4	0.2814	11.6	0.2215	9.9
Iterations	9		9		7		9	
No of observations	1199		1198		1199		1198	
Null log likelihood	-8124.6		-8115.7		-8124.6		-8119.0	
Model log likelihood	-5569.3		-5561.5		-5564.9		-5494.9	
rhobarsquared	0.3116		0.3118		0.3122		0.3204	

Table 5.4 : Calculation of average AM Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 5-8)

HBO_AM-lnPT	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.05989	29.6	-0.05718	22.4	-0.05527	20.7	-0.0541	22.1
CarlnGenCost	-0.00925	0.2	-0.05363	1.0	-0.198787	3.9	-0.1596	3.3
PTGenCost	-0.03036	37.2	-0.0303	33.4	-0.028613	37.2	-0.0272	35.9
PTlnGenCost								
Intrazonal	1.65906	16.8	1.70117	17.0	1.491968	14.9	1.50359	15.2
Structural 1	0.2266	10.5	0.2266	10.4	0.2828	11.4	0.2903	11.6
Structural 2	0.2266	10.5	0.2266	10.4	0.2828	11.4	0.2903	11.6
Iterations	10		9		7		8	
No of observations	1198		1198		1199		1198	
Null log likelihood	-8116.4		-8114.9		-8124.5		-8118.6	
Model log likelihood	-5454.3		-5468.1		-5504.01		-5601.3	
rhobarsquared	0.3252		0.3233		0.3197		0.3072	

Table 5.5 : Calculation of average AM Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 9,10 and resulting Average)

HBO_AM-InPT	Run9	tstat	Run10	tstat	Average	Std. Dev.	Std. Dev as %	Avg. t
CarGenCost	-0.06018	23.4	-0.06284	23.7	-0.05735	0.003	-5%	25.1
CarInGenCost	0.07961	1.8	0.12193	2.5	-0.12337	0.065	-52%	2.5
PTGenCost	-0.02814	43.5	-0.02788	37.3	-0.02872	0.001	-4%	36.6
PTInGenCost								
Intrazonal	1.80496	18.8	1.75994	18	1.65557	0.118	7%	16.7
Structural 1	0.2287	10.3	0.2272	10	0.2464	0.028	7%	10.7
Structural 2	0.2287	10.3	0.2272	10	0.2464	0.028	11%	10.7
Iterations	9		10		8.7			
No of observations	1198		1198		1198.3			
Null log likelihood	-8118.78		-8118.18		-8119.521			
Model log likelihood	-5515.47		-5509.25		-5524.325			
rhobarsquared	0.3178		0.3185		0.31677			

Orange cells in the previous tables indicate that the run gave a positive coefficient that should be negative and red cells indicate a poor 't' statistic. These runs were omitted from the calculation of the average coefficient. It was only necessary to exclude certain runs on these grounds when calculating the AM Home-Based Other coefficients and all ten runs were used for the other coefficients. The standard deviation of the average is given both as an absolute value and a percentage. The 'Average' values in Table 5.5 are those in the 'All' rows in Table 5.2 and are used to calculate the coefficients by car availability as described previously. Similar sets of tables were used to obtain the coefficients for AM Home-Based Work and AM Employer's Business and for the same purposes in the inter peak.

The coefficients obtained are averaged from runs that produced coefficients of the correct sign – positive for the intrazonal and structural parameters and negative for the others – and had statistically significant 't' statistics greater than two. The rho bar squared values are around 0.32 for all runs and values above 0.2 are considered acceptable.

The ASCs used for the run are shown in Table 5.6. These were calculated by Local Authority area with separate ones for Road and Public Transport.

The ASCs were calculated using the same method described in the TMfS07 Demand Model Development Report:

$$ASC' = ASC + \ln\left(\frac{S_A}{S_F}\right)$$

Where:
ASC is the base ASC value;
ASC' is the new ASC value
S_A is the actual share; and
S_F is the modelled share.

Table 5.6 : ASCs by Local Authority area used in the AM Other run shown in Table 5.2 to Table 5.5

LA Area	HY ASCs	PT ASCs
Dunfries and Galloway	-0.0691	0.2243
Scottish Borders	0.2108	0.4638
East Lothian	0.0489	0.1799
Midlothian	0.0891	-0.2282
Edinburgh, City of	-0.1324	0.0183
West Lothian	-0.1673	-0.3226
South Lanarkshire	0.0068	-0.1545
East Ayrshire	0.0806	-0.4127
South Ayrshire	-0.0114	-0.115
North Ayrshire	0.1483	-0.4326
East Renfrewshire	0.0984	-0.3488
Glasgow City	-0.0086	0.0387
North Lanarkshire	-0.0148	-0.2484
Falkirk	0.0840	-0.1763
East Dunbartonshire	-0.1186	-0.3195
Renfrewshire	0.0931	0.0434
Inverclyde	0.106	0.2011
West Dunbartonshire	-0.0877	-0.1716
Stirling	-0.0561	-0.3534
Clackmannanshire	0.3642	-0.6513
Fife	0.0815	-0.0073
Perth and Kinross	0.0481	0.2091
Dundee City	0.2696	0.4577
Angus	-0.1118	-0.0915
Aberdeenshire	-0.2276	0.0035
Aberdeen City	0.059	0.3757
Moray	-0.0242	0.2799
Argyll and Bute	-0.2441	0.2935
Orkney Islands	-0.0748	-0.6264
Shetland Islands	0.2122	-1.059
Eilean Siar	0.0354	-0.8009
Highland	0.0079	0.2715

5.6.2 Home-Based Work AM Coefficients

The calculation of the Home-Based Work AM coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.7. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.1.

The new coefficients that are in TMfS14 are in the column headed B-2c-v2 with their ‘t’ statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS14 ‘All’ value to the TMfS07 ‘All’ value. The TMfS07 ‘All’ value is the average of the coefficients split by car availability.

Table 5.7 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its ‘t’ statistic

Table 5.7 : Calculation of HBW AM Mode and Destination Choice Coefficients by Car Availability

	HBW_AM	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Gamma HY	Car cost													
	All	-0.05097	-0.06062	22	-0.0601	21	-0.06001	21	-0.06	21	-0.05636	27	-0.06006	21
	C11	-0.05800	-0.06899	8%	-0.06839	8%	-0.06829	8%	-0.06828	8%	-0.06413	7%	-0.06835	8%
	C12	-0.04820	-0.05733	-0.0097	-0.05684	+0.0005	-0.05675	+0.0001	-0.05675	+0.0001	-0.05330	+0.0036	-0.0568	-0.0001
	C2	-0.04670	-0.05555	+19%	-0.05507	-1%	-0.05498	0%	-0.05498	0%	-0.05164	-6%	-0.05503	+0%
Beta HY	Car log cost													
	All	-0.63497	-0.22577	3	-0.21976	2	-0.22305	2	-0.22463	2	-0.23582	5	-0.22639	3
	C11	-0.65550	-0.23307	64%	-0.022687	39%	-0.23026	39%	-0.23189	38%	-0.24344	3%	-0.23371	38%
	C12	-0.65820	-0.23403	+0.4092	-0.2278	+0.0060	-0.23121	-0.0033	-0.23285	-0.0049	-0.24445	-0.0112	-0.23468	-0.0018
	C2	-0.59120	-0.21021	-64%	-0.20462	-3%	-0.20768	+1%	-0.20914	+2%	-0.21956	+5%	-0.21079	+1%
Gamma PT	PT cost													
	All	-0.02328	-0.02877	22%	-0.0292	22	-0.02829	21	-0.02881	22	-0.02713	29	-0.02856	21
	C0	-0.02930	-0.03622	5%	-0.03675	5%	-0.03561	6%	-0.03627	5%	-0.03415	3%	-0.03595	6%
	C11	-0.02370	-0.02929	-0.0055	-0.02973	-0.0004	-0.02880	+0.0009	-0.02934	+0.0004	-0.02762	+0.0017	-0.02908	+0.0003
	C12	-0.02140	-0.02645	+24%	-0.02684	+1%	-0.02601	-3%	-0.02649	-1%	-0.02494	-6%	-0.02626	-1%
	C2	-0.01870	-0.02311		-0.02346		-0.02273		-0.02315		-0.02179		-0.02295	
Beta PT	PT log cost													
	All	-0.59850	0	2	0	0	0.00000	0	0	0	0.00000	0	0	0
	C0	-0.04570	0	0	0	0	0.00000	0	0	0%	0.00000	0%	0	0%
	C11	-0.89610	0	+0.5985	0	+0.0000	0.00000	+0.0000	0	+0.0000	0.00000	+0.0000	0	+0.0000
	C12	-0.64380	0	-100%	0	0	0.00000	0	0	0	0.00000	0	0	0
	C2	-0.80840	0		0		0.00000		0		0.00000		0	
	Intrazonal													
	All	0.74920	0.589979	5	0.657576	5	0.64527	5	0.648171	5	0.56034	5	0.643520	5
	C0	0.0436	0.034334	19%	0.038268	17%	0.03755	18%	0.037721	18%	0.03261	22%	0.03745	18%
	C11	0.9336	0.73519	-0.1592	0.819424	+0.0676	0.80409	-0.0123	0.807704	-0.0094	0.69826	-0.0878	0.801910	-0.0047
	C12	0.9789	0.770863	-21%	0.859184	+11%	0.84310	-2%	0.846896	-1%	0.73214	-14%	0.840820	-1%
	C2	1.0407	0.819529		0.913426		0.89633		0.900362		0.77836		0.8939	
	Structural parameter													
	All	0.63777	0.7366	35	0.71779	33	0.70625	26	0.72519	34	0.65327	28	0.71435	33
	C11	0.6227	0.719198	6%	0.700833	10%	0.68957	8%	0.708058	9%	0.63784	13%	0.69747	8%
	C12	0.6496	0.750267	+0.0988	0.731108	-0.0188	0.71935	-0.0115	0.738645	+0.0074	0.66539	-0.0719	0.72760	-0.0108
	C2	0.641	0.740334	+15%	0.721429	-3%	0.70983	-2%	0.728867	+1%	0.65658	-10%	0.71797	-1%
	Iterations				25		19		25		19		0	
	N		1200		1200		1200		1200		1200		1200	
	Null LL		-8128		-8128		-8128		-8128		-8128		-8128	
	Model LL		-5596		-5599		-5599		-5586		-5587		-5577	
	Rho^2		0.31		0.31		0.31		0.31		0.30968		0.31	

The coefficients in Table 5.7 that are in TMfS14, the values in the B-2c-v2 column, were calculated from the average of ten runs as shown in Table 5.8 . Each run is shown with its ‘t’ statistic.

Table 5.8 : Calculation of average AM Home-Based Work coefficient from 10 estimation runs (Runs 1-4)

AM_NWC-InPT	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.05282	23.3	-0.0564	29.7	-0.05758	35.0	-0.0562	27.2
CarInGenCost	-0.31272	5.7	-0.2363	4.6	-0.21593	4.8	-0.26008	5.0
PTGenCost	-0.02514	27.3	-0.0277	29.4	-0.02647	30.9	-0.0278	28.4
PTInGenCost								
Intrazonal	0.69864	6.5	0.35103	2.9	0.58387	5.3	0.58693	5.2
Structural 1	0.8207	33.0	0.6221	28.2	0.6557	31.3	0.643	27.6
Structural 2	0.8207	33.0	0.6221	28.2	0.6557	31.3	0.643	27.6
Iterations	15		15		19		15	
No of observations	1201		1200		1201		1200	
Null log likelihood	-8132.0		-8124.9		-8134.1		-8124.7	
Model log likelihood	-5602.9		-5622.4		-5581.7		-5547.3	
rhobarsquared	0.3081		0.3051		0.3109		0.3144	

Table 5.9 : Calculation of average AM Home-Based Work coefficient from 10 estimation runs (Runs 5-8)

AM_NWC-InPT	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.06148	26.0	-0.06174	24.6	-0.0575	24.7	-0.05079	29.1
CarInGenCost	-0.10524	1.9	-0.10867	1.9	-0.12906	2.4	-0.40258	8.2
PTGenCost	-0.02735	27.7	-0.02714	28.4	-0.02657	29.6	-0.02804	29.4
PTInGenCost								
Intrazonal	0.38693	3.2	0.46948	4.0	0.66448	5.8	0.65311	6.0
Structural 1	0.5582	26.7	0.5598	26.0	0.5547	24.7	0.7561	28.5
Structural 2	0.5882	26.7	0.5598	26.0	0.5547	24.7	0.7561	28.5
Iterations	20		22		22		26	
No of observations	1200		1200		1201		1200	
Null log likelihood	8126.3		-8126.1		8133.7		-8124.7	
Model log likelihood	-5603.5		-5598.3		-5647.0		-5544.3	
rhobarsquared	0.3076		0.3082		0.3028		0.3147	

Table 5.10 : Calculation of average AM Home-Based Work coefficient from 10 estimation runs (Runs 9,10 and resulting average)

AM_NWC-InPT	Run9	tstat	Run10	tstat	Average	Std. Dev.	d. Dev as %	Avg. t
CarGenCost	-0.05193	26.43	-0.05711	22.78	-0.05636	0.004	-7%	26.89
CarInGenCost	-0.35504	6.874	-0.23257	4.133	-0.23582	0.102	-43%	4.548
PTGenCost	-0.02803	27.92	-0.02701	28.6	-0.02713	0.0009	-3%	28.76
PTInGenCost								
Intrazonal	0.67247	6.079	0.53649	4.75	0.56034	0.123	22%	4.989
Structural 1	0.6976	28.22	0.6648	29.35	0.65327	0.088	13%	28.35
Structural 2	0.6976	28.22	0.6648	29.35	0.65327	0.088	13%	28.35
Iterations	13		21		18.8			
No of observations	1200		1200		1200.3			
Null log likelihood	-8124.44		-8125.81		-8127.68			
Model log likelihood	-5548.93		-5575.93		-5587.23			
rhobarsquared	0.3141		0.3109		0.30968			

All ten runs were used to calculate the average as none needed to be excluded on account of poor ‘t’ statistics or positive coefficient values. The coefficients were obtained from a set of runs with good ‘t’ statistics and rho bar squared values.

5.6.3 Home-Based Employer's Business AM Coefficients

The calculation of the Home-Based Business AM coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.11. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.1.

The new coefficients that are in TMfS14 are in the column headed B-2c-v2 with their 't' statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS12 'All' value to the TMfS07 'All' value. The TMfS07 'All' value is the average of the coefficients split by car availability.

Table 5.11 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its 't' statistic.

Table 5.11 : Calculation of HBEB AM Mode and Destination Coefficients by Car Availability

	HBW_AM	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Gamma HY	Car cost													
	All	-0.05097	-0.06062	22	-0.0601	21	-0.06001	21	-0.06	21	-0.05636	27	-0.06006	21
	C11	-0.05800	-0.06899	8%	-0.06839	8%	-0.06829	8%	-0.06828	-8%	-0.06413	7%	-0.06835	8%
	C12	-0.04820	-0.05733	-0.0097	-0.05684	+0.0005	-0.05675	+0.00001	-0.05675	+0.00001	0.00000	+0.0036	-0.0568	-0.0001
	C2	-0.04670	-0.05555	+19%	-0.05507	-1%	-0.05498	-0%	-0.05498	-0%	-0.05164	-6%	-0.05503	+0%
Beta HY	Car log cost													
	All	-0.63497	-0.22577	3	-0.21976	2	-0.22305	2	-0.22463	2	-0.23582	5	-0.22639	3
	C11	-0.65550	-0.23307	64%	-0.22687	39%	-0.23026	39%	-0.23189	38%	-0.24344	43%	-0.23371	38%
	C12	-0.65820	-0.23403	+0.4092	-0.2278	+0.0060	-0.23121	-0.0033	-0.23285	-0.0049	-0.24445	-0.0112	-0.23468	-0.0018
	C2	-0.59120	-0.21021	-64%	-0.20462	-3%	-0.20768	+1%	-0.20914	+2%	-0.21956	+5%	-0.21079	+1%
Gamma PT	PT cost													
	All	-0.02328	-0.02877	22	-0.0292	22	-0.02829	21	-0.02881	22	-0.02713	29	-0.02856	21
	C0	-0.02930	-0.03622	5%	-0.03675	5%	-0.03561	6%	-0.03627	5%	-0.03415	3%	-0.03595	6%
	C11	-0.02370	-0.02929	-0.00055	-0.02973	-0.0004	-0.0288	+0.0009	-0.02934	+0.0004	-0.02762	+0.0017	-0.02908	+0.0003
	C12	-0.02140	-0.02645	+24%	-0.02684	+1%	-0.02601	-3%	-0.02649	-1%	-0.02494	-6%	-0.02626	-1%
	C2	-0.01870	-0.02311		-0.02346		-0.02273		-0.02315		-0.02179		-0.02295	
Beta PT	PT log cost													
	All	-0.59850	0	2	0	0	0.00000	0	0	0	0.00000	0	0	0
	C0	-0.04570	0	0	0	0	0.00000	0	0	0%	0.00000	0%	0	0%
	C11	-0.89610	0	+0.5985	0	+0.0000	0.00000	+0.0000	0	+0.0000	0.00000	+0.0000	0	+0.0000
	C12	-0.64380	0	-100%	0	0	0.00000	0	0	0	0.00000	0	0	0
	C2	-0.80840	0		0		0.00000		0		0.00000		0	
	Intrazonal													
	All	0.74920	0.58998	5	0.65758	5	0.64527	5	0.64817	5	0.56034	5	0.64352	5
	C0	0.0436	0.03433	19%	0.03827	17%	0.03755	18%	0.03772	18%	0.03261	22%	0.03745	18%
	C11	0.9336	0.73519	-0.1592	0.81942	+0.0676	0.80409	-0.0123	0.80770	-0.0094	0.69826	-0.0878	0.80191	-0.0047
	C12	0.9789	0.77086	-21%	0.85918	+11%	0.84310	-2%	0.84690	-1%	0.73214	-14%	0.84082	-1%
	C2	1.0407	0.81953		0.91343		0.89633		0.90036		0.77836		0.89390	
	Structural parameter													
	All	0.63777	0.73660	35	0.71779	33	0.70625	26	0.72519	34	0.65327	28	0.71435	33
	C11	0.6227	0.71920	6%	0.70083	10%	0.68957	8%	0.70806	9%	0.63784	13%	0.69747	8%
	C12	0.6496	0.75027	+0.0988	0.73111	-0.0188	0.71935	-0.0115	0.73865	+0.0074	0.66539	-0.0719	0.72760	-0.0108
	C2	0.641	0.74033	+15%	0.72143	-3%	0.70983	-2%	0.72887	+1%	0.65658	-10%	0.71797	-1%
	Iterations				25		19		25		19		0	
	N		1200		1200		1200		1200		1200		1200	
	Null LL		-8128		-8128		-8128		-8128		-8128		-8128	
	Model LL		-5596		-5603		-5599		-5586		-5587		-5577	
	Rho^2		0.31		0.31		0.31		0.31		0.30968		0.31	

The coefficients in Table 5.11 that are in TMfS14, the values in the B-2c-v2 column, were calculated from the average of ten runs as shown in Table 5.12 to Table 5.14. Each run is shown with its 't' statistic.

Table 5.12 : Calculation of average AM Employer's Business Mode and destination choice coefficients from 10 estimation runs (Runs 1-4)

AM_IW-InHy	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.06565	39.9	-0.06297	41.5	-0.06223	40.0	-0.06525	44.3
CarInGenCost								
PTGenCost	-0.02796	22.9	-0.02662	26.7	-0.02730	20.8	-0.02853	18.0
PTInGenCost	-0.21872	6.1	-0.25525	8.0	-0.16001	4.1	-0.30897	7.1
Intrazonal	0.25818	2.1	0.27276	2.2	0.37228	3.1	0.07910	0.6
Structural 1	0.64970	35.5	0.62930	33.8	0.71530	34.3	0.55100	28.1
Structural 2	0.64970	35.5	0.62930	33.8	0.71530	34.3	0.55100	28.1
Iterations	43		43		34		42	
No of observations	1235		1235		1235		1234	
Null log likelihood	-8368.7		-8370.2		-8370.3		-8362.1	
Model log likelihood	-5908.9		-6004.7		-6003.0		-5957.4	
rhobarsquared	0.2911		0.2797		0.2799		0.2847	

Table 5.13 : Calculation of average AM Employer's Business Mode and destination choice coefficients from 10 estimation runs (Runs 5-8)

AM_IW-InHy	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.06309	39.6	-0.06273	39.0	-0.06299	42.0	-0.06549	45.1
CarInGenCost								
PTGenCost	-0.02715	19.9	-0.02724	19.7	-0.02680	30.3	-0.02819	19.8
PTInGenCost	-0.23888	6.0	-0.17337	4.3	-0.14838	5.4	-0.22349	5.5
Intrazonal	0.37332	3.2	0.26602	2.1	0.49018	4.3	0.40329	3.5
Structural 1	0.62760	30.7	0.70910	35.1	0.75060	49.1	0.63520	32.5
Structural 2	0.62760	30.7	0.70910	35.1	0.75060	49.1	0.63520	32.5
Iterations	37		27		31		35	
No of observations	1235		1235		1235		1234	
Null log likelihood	-8371.5		-8370.8		8369.7		-8361.1	
Model log likelihood	-5983.3		-6004.2		-5975.9		-5901.3	
rhobarsquared	0.2824		0.2798		0.2831		0.2913	

Table 5.14 : Calculation of average AM Employer's Business Mode and destination choice coefficients from 10 estimation runs (Runs 9,10 and resulting Average)

AM_IW-InHy	Run9	tstat	Run10	tstat	Average	Std. Dev.	Std. Dev as %	Avg. t
CarGenCost	-0.06517	45.05	-0.06448	45.23	-0.064	0.001	-2%	42.16
CarInGenCost								
PTGenCost	-0.02859	17.65	-0.02860	18.17	-0.02770	0.001	-3%	21.38
PTInGenCost	-0.23915	5.373	-0.16854	3.807	-0.21348	0.051	-24%	5.567
Intrazonal	0.26589	2.253	0.33413	2.88	0.33777	0.081	24%	2.848
Structural 1	0.60860	29.99	0.67880	2.97	0.65552	0.059	9%	33.87
Structural 2	0.60860	29.99	0.67880	2.97	0.65552	0.059	9%	33.87
Iterations	22		22		33.6			
No of observations	1234		1235		1234.7			
Null log likelihood	-8361.45		-8372.52		-8367.83			
Model log likelihood	-5926.63		-5956.45		-5962.18			
rhobarsquared	0.2883		0.2857		0.2846			

All ten runs were used to calculate the average as none needed to be excluded on account of poor 't' statistics or positive coefficient values. As with the AM Commuting, a set of coefficients has been obtained from a set of runs that all had good 't' statistics and rho bar squared values.

5.7 Calculation of the Final IP Coefficients

The Inter Peak coefficients and their t-statistics are shown in Table 5.15. The coefficients for the log of PT generalised cost for Home-Based Work were found to be positive and were set to zero in TMfS14. For each purpose, these were derived in the same manner as the AM Home-Based Other described earlier.

Table 5.15 : IP Mode and Destination Choice Coefficients

IP Coefficients	HBW	HBW t-stat	HBEB	HBEB t-stat	HBO	HBO t-stat
β_0 intrazonal						
C0	0.03193	5	0.85013	3	1.37468	10
C11	0.6837	5	0.13881	3	0.9811	10
C12	0.71688	5	0.11785	3	0.88271	10
C2	0.76124	5	0.49597	3	0.65191	10
β_1 ln (cost)						
C11C	-0.19472	4	-0.33016	3	-0.39545	3
C12C	-0.19552	4	-0.33693	3	-0.13628	3
C2C	-0.17562	4	-0.19224	3	-0.10348	3
C11P	0	0	-0.22285	5	-0.31869	6
C12P	0	0	-0.23945	5	-0.43111	6
C2P	0	0	-0.80749	5	-0.43317	6
C0P	0	0	-0.22773	5	-0.21669	6
β_2 cost						
C11C	-0.0725	30	-0.04744	21	-0.06856	21
C12C	-0.06025	30	-0.04462	21	-0.07291	21
C2C	-0.05838	30	-0.09866	21	-0.06998	21
C11P	-0.02851	27	-0.02677	12	-0.03655	23
C12P	-0.02574	27	-0.0244	12	-0.0178	23
C2P	-0.02249	27	-0.00976	12	-0.02415	23
C0P	-0.03524	27	-0.06185	12	-0.03639	23
θ *spread*						
C11	0.787398	37	0.972672	29	0.490049	18
C12	0.821413	37	0.956224	29	0.327187	18
C2	0.810539	37	0.256184	29	0.346584	18

The calculations behind the IP Coefficients are shown as follows. The format of the tables is the same as for the AM tables.

5.7.1 Home-Based Other IP Coefficients

The calculation of the Home-Based Other AM coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.16. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.15.

The new coefficients that are in TMfS14 are in the columns headed B-2c-v2 and B2-b with their ‘t’ statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS12 ‘All’ value to the TMfS07 ‘All’ value. The TMfS07 ‘All’ value is the average of the coefficients split by car availability. The B2-b result was satisfactory and was not rerun for B-2c-v2.

Table 5.16 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its ‘t’ statistic

Table 5.16 : Calculation of average IP Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs.

	HBO_IP	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Gamma HY	Car cost													
	All	-0.06970	-0.04597	9	-0.06986	21	-0.0706	21	-0.07048	21	-0.07048	21	-0.07131	21
	C11	-0.06780	-0.04472	5%	-0.06795	8%	-0.06868	8%	-0.06856	8%	-0.06856	8%	-0.06936	8%
	C12	-0.07210	-0.04756	+0.0237	-0.07226	-0.0239	-0.07303	-0.0007	-0.07291	-0.0006	-0.07291	+0.0000	-0.07376	-0.0008
	C2	-0.06920	-0.04565	-34%	-0.06936	+52%	-0.0701	+1%	-0.06998	+1%	-0.06998	+0%	-0.07079	+1%
Beta HY	Car log cost													
	All	-0.18007	-1.2881	12	-0.23968	3	-0.20812	3	-0.21174	3	-0.21174	3	-0.18435	2
	C11	-0.33630	-2.40572	4%	-0.44764	42%	-0.38868	49%	-0.39545	48%	-0.39545	-48%	-0.34431	55%
	C12	-0.11590	-0.82909	-1.108	-0.15427	+1.0484	-0.13628	+0.0316	-0.13628	+0.0279	-0.13628	+0.0000	-0.11866	+0.0274
	C2	-0.08800	-0.62951	+615%	-0.11714	-81%	-0.10171	-13%	-0.10348	-12%	-0.10348	+0%	-0.09009	-13%
Gamma PT	PT cost													
	All	-0.01808	-0.0242	17	-0.02835	23	-0.02841	23	-0.02872	23	-0.02872	23	-0.02912	24
	C0	-0.02290	-0.03065	6%	-0.03592	5%	-0.03599	5%	-0.03639	5%	-0.03639	-5%	-0.0369	5%
	C11	-0.02300	-0.03079	-0.0061	-0.03607	-0.0042	-0.03615	-0.0001	-0.03655	-0.0004	-0.03655	+0.0000	-0.03706	-0.0004
	C12	-0.01120	-0.01499	+34%	-0.01757	+17%	-0.01760	+0%	-0.0178	+1%	-0.0178	+0%	-0.01805	+1%
	C2	-0.01520	-0.02035		-0.02384		-0.02389		-0.02415		-0.02315		-0.02449	
Beta PT	PT log cost													
	All	-1.61480	-0.79349	12	-0.39263	7	-0.41588	7	-0.34992	6	-0.34992	6	-0.31988	5
	C0	-1.00000	-0.49138	4%	-0.24314	24%	-0.25755	24%	-0.21669	28%	-0.21669	-28%	-0.19809	32%
	C11	-1.47070	-0.72268	+0.8213	-0.35759	+0.4009	-0.37877	-0.0233	-0.31869	+0.0427	-0.31869	+0.0000	-0.29134	+0.0300
	C12	-1.98950	-0.97761	-51%	-0.48373	-51%	-0.51239	+6%	-0.43111	-11%	-0.43111	+0%	-0.39411	-9%
	C2	-1.99900	-0.98228		-0.48604		-0.51483		-0.43317		-0.43317		-0.39599	
	Intrazonal													
	All	-0.24020	0.32697	2	0.93808	9	0.97267	10	0.97260	10	0.97260	10	1.00751	10
	C0	-0.3395	0.46214	17%	1.32589	12%	1.37478	12%	1.37468	12%	1.37468	+12%	1.42401	12%
	C11	-0.2423	0.32983	+0.5672	0.94628	+0.6111	0.98117	+0.0346	0.98110	+0.0345	0.98110	+0.0000	1.016310	+0.0349
	C12	-0.218	0.29675	-236%	0.85138	+18%	0.88277	+4%	0.88271	+4%	0.88271	+0%	0.91439	+4%
	C2	-0.161	0.21916		0.62877		0.65196		0.65191		0.65191		0.67531	
	Structural parameter													
	All	0.31800	0.85389	25	0.38038	18	0.36556	20	0.38794	18	0.38794	18	0.38866	18
	C11	0.4017	1.07864	4%	0.48050	9%	0.46178	8%	0.49005	9%	0.49005	+9%	0.49096	9%
	C12	0.2682	0.72017	+0.5359	0.32081	-0.4735	0.30831	-0.0148	0.32719	+0.0076	0.32719	+0.0000	0.32779	+0.0007
	C2	0.2841	0.76286	+169%	0.33983	-55%	0.32659	-4%	0.34658	+2%	0.34658	+0%	0.34723	+0%
	Iterations				#DIV/0!		17		#DIV/0!		#DIV/0!		#DIV/0!	
	N		1197		1197		1197		1197		########		1197	
	Null LL		-6913.21		-8122		-8122		-8122		########		-8122	
	Model LL		-3523.58		-5402		-5418		-5408		########		-5424	
	Rho^2		0.48774		0.33		0.33		0.33		0.33079		0.33	

The coefficients in Table 5.16 that are in TMfS14, the values in the B-2c-v2 and B2b columns, were calculated from the average of ten runs as shown in Table 5.17 to Table 5.19. Each run is shown with its ‘t’ statistic. This estimation was not rerun for the B-2c-v2 as the B2b run result was considered satisfactory.

Table 5.17 : Calculation of average IP Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 1-4)

IP_NWO	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.07245	22.4	-0.06642	38.5	-0.06888	22.4	-0.07263	18.4
CarInGenCost	-0.02482	0.3	-0.34315	5.0	-0.13440	1.6	-0.13215	1.3
PTGenCost	-0.02726	23.6	-0.02915	24.8	-0.02993	23.2	-0.03037	26.1
PTInGenCost	-0.28676	4.8	-0.46451	8.6	-0.17481	2.9	-0.29619	4.7
Intrazonal	1.17927	11.5	0.87014	8.6	1.12930	11.3	0.99145	9.4
Structural 1	0.3874	16.9	0.3575	19.0	0.4485	18.7	0.3741	18.3
Structural 2	0.3874	16.9	0.3575	19.0	0.4485	18.7	0.3741	18.3
Iterations								
No of observations	1198		1197		1198		1197	
Null log likelihood	-8126.2		-8118.3		-8127.5		-8118.2	
Model log likelihood	-5471.5		-5380.7		-5436.3		-5384.7	
rhobarsquared	0.3233		0.3339		0.3277		0.3334	

Table 5.18 : Calculation of average IP Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 5-8)

IP_NWO	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.06793	29.6	-0.07766	18.7	-0.06639	30.9	-0.07053	22.3
CarInGenCost	-0.30697	4.1	-0.12133	1.2	-0.37919	5.4	-0.17938	2.0
PTGenCost	-0.03021	23.7	-0.02864	22.1	-0.02632	21.2	-0.02938	24.4
PTInGenCost	-0.45303	7.9	-0.39463	6.1	-0.42913	7.9	-0.28776	4.8
Intrazonal	0.88682	8.8	0.90077	8.7	0.87214	8.5	1.03052	10.3
Structural 1	0.3448	18.7	0.3578	17.2	0.4387	18.4	0.4074	17.8
Structural 2	0.3448	18.7	0.3578	17.2	0.4387	18.4	0.4074	17.8
Iterations								
No of observations	1197		1198		1198		1197	
Null log likelihood	-8118.08		-8125.537		-8127.698		-8119.51	
Model log likelihood	-5360.17		-5349.341		-5399.704		-5401.8	
rhobarsquared	0.3364		0.3383		0.3323		0.3314	

Table 5.19 : Calculation of average IP Home-Based Other Mode and Destination Choice coefficients from 10 estimation runs (Runs 9, 10 and resulting Average)

IP_NWO	Run9	tstat	Run10	tstat	Average	Std. Dev.	Std. Dev as %	Avg. t
CarGenCost	-0.0699	21.73	-0.07207	18.46	-0.07048	0.003	-0.05	24.4
CarInGenCost	-0.16283	1.774	-0.14622	1.381	-0.21174	0.102	-0.48	2.63
PTGenCost	-0.02946	24.68	-0.02649	20.96	-0.02872	0.002	-0.05	23.5
PTInGenCost	-0.27834	4.641	-0.43401	6.413	-0.34992	0.098	-0.28	5.88
Intrazonal	1.02466	9.928	0.84092	8.073	0.97260	0.117	0.12	9.51
Structural 1	0.4018	18.06	0.3614	17.51	0.38794	0.036	0.09	18.1
Structural 2	0.4018	18.06	0.3614	17.51	0.38794	0.036	0.09	18.1
Iterations								
No of observations	1197		1197		1197.4			
Null log likelihood	-8118.03		-8118.97		-8121.8			
Model log likelihood	-5422.51		-5472.7		-5407.95			
rhobarsquared	0.3287		0.3225		0.33079			

All ten runs were used to calculate the average as none needed to be excluded on account of poor ‘t’ statistics or positive coefficient values. The sole exception was CarlnGenCost in Run1, which had a low ‘t’ statistic. A set of IP Commuting coefficients was therefore obtained from runs with good ‘t’ statistics and rho bar squared values.

The ASCs used for the run are shown in Table 5.20. These were calculated by Local Authority area with separate ones for Road and Public Transport.

Table 5.20 : ASCs by Local Authority area used in the IP Other run shown in Table 5.16 to Table 5.19

LA Area	HY ASCs	PT ASCs
Dumfries and Galloway	0.0181	0.2878
Scottish Borders	-0.0019	0.1531
East Lothian	-0.0603	0.1083
Midlothian	-0.2309	-0.145
Edinburgh, City of	0.1319	0.0491
West Lothian	-0.0646	0.0483
South Lanarkshire	0.0074	-0.1913
East Ayrshire	-0.0159	-0.0929
South Ayrshire	0.0736	0.0023
North Ayrshire	0.1554	-0.0082
East Renfrewshire	0.0929	-0.3984
Glasgow City	-0.0453	-0.1184
North Lanarkshire	-0.0477	-0.1125
Falkirk	-0.0196	-0.0018
East Dunbartonshire	-0.1747	-0.3496
Renfrewshire	-0.1361	-0.1051
Inverclyde	0.0795	0.2589
West Dunbartonshire	0.028	-0.1575
Stirling	-0.0387	-0.3334
Clackmannanshire	0.2109	-0.0104
Fife	-0.061	0.037
Perth and Kinross	-0.0578	-0.0888
Dundee City	0.2703	0.3451
Angus	-0.1356	0.0553
Aberdeenshire	-0.1123	0.1771
Aberdeen City	0.1279	0.1597
Moray	-0.0634	0.2011
Argyll and Bute	-0.1186	0.1468
Orkney Islands	0.0846	-0.1357
Shetland Islands	0.1903	-0.3755
Eilean Siar	0.0943	-0.2255
Highland	0.0318	0.246

5.7.2 Home-Based Work Coefficients

The calculation of the Home-Based Work IP coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.21. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.1.

The new coefficients that are in TMfS14 are in the column headed B-2c-v2 with their ‘t’ statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS14 ‘All’ value to the TMfS07 ‘All’ value. The TMfS07 ‘All’ value is the average of the coefficients split by car availability.

Table 5.21 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its ‘t’ statistic.

Table 5.21 : Calculation of average IP Home-Based Work coefficient from 10 estimation runs

	HBW_IP	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Gamma HY	Car cost													
	All	-0.05097	-0.06797	25	-0.06569	21	-0.06607	21	-0.06758	21	-0.06371	30	-0.06814	21
	C11	-0.05800	-0.07735	10%	0.07476	8%	-0.07518	-8%	-0.07691	-8%	-0.0725	-8%	-0.07754	-8%
	C12	-0.04820	-0.06428	-0.0170	-0.06213	+0.0023	-0.06248	-0.0004	-0.06391	-0.0019	-0.06025	+0.0039	-0.06444	-0.0006
	C2	-0.04670	-0.06228	+33%	-0.06019	-3%	-0.06054	+1%	-0.06192	+3%	-0.05838	-6%	-0.06244	+1%
Beta HY	Car log cost													
	All	-0.63497	-0.23129	3	-0.26844	4	-0.2546	4	-0.1355	3	-0.18862	4	-0.12628	3
	C11	-0.65550	-0.23876	82%	-0.27712	14%	-0.26283	14%	-0.13988	147%	-0.19471	34%	-0.13036	158%
	C12	-0.65820	-0.23975	+0.4037	-0.27827	-0.0372	-0.26391	+0.0138	-0.14046	+0.1329	-0.19552	-0.0531	-0.1309	+0.0092
	C2	-0.59120	-0.21534	-64%	-0.24994	+16%	-0.23705	-5%	-0.12616	-50%	-0.17561	+39%	-0.11757	-7%
Gamma PT	PT cost													
	All	-0.02328	-0.03135	21	-0.03059	20	-0.02868	19	-0.02966	19	-0.02799	27	-0.02865	19
	C0	-0.02930	-0.03947	4%	-0.03851	4%	-0.03611	4%	-0.03734	5%	-0.03524	4%	-0.03606	5%
	C11	-0.02370	-0.03192	-0.0081	-0.03115	+0.0008	-0.0292	+0.0019	-0.0302	+0.0009	-0.02851	+0.0017	-0.02917	+0.001
	C12	-0.02140	-0.02883	+35%	-0.02812	-2%	-0.02637	-6%	-0.02727	-3%	-0.02574	-6%	-0.02634	-3%
	C2	-0.01870	-0.02519		-0.02458		-0.02304		-0.02383		-0.02249		-0.02302	
Beta PT	PT log cost													
	All	-0.59850	0	0	0	0	0	0	0	0	0	0	0	0
	C0	-0.04570	0	0	0	0	0	0	0	0%	0	0%	0	0%
	C11	-0.89610	0	+0.5985	0	+0.0000	0	+0.0000	0	+0.0000	0	+0.0000	0	+0.0000
	C12	-0.64380	0	-100%	0	0	0	0	0	0	0	0	0	0
	C2	-0.80840	0		0		0		0		0		0	
	Intrazonal													
	All	0.74920	0.58998	5	0.59470	5	0.59847	5	0.61834	5	0.54866	5	0.62332	5
	C0	0.0436	0.03415	16%	0.03461	14%	0.03483	14%	0.03598	15%	0.03193	12%	0.03627	15%
	C11	0.9336	0.73133	-0.1623	0.74107	+0.0078	0.74577	+0.0038	0.77053	+0.0236	0.68370	-0.0697	0.77674	+0.0050
	C12	0.9789	0.76682	-22%	0.77703	+1%	0.78196	+1%	0.80792	+4%	0.71688	-11%	0.81443	+1%
	C2	1.0407	0.81523		0.82608		0.83132		0.85892		0.76214		0.86584	
	Structural parameter													
	All	0.63777	0.81458	40	0.89863	43	0.86540	33	0.86724	42	0.80645	37	0.81883	39
	C11	0.6227	0.79534	10%	0.87740	12%	0.84496	11%	0.84675	12%	0.78740	14%	0.79949	12%
	C12	0.6496	0.82969	+0.1768	0.91530	+0.0841	0.88146	-0.0332	0.88333	-0.0314	0.82141	-0.0608	0.83402	-0.0484
	C2	0.641	0.81871	+28%	0.90319	+10%	0.86979	-4%	0.87164	-3%	0.81054	-7%	0.82298	-6%
	Iterations				67		85		67		105			
	N		1190		1190		1190		1190		1190		1190	
	Null LL		-8086		-8086		-8086		-8086		-8086		-8086	
	Model LL		-5648		-5669		-5682		-5661		-5663		-5689	
	Rho^2		0.30		0.30		0.29		0.30		0.29673		0.29	

The coefficients in Table 5.21 that are in TMfS14, the values in the B-2c-v2 column, were calculated from the average of ten runs as shown in Table 5.22 to Table 5.24. Each run is shown with its ‘t’ statistic.

Table 5.22 : Calculation of average IP Home-Based Work Mode and Destination Choice coefficients from 10 estimation runs (Runs 1-4)

IP_NWC-InPT	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.06026	25.8	-0.06734	28.1	-0.06026	25.8	-0.05701	38.1
CarInGenCost	-0.1662	3	-0.00877	0.2	-0.1662	3	-0.23731	5.2
PTGenCost	-0.02764	25.5	-0.02911	27.4	-0.02764	25.5	-0.02856	27.7
PTInGenCost								
Intrazonal	0.54707	4.8	0.64055	5.7	0.54707	4.8	0.49132	4.2
Structural 1	0.899	40.5	0.651	31	0.899	40.5	0.8823	38.7
Structural 2	0.899	40.5	0.651	31	0.899	40.5	0.8823	38.7
Iterations	102		121		102		103	
No of observations	1190		1190		1190		1190	
Null log likelihood	-8086.8		-8086.2		-8086.8		-8086.3	
Model log likelihood	-5688.4		-5612.4		-5688.4		-5716.6	
rhobarsquared	-0.2936		0.303		0.2936		0.2901	

Table 5.23 : Calculation of average IP Home-Based Work Mode and Destination Choice coefficients from 10 estimation runs (Runs 5-8)

IP_NWC-InPT	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.07008	27.4	-0.07048	27.9	-0.06689	26.1	-0.06525	23.9
CarInGenCost	0.04598	0.8	0.040749	0.7	-0.05321	1	-0.05858	1
PTGenCost	-0.02732	26.7	-0.02823	28.1	-0.0282	27.7	-0.02523	24.7
PTInGenCost								
Intrazonal	0.61379	5.4	0.43283	3.6	0.4802	4.2	0.55663	4.8
Structural 1	0.7092	34.5	0.6629	33.9	0.769	37.9	0.9573	44.6
Structural 2	0.7092	34.5	0.6629	33.9	0.769	37.9	0.9573	44.6
Iterations	111		168		102		76	
No of observations	1190		1190		1190		1190	
Null log likelihood	-8086.5		-8085.7		-8086.5		-8086.4	
Model log likelihood	-5618		-5630.6		-5638.2		-5685.4	
rhobarsquared	0.3023		0.3007		0.2998		0.2939	

Table 5.24 : Calculation of average IP Home-Based Work Mode and Destination Choice coefficients from 10 estimation runs (Runs 9, 10 and resulting Average)

IP_NWC-InPT	Run9	tstat	Run10	tstat	Average	Std. Dev.	. Dev as %	Avg. t
CarGenCost	-0.0551	42.6	-0.06445	34.3	-0.06371	0.005	-8%	30.0
CarInGenCost	-0.26785	6.0	-0.10553	2.1	-0.18862	0.064	-34%	3.9
PTGenCost	-0.02849	27.4	-0.02954	27.2	-0.02799	0.001	-4%	26.8
PTInGenCost								
Intrazonal	0.54818	4.8	0.629	5.6	0.54866	0.067	12%	4.8
Structural 1	0.9077	39.4	0.7271	31.8	0.80645	0.114	14%	37.3
Structural 2	0.9077	39.4	0.7271	31.8	0.80645	0.114	14%	37.3
Iterations	65		101		105.1			
No of observations	1190		1190		1190			
Null log likelihood	-8085.92		-8086.81		-8086.39			
Model log likelihood	-5735.56		-5616.29		-5662.98			
rhobarsquared	0.2877		0.3026		0.29673			

All ten runs were used to calculate the average as none needed to be excluded on account of poor ‘t’ statistics or positive coefficient values. The exception was CarlnGenCost, where five of the runs were excluded on account of poor ‘t’ statistics or positive coefficient values. All the runs used had good ‘t’ statistics and rho bar squared values, so a good set of coefficients was obtained.

5.7.3 Home-Based Employer’s Business IP Coefficients

The calculation of the Home-Based Business IP coefficients by car availability from the overall coefficients produced by the estimations is shown in Table 5.25. This gives the TMfS07 parameter values in the TMfS07 column and the structural parameter is θ in Table 5.15.

The new coefficients that are in TMfS14 are in the columns headed B-2b and B-2c-v2 with their ‘t’ statistics in the following column. The coefficients are calculated by multiplying the TMfs07 coefficient for each car availability category by the ratio of the new TMfS12 ‘All’ value to the TMfS07 ‘All’ value. The TMfS07 ‘All’ value is the average of the coefficients split by car availability. As the B-2b results were satisfactory, the estimation was not rerun for B-2c-v2.

Table 5.11 also shows the previous and subsequent estimations. These have the names V4.1.1, B-1, B-2, B-2, B-2b, and B-3 and each is shown with its ‘t’ statistic

Table 5.25 : Calculation of HBEB IP Coefficients by Car Availability

	HBW_IP	TMfS07	V4.1.1	t-stat	B-1	t-stat	B-2	t-stat	B-2b	t-stat	B-2c-v2	t-stat	B-3	t-stat
Gamma H\	Car cost													
	All	-0.04317	-0.06352	27	-0.06239	21	-0.06346	21	-0.06357	21	-0.06357	21	-0.06503	21
	C11	-0.03222	-0.04741	11%	-0.04656	8%	-0.04736	-8%	-0.04744	-8%	-0.04744	-8%	-0.04853	-8%
	C12	-0.0303	-0.04458	-0.0204	-0.04378	+0.0011	-0.04454	-0.0011	-0.04462	-0.0012	-0.04462	+0.0000	-0.4564	-0.0015
	C2	-0.067	-0.09858	+47%	-0.09682	-2%	-0.09848	+2%	-0.09866	+2%	-0.09866	+0%	-0.10092	+2%
Beta HY	Car log cost													
	All	-1.11677	-0.3257	5	-0.32779	5	-0.28675	4	-0.28644	3	-0.28644	3	-0.25125	4
	C11	-1.28720	-0.3754	45%	-0.37782	44%	-0.33051	51%	-0.33016	51%	-0.33016	-51%	-0.2896	60%
	C12	-1.31360	-0.3831	+0.7911	-0.38557	-0.0021	-0.33729	+0.0410	-0.33693	+0.0413	-0.33693	+0.0000	-0.29554	+0.0352
	C2	-0.74950	-0.21859	-71%	-0.21999	+1%	-0.19245	-13%	-0.19224	-13%	-0.19224	+0%	-0.16863	-12%
Gamma P1	PT cost													
	All	-0.02328	-0.03018	18	-0.02969	17	-0.02968	17	-0.03069	12	-0.03069	12	-0.03186	18
	C0	-0.04690	-0.06081	10%	-0.05982	11%	-0.0598	11%	-0.06185	11%	-0.06185	-11%	-0.0642	12%
	C11	-0.02030	-0.02632	-0.0069	-0.02589	+0.0005	-0.02588	+0.0000	-0.02677	-0.0010	-0.02677	+0.0000	-0.02779	-0.0012
	C12	-0.01850	-0.02399	+30%	-0.0236	-2%	-0.02359	-0%	-0.0244	+3%	-0.02440	+0%	-0.02532	+4%
	C2	-0.00740	-0.00959		-0.00944		-0.00944		-0.00976		-0.00976		-0.01013	
Beta PT	PT log cost													
	All	-1.64400	-0.42363	6	-0.45301	7	-0.49459	8	-0.37438	5	-0.37438	5	-0.36106	6
	C0	-1.00000	-0.25768	33%	-0.27555	33%	-0.30084	32%	-0.22773	44%	-0.22773	-44%	-0.21962	52%
	C11	-0.97860	-0.25217	+1.2204	-0.26965	-0.0294	-0.29441	-0.0416	-0.22285	+0.0786	-0.22285	+0.0000	-0.21492	+0.0133
	C12	-1.05150	-0.27096	-74%	-0.28974	+7%	-0.31634	+9%	-0.23945	-17%	-0.23945	+0%	-0.23093	-4%
	C2	-3.54590	-0.91372		-0.97708		-1.06676		-0.80749		-0.80749		-0.77876	
	Intrazonal													
	All	-0.33455	0.32402	3	0.352550	3	0.4001	3	0.40069	3	0.40069	3	0.44309	4
	C0	-0.7098	0.68746	27%	0.74800	25%	0.84887	23%	0.85013	23%	0.85013	+23%	0.94009	21%
	C11	-0.1159	0.11225	+0.6586	0.12214	+0.0285	0.13861	+0.0475	0.13881	+0.0481	0.13881	+0.0000	0.15350	+0.0424
	C12	-0.0984	0.09530	-197%	0.10370	+9%	0.11768	+13%	0.11785	+14%	0.11785	+0%	0.13033	+11%
	C2	-0.4141	0.40106		0.43639		0.49523		0.49597		0.49597		0.54845	
	Structural parameter													
	All	0.61553	0.69341	29	0.72103	28	0.67726	26	0.72836	29	0.72836	29	0.66945	26
	C11	0.822	0.92600	10%	0.96288	11%	0.90443	10%	0.97267	13%	0.97267	+13%	0.89400	12%
	C12	0.8081	0.91034	+0.0779	0.94660	+0.0276	0.88914	-0.0438	0.95622	+0.0073	0.95622	+0.0000	0.87888	-0.0589
	C2	0.2165	0.24389	+13%	0.25361	+4%	0.23821	-6%	0.25618	+1%	0.25618	+0%	0.23546	-8%
	Iterations				35		31		35		35			
	N		1265.1		1265		1265		1265		1265		1265	
	Null LL		-8593.46		-8593		-8593		-8593		-8593.46		-8563	
	Model LL		-6010.39		-5984		-6004		-5994		-5993.78		-6033	
	Rho^2		0.29725		0.30		0.30		0.30		0.29925		0.29	

The coefficients in Table 5.25 that are in TMfS14, the values in the B-2c-v2 and B2b columns, were calculated from the average of ten runs as shown in Table 5.26 to Table 5.28. Each run is shown with its ‘t’ statistic. As with the IP Home-Based Other, this estimation was not rerun for the B-2c-v2 as the B2b run result was considered satisfactory.

Table 5.26 : Calculation of average IP Employer's Business Mode and Destination Choice coefficients from 10 estimation runs (Runs 1-4)

IP_IW	Run1	tstat	Run2	tstat	Run3	tstat	Run4	tstat
CarGenCost	-0.06324	27.8	-0.06562	20.2	-0.05927	32.5	-0.04658	53.9
CarInGenCost	-0.28024	4.0	-0.25701	2.9	-0.32713	4.9	-0.64565	12.4
PTGenCost	-0.02861	28.4	-0.02964	17.3	-0.03444	15	-0.02453	15.5
PTInGenCost	-0.48373	9.4	-0.37919	5.4	-0.37381	5.2	-0.73677	13.2
Intrazonal	0.34273	3.0	0.3692	3.1	0.51137	4.5	0.23189	2.0
Structural 1	0.6607	26.8	0.746	30.3	0.6481	27.3	0.6471	25.1
Structural 2	0.6607	26.8	0.746	30.3	0.6481	27.3	0.6471	25.1
Iterations	37		36		35		51	
No of observations	1266		1265		1265		1265	
Null log likelihood	-8598.3		-8591.6		-8593.2		-8593.2	
Model log likelihood	-6007.8		-5968.6		-6005.8		-6128.1	
rhobarsquared	0.298		0.302		0.2978		0.2835	

Table 5.27 : Calculation of average IP Employer's Business Mode and Destination Choice coefficients from 10 estimation runs (Runs 5-8)

IP_IW	Run5	tstat	Run6	tstat	Run7	tstat	Run8	tstat
CarGenCost	-0.06685	20.0	-0.06110	-20.1	-0.06677	19.6	-0.07207	21.5
CarInGenCost	-0.14341	1.6	-0.30450	-3.5	-0.24064	2.6	-0.10292	1.1
PTGenCost	-0.03316	13.1	-0.02730	-27.6	-0.03055	15.3	-0.03569	13.9
PTInGenCost	-0.17198	2.1	-0.36320	-6.2	-0.47785	6.4	-0.23938	2.9
Intrazonal	0.51067	4.4	0.46500	4.1	0.30172	2.6	0.45216	4.0
Structural 1	0.8299	30.9	0.8423	38.8	0.6201	24.8	0.6777	26.0
Structural 2	0.8299	30.9	0.8423	38.8	0.6201	24.8	0.6777	26.0
Iterations	33		35		34		27	
No of observations	1265		1265		1265		1265	
Null log likelihood	-8594.0		-8592.3		-8592.3		-8591.7	
Model log likelihood	-6001.4		-6024.3		-5951.6		-5905.8	
rhobarsquared	0.2983		0.2961		0.304		0.3093	

Table 5.28 : Calculation of average IP Employer's Business Mode and Destination Choice coefficients from 10 estimation runs (Runs 9, 10 and resulting average)

IP_IW	Run9	tstat	Run10	tstat	Average	Std. Dev.	Std. Dev as %	Avg. t
CarGenCost	-0.06746	30.18	-0.06676	19.18	-0.06357	0.007	-11%	22.48
CarInGenCost	-0.19884	2.776	-0.18057	1.94	-0.28644	0.147	-51%	3.285
PTGenCost	-0.03183	14.53	-0.03119	13.69	-0.03069	0.003	-11%	11.92
PTInGenCost	-0.30866	4.426	-0.20923	2.615	-0.37438	0.165	-44%	4.542
Intrazonal	0.41804	3.588	0.40414	3.461	0.40070	0.091	23%	3.474
Structural 1	0.7327	26.25	0.879	33.22	0.72836	0.093	13%	28.95
Structural 2	0.7327	26.25	0.879	33.22	0.72836	0.093	13%	28.95
Iterations	36		25		35			
No of observations	1265		1265		1265			
Null log likelihood	-8593.64		-8594.49		-8593.46			
Model log likelihood	-5958.04		-5986.59		-5993.78			
rhobarsquared	0.3034		0.3001		0.29925			

All ten runs were used to calculate the average as none needed to be excluded on account of poor ‘t’ statistics or positive coefficient values except for Run 8 CarinGenCost, which had a poor ‘t’ stat. All the other ‘t’ statistics and rho bar squared vales were acceptable, so an acceptable set of coefficients was obtained.

6 OTHER UPDATES

The vehicle occupancy matrices were updated to be in line with the trends from the November 2014 WebTAG guidance *(November 2014 – webtag-data-boook-may2014.xlm)*, sheet A1.3.3.

New Park & Ride sites with their capacities and costs (where appropriate) were added to the Park & Rite site file with their transfer times set to zero. The Park & Ride model was run for one iteration and the resulting calculated transfer times were set as the base transfer times.

6.1 New incremental matrices

TMfS14 makes use of incremental matrices which are an adjustment applied to the synthetic matrices output from the mode and destination choice and reverse factoring processes.

The base year validated matrices were accepted as the best representation of the base year travel pattern and so the incremental matrices are conceptually the ‘correction’ required to arrive at these matrices from a starting point of the synthetic base year matrices produced by the demand model.

The incremental matrices remain constant for all model runs and the same adjustment or ‘correction’ is applied to the forecast year synthesised trip matrices which are produced by forecast runs of the Demand Model.

As part of the TMfS14 update the new incremental matrices were developed such that, when run for 2014, the trip matrices output by the first iteration of the demand model match precisely the validated 2014 base year assignment matrices.

The cells of the incremental matrices were generated in one of two ways:

Case 1 $$F = S_f + (B - S_b)$$

Case 2 $$F = S_f * \left(\frac{B}{S_b}\right)$$

Where
B Base observed trips
S_b Base modelled (synthesised) trips
S_f Future modelled (synthesised) trips
F Future Trips

The following cases were defined when creating or applying the incremental matrices:

Case 1:
Was used where B is zero or where we have high B and low Sb, defined as the case where B/Sb>2.

Case 2:
Was used in the following circumstances:

- Low B, high Sb
- Low B low Sb
- High B high Sb

This allowed zero cells in the base year to be incremented using Case 1 and avoids applying high multiplicative factors. The bracketed terms above form the incremental matrices. The equations show how they are applied in forecasting.

6.2 Park & Ride model update

The inputs to the site choice calibration are the Park & Ride generalised costs and Park & Ride sites. Each site file contains a specification of the site catchment area, which are defined as a list of zones, which in nearly every case are all other zones.

The site file also contains the Car Park Charge (if any) and the number of 'official' car parking spaces.

Note the Park & Ride station choice model allows users to park outside the 'official' car parking spaces, as is the reality at a number of stations.

Each Park & Ride site also has a calibrated transfer time, which is added to the generalised costs within the car park choice process and is specified in the site file. The transfer time aims to reflect a variety of attributes of the Park & Ride site (e.g. cleanliness, ease of transfer, security etc.) and is used as a calibration tool. This parameter does not vary with car park occupancy.

The TMfS14 update of the Park and Ride model was primarily the inclusion of thirty nine additional Park & Ride sites along with any changes to the number of parking spaces at each site. The change in the TMfS14 zone system was also incorporated into the park and ride model inputs. The TMfS12 observed Park & Ride data was not updated as part of the TMfS14 development and no observed data for the additional park and ride sites was available within the timescales of the model development.

Table 6.1 shows the total usage of Park & Ride Sites by Local Authority. The new TMfS14 sites were not included as there was insufficient time to include observed data. The total observed trips is in vehicles. The modelled total is calculated from the period person matrices, but with an average occupancy of 1.2 applied. The calibration of each Park & Ride site by journey purpose is included in Appendix D.

Table 6.1 : Park and Rite Site Calibration by Local Authority

Local Authority*	Total Observed	Total Modelled	Difference	GEH
Aberdeenshire	391	398	7	0.35
Angus	165	110	-55	4.69
Argyll and Bute	248	149	-99	7.03
Aberdeen City	721	656	-65	2.48
Dundee City	129	45	-84	9.01
Edinburgh, City of	1466	1602	136	3.47
Glasgow City	890	1061	171	5.47
Clackmannanshire	0	0	0	0.00
Dumfries and Gallowa	34	152	118	12.24
East Ayrshire	199	197	-2	0.14
East Dunbartonshire	891	736	-155	5.43
East Lothian	416	646	230	9.98
East Renfrewshire	673	856	183	6.62
Falkirk	1062	1467	405	11.39
Fife	1992	3084	1092	21.68
Highland	105	110	5	0.48
Inverclyde	260	404	144	7.90
Midlothian	0	0	0	0.00
Moray	72	46	-26	3.38
North Ayrshire	444	440	-4	0.19
North Lanarkshire	1842	1793	-49	1.15
Perth and Kinross	334	473	139	6.92
Renfrewshire	804	893	89	3.06
South Ayrshire	513	493	-20	0.89
South Lanarkshire	1709	1286	-423	10.93
Stirling	719	705	-14	0.52
West Dunbartonshire	620	701	81	3.15
West Lothian	1064	1211	147	4.36
Total	17763	19714		14.25

*data does not include new TMfS14 Sites

Table 6.1 shows that overall the model predictions of Park & Ride are high however this is largely due to differences in Fife and Falkirk. The remaining authorities, particularly on the Perth to Inverness and Inverness to Aberdeen corridors; Aberdeenshire, Aberdeen City, Moray and Highland achieve a very good match with observed data at a Local Authority level. At an individual station level, the match is not as good, but this is to be expected, given the strategic nature of the model and the corresponding lack of zone and network detail. The calibration of each Park & Ride site by journey purpose is included in Appendix D, Tables 6-9.

7 SENSITIVITY TESTS

7.1 Introduction

The sensitivity tests were run in accordance with the guidance in the DfT's TAG unit M2 Variable Demand Modelling (January 2014), which recommends checking the elasticity of demand with respect to:

- Road fuel price
- Public transport fares
- Road journey time

The demand model runs that were undertaken to test these responses were as follows:

- 10% increase in fuel cost
- 10% increase in PT fares
- 10% increase in Road journey times

The rest of the parameters were kept unchanged. External and long distance trips were excluded from the tests and all others were included. For the car fuel cost sensitivity tests, the elasticities were calculated by weighting the trips by distance to get vehicle kilometres. For Road journey time and PT fares, the number of trips were used, as required by WebTAG.

The method for calculating the elasticity is shown below using car fuel prices as an example, where C and C' are the base and test car fuel prices (indices), and K and K' are the base and test car vehicle kilometres.

The elasticities were calculated using:

$$e = \frac{\ln(k') - \ln(k)}{\ln(C') - \ln(C)}$$

This ensured that the elasticity was a good approximation to the point elasticity at the midpoint of the data.

7.2 Results

The results are firstly given at an aggregate level and then split by time period and purpose. The elasticities are also reported separately for journeys that are in the A9/A96 corridor (identified as a corridor of particular interest) and those that are not, with the combined results also given. Commentary on the results is given in Section 8.4.

The results are also given in two separate sets: one set calculated using the trip matrices just before inclusion of external trips and application of the incremental matrices (in the Assignment Prep module), and the other set calculated directly after the Mode and Destination Choice application. While the latter set are not required for review against WebTAG, they are included to help illustrate how the model responds. Finally, a brief overall summary of the outcome of the realism tests is included after the results.

The following table is based on WebTAG's summary *(Table 6.2, TAG Unit M2, January 2014)* of the recommended elasticity ranges for the three realism tests.

Table 7.1 : WebTAG Elasticity Ranges (Table 6.2, TAG Unit M2, January 2014)

Elasticity	High	Low
Average Fuel Cost (kms)	-0.35	-0.25
Car Journey Time (trips)	No stronger than -2.0	
PT Main Mode Fare (trips)	-0.90	-0.20

It should be noted that WebTAG provides national guidelines yet calls for calibration using local data if possible. The results of the TMfS14 estimations should ideally be compared with and measured against the data behind WebTAG, together with their associated t-statistics, specific contexts, and assumptions.

7.3 Combined Results

The elasticities calculated at the Assignment Prep module for combined purposes and time periods are shown in Table 7.2.

Table 7.2 : Calculated TMfS14 Elasticity Ranges

Elasticity test	All trips	A9/A96	Non A9/A96
Fuel cost sensitivity	-0.31	-0.35	-0.30
Car journey time	-0.05	-0.11	-0.05
PT fare	-0.55	-0.60	-0.54

WebTAG guidance recommends that, at an overall combined purpose level, the elasticities for fuel cost should be in the range -0.25 to -0.35 and, further, 'on the right side of -0.3.' WebTAG goes on to state that fuel cost elasticities would be expected to be weaker than -0.3 where:

- Trip lengths are shorter than average
- Car driver mode shares are higher than average
- Proportions of low elasticity demand segments (such as employers' business) are higher than average

Where the opposite applies the fuel cost elasticities are to be expected to be stronger than -0.3.

The model gives elasticities within this range for the combined purposes, with the elasticities for trips on the A9/A96 corridor, which will typically be longer distance trips, having an elasticity stronger than -0.3 and the non A9/A96 trips having an elasticity just weaker than -0.3 (-0.295).

For car journey time, the guidelines state that the elasticity should be checked "to ensure that the model does not produce very high output elasticities (say stronger than - 2.0". The modelled elasticities for car journey time are weaker than -2.

WebTAG suggests that the Public Transport fare elasticities should lie between -0.2 and -0.9 for changes over a period longer than a year. The results observed are within this range.

7.4 AM Elasticities

The results for the AM peak, split by purpose and calculated from the Assignment Prep stage (just before external trips are added in and the incremental matrices applied) are shown in Table 7.3 to Table 7.5.

Table 7.3 shows the elasticities with respect to fuel cost. The WebTAG guidance *(TAG Unit M2 6.4.17, January 2014)* states that elasticities may also be regarded as more plausible if they are in the range -0.1 to -0.4 with employer's business trips being near to -0.1, discretionary trips near to -0.4, and commuting and education trips somewhere near the average.

Table 7.3 : AM Peak Fuel Sensitivity Test Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.08	-0.09	-0.08
Home-based work	-0.38	-0.44	-0.37
Home-based other	-0.21	-0.27	-0.20

The Home-Based Other and employer's business trips were generally in accordance with this, although the response of Home-Based Other trips is somewhat weaker than that for commute. As seen at the overall level, elasticities are slightly stronger on the A9/A96 corridor, which is likely to include a greater proportion of long distance trips.

Table 7.4 shows the Car Journey Time Elasticities. Time makes up about 70-80% of the overall Car Generalised Costs. WebTAG guidance gives no specific range for these, but suggests that they should be no stronger than -2.0. The elasticities found were significantly less than both this value and the fuel cost elasticities.

Table 7.4 : AM Peak Car Journey Time Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.03	-0.09	-0.02
Home-based work	-0.10	-0.12	-0.10
Home-based other	0.00	-0.06	0.01

This test does, however, result in a positive (though very small) car journey time elasticity for non A9/A96 Home-Based Other trips. This is counterintuitive since it would suggest that there is a small increase in these trips when car journey times (for both A9/A96 and non A9/A96 trips) are increased. This counterintuitive figure could potentially be connected to noise in the interactions between the mode and destination choice models. Again, one would expect longer distance trips to be more sensitive; the higher elasticities for the A9/A96 corridor would seem to support this.

Table 7.5 : AM Peak Public Transport Fare Demand Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.46	-0.62	-0.45
Home-based work	-0.99	-1.70	-0.95
Home-based other	-0.06	-0.06	-0.06

Table 7.5 shows the public transport fare demand elasticities. WebTAG, Unit M2, Section 6.4.21 suggests that overall the PT fare elasticities should lie between -0.2 and -0.9. The modelled elasticities are within this range for employers' business trips, while the elasticities for all Home-Based Work trips show a stronger response, slightly outside the range given in WebTAG, however, Home-Based Other elasticities are very weak in these tests as these trips would generally be expected to show a stronger response than employer's business travel.

The longer distance trips on the A9/A96 show a stronger elasticity, in line with expectations.

7.5 Inter Peak Elasticities

The Inter Peak Elasticities split by purpose and taken from the Assignment Prep stage (i.e. just before the inclusion of external trips and application of the incremental matrices) are shown in Table 7.6 to Table 7.8. Note that, generally speaking, inter peak elasticities are expected to be higher than AM peak elasticities and this is borne out in the results for Home-Based work and Home-Based other trips.

Table 7.6 : Inter Peak Fuel Sensitivity Test Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.08	-0.07	-0.09
Home-based work	-0.43	-0.48	-0.42
Home-based other	-0.29	-0.33	-0.27

WebTAG suggests that a plausible range of elasticities is from -0.1 to -0.4. As per the results from the AM peak, the overall fuel cost elasticities for the inter peak are generally in line with this range. Employer's business trips are least sensitive, as expected.

Home-Based Work and Home-Based Other show a slightly stronger response when compared to the equivalent AM results and the Home-Based Work elasticity for the longer distance A9/A96 trips is slightly above the range described in WebTAG. Home-Based other trips are less elastic than the commute trips which was contrary to expectations.

Table 7.7 : Inter Peak Car Journey Time Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.05	-0.07	-0.05
Home-based work	-0.13	-0.14	-0.13
Home-based other	-0.02	-0.10	0.00

The car journey time sensitivity is higher for Home-Based Work in the inter peak than in the AM peak. This is also observed with employer's business, except on the A9/A96 corridor, where it is lower. Home-Based Other also shows an increase in sensitivity when compared with the AM peak. All of the elasticities are weaker than -2.0, as required by WebTAG.

For Public Transport Main Mode Fare Elasticities WebTAG *(TAG Unit M2 6.4.21, January 2014)* states that elasticities of public transport trips with respect to public transport fares have been found to lie typically in the range -0.2 to -0.9, and that values at the weaker end of that range are unlikely for the whole public transport market unless this includes a high proportion of concessionary fare trips with a significant number made free of charge.

Table 7.8 : Inter Peak Public Transport Fare Demand Elasticities by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.67	-0.79	-0.65
Home-based work	-1.02	-1.59	-0.98
Home-based other	-0.22	-0.27	-0.21

As expected, the PT fare sensitivity is greater in the inter peak than in the AM peak for Home-Based employer's business and Home-Based Other, except for Home-Based Work, which is at a similar level. The sensitivity for Home-Based Work is higher than expected, particularly when compared with the response of Home-Based Other trips.

8 FURTHER EXAMINATION OF MODEL RESPONSES

8.1 Overall elasticities taken directly after Mode and Destination Choice

The following tabulations are taken from earlier in the model run sequence and do not relate to the tests required by WebTAG. They are included for information and to better understand the behaviour of the demand model.

Table 8.1 shows results for combined purposes split by journey type, taken directly after the Mode and Destination Choice application.

Table 8.1 : Combined Purpose Elasticities by Journey Type and location

Elasticity test	All trips	A9/A96	Non A9/A96
Fuel cost sensitivity	-0.38	-0.48	-0.36
Car journey time	-0.07	-0.13	-0.06
PT fare	-0.76	-1.12	-0.73

Compared with the results from the Assignment Prep stage (discussed in the previous section), the response directly after the Mode and Destination Choice application generally exhibits a similar pattern, although with elasticities which are consistently stronger.

The combined purpose results in Table. 8.1 indicate that the elasticities are stronger when taken at this stage of the model.

On the A9/A96 corridor they show a fuel sensitivity just outside the -0.25 to -0.35 range and a PT fare sensitivity that is close to but above the -0.9 guideline figure on the A9/A96 corridor, otherwise they are within the expected range.

The main process between this point and the Assignment Preparation (from where the earlier elasticities were taken) is the reverse factoring module. We suggest that at the next model update, these factors be revised in the model on the basis of the latest Scottish Household Survey (SHS) data. This could bring these elasticities more in line with those taken at the assignment preparation stage.

8.2 AM Elasticities taken directly after Mode and Destination Choice

These are not the tests required by WebTAG (see Section 4.3.1 first paragraph). They are provided so as to understand the model.

For the AM peak, when the results are considered directly after the Mode and Destination Choice application a similar pattern is observed to the results from the Assignment Prep stage, with the elasticities being consistently greater. This is not unexpected, since the processes that take place after this part of the model do not all take generalised costs into account, as an example education trips are created after the mode and destination choice application and so will not respond directly to the changes in costs.

The results split by purpose are shown in Table 8.2 to Table 8.4. The fuel cost sensitivities are with the recommend range (-0.1 to -0.4) except for Home-Based Work and Home-Based Other, which are a little more sensitive than the -0.4 upper end of the range.

Table 8.2 : AM Peak Fuel Sensitivities, taken directly after Mode and Destination Choice by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.12	-0.16	-0.10
Home-based work	-0.40	-0.45	-0.39
Home-based other	-0.34	-0.49	-0.31

The car journey time elasticities in Table 8.3 remain below the fuel cost sensitivity values, and weaker than -2.0, as required in WebTAG.

Table 8.3 : AM Peak Car Journey Time Elasticities, taken directly after Mode and Destination Choice. by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.07	-0.15	-0.06
Home-based work	-0.13	-0.13	-0.13
Home-based other	-0.02	-0.10	-0.01

The fare elasticities in Table 8.4 are now stronger for employers' business and significantly stronger (bigger negative) for Home-Based Other, where they now lie within the WebTAG range of -0.2 to -0.9. For Home-Based Work, the sensitivities are almost the same as when taken at the Assignment Prep stage.

Table 8.4 : AM Peak Public Transport Fare Demand Elasticities, taken directly after Mode and Destination Choice by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.64	-0.89	-0.60
Home-based work	-0.97	-1.66	-0.93
Home-based other	-0.29	-0.39	-0.28

8.3 IP Elasticities taken directly after Mode and Destination Choice

These are not the tests required by WebTAG (see Section 4.3.1 first paragraph). They are provided so as to understand the model.

The variation between AM and IP sensitivities with the results taken after Mode and Destination Choice is similar to that observed with the elasticities calculated from the Assignment Prep module. The inter peak elasticities are generally slightly stronger than the equivalent AM peak elasticities.

The inter peak elasticities split by purpose and taken from directly after Mode and Destination Choice are shown in Table 8.5 to Table 8.7.

Table 8.5 : Inter Peak Fuel Sensitivity Test, taken directly after Mode and Destination Choice by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.13	-0.17	-0.12
Home-based work	-0.47	-0.53	-0.46
Home-based other	-0.38	-0.54	-0.35

Fuel cost elasticities for Home-Based Work are stronger than the upper end of the range described in WebTAG, in particular on the A9/A96 corridor. Elasticities for employers' business and Home-Based Other trips are within the expected range, although the Home-Based Other response for the A9/A96 corridor is higher than expected.

Table 8.6 : Inter Peak Car Journey Time Elasticities, taken directly after Mode and Destination Choice by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.06	-0.14	-0.04
Home-based work	-0.15	-0.15	-0.15
Home-based other	-0.03	-0.13	-0.01

Compared back to the equivalent AM peak results, car journey time shows increased sensitivity for Home-Based Work and other trips, but employers' business shows a slight drop in sensitivity. The modelled elasticities are still significantly weaker than -2.0.

Table 8.7 : Inter Peak Public Transport Fare Demand Elasticities, taken directly after Mode and Destination Choice by location

Purpose	All trips	A9/A96	Non A9/A96
Home-based employer's business	-0.35	-1.12	-0.26
Home-based work	-1.14	-1.86	-1.09
Home-based other	-0.44	-0.67	-0.42

PT fare sensitivity is also greater in the inter-peak for Home-Based Work and Home-Based Other trips, although Home-Based employers' business trips, show, overall, a weaker response in the inter peak. The PT fare elasticities for Home-Based Work trips are stronger than the range specified in WebTAG and this is also the case for employers' business trips on the A9/A96 corridor.

8.4 Summary of modelled elasticities

While WebTAG provides guidelines and reports on typical ranges of values, this study has estimated the coefficients from local Revealed Preference data with full sensitivity parameter estimation and good ‘t’ statistics. The results should be weighed up against the WebTAG evidence for a fair comparison, rather than simply referring to WebTAG ranges.

Looking at elasticities by purpose and time period most values fall within the broader ranges, although it should be noted that the modelled Home-Based Other elasticities are generally less sensitive than the Home-Based Work elasticities. Home-Based Other would normally be expected to be more sensitive than Home-Based Work on the basis that people making leisure journeys may be more willing to have a slower journey in return for cost savings so the model is either not behaving correctly or this is not reflected in the data or this study area is different or some combination of these. We suggest this is investigated at some convenient juncture.

Fuel sensitivities are mostly within WebTAG guidelines, with employers’ business trips being at the weaker end of the -0.1 to -0.4 range, although Home-Based Work trips, particularly on the A9/A96 corridor in the inter peak, are perhaps more sensitive than expected.

Car journey time elasticities are relatively weak when compared with fuel sensitivities, for example (though note that while the former are calculated on a trip basis, the latter use vehicle-kilometres), and are all within the WebTAG guidance.

PT fare elasticity is greater than the WebTAG guideline for Home-Based Work, particularly in the inter peak, but within the guidelines for all other purposes.

The PT fare elasticity is generally within the guidelines except for Home-Based Work, particularly within the inter peak.

The A9/A96 elasticities are generally higher than the non-A9/A96 elasticities, as would be expected.

The all-purpose averages we have obtained are within the recommended ranges. We have applied a series of more stringent tests, by splitting them by purpose. WebTAG does not suggest different values for different purposes except to suggest that fuel elasticities may be regarded as more plausible if they show values for Employers Business of around -0.1 and around -0.4 for Home-based other with Home-based work near the average, although it adds that there is little or no empirical evidence to support the variation by purpose. The model conforms to WebTAG apart from the Home-Based Other being less sensitive than the Home-Based Work, but the overall sensitivities are still within the guidelines.

All of the overall calculated elasticities based on the matrices at the Assignment Prep stage, i.e. before adding in external trips and applying the incremental matrices are within the WebTAG guidelines, however, care should be taken with forecasts for schemes where Home-based other trips experience more than the average journey time savings.

9 FORECASTING PROCEDURES

9.1 Introduction

The function of the Base Year Demand Model is to:

- Demonstrate and validate the model operation and procedures
- Test the sensitivity of model parameters
- Establish the incremental adjustment matrices

The forecasting process is designed to provide forecast matrices using an incremental procedure. The Base Year Demand Model structure is designed to operate in an iterative manner to deal with the supply/demand convergence issue.

The general application of the Demand Model for forecasting requires the following inputs:

- Model parameters
- Trip ends
- Road and public transport cost matrices
- Road and public transport networks

The requirements and sources of these inputs are described in Sections 9.4 to 9.7.

The treatment of goods vehicles, long distance trips and external trips in forecasting is dealt with in Sections 9.8, 9.9, and 9.10.

9.2 Overall Operation of the Demand Model

For a given forecast year and land-use scenario, the Trip End creation procedure is run to produce forecast trip productions and attractions. Analyses of the broad travel demand effects of the land-use planning and economic assumptions, excluding the impacts of travel costs, can be undertaken at this stage. The remaining sub-models operate in an iterative manner to produce final road traffic and public transport assignments.

The iterative balancing process is described in more detail in Appendix B. There are two main loops:

- Inner Loops
  Iterate between the Mode Choice and Distribution Choice Models
- External Loops
  Iterate between Assignment Models and the Mode and Destination Choice Models

The Inner Loops are the primary iterative process to achieve a converged state between the two main travel choices within the Demand Model - mode and distribution choice. It is necessary to undertake the Inner Loops before initiating the External Loop.

Note: The inner loops are not necessary for the singly constrained purposes, as the composite utilities do not change from loop to loop.

The Inner Loops can be run until a converged state is reached. This may vary with the forecast year and economic assumptions and between a Do-Minimum and Do-Something test. The model defaults to four such loops.

The External Loop provides the link between the Assignment Models and the Demand Model. Infrastructure and pricing changes in a future year will change travel costs within the Assignment Models. The resultant converged state assigned travel costs are skimmed and supplied to the Distribution Choice using the same logsum composite utility calculations as for the Mode Choice Model. The sub-models are then run with the revised costs to complete the External Loop.

As standard, the Public Transport costs are set after one external loop of the Demand Model, however, if crowding effects (see PT Model report for a description of Crowding effects) are considered sufficient to cause large changes (such as to change the forecasts), it can be run on every external loop. The Road Assignment Model is run for each External Loop.

The External Loop should be run until a converged state is reached. The level of convergence achieved should be compared (using the current WebTAG guidance criteria) to determine if sufficient loops have been undertaken. This would vary with the forecast year and economic assumptions and between a Do-Minimum and Do-Something test. External Loop assignment matrices can be inspected between successive loops to determine whether to select to undertake further External Loops.

On each external loop of the demand model a process of trip damping takes place, which combines 50% of the current matrix, with 50% of that from the previous loop. This is the same in effect as the fixed step approach, which is included in DIADEM.

Gap analysis is undertaken on each External Demand Model Loop. This provides a measure of convergence of the demand model. It is not used as a stopping criteria, but the user can use it to assess if additional demand model loops need to be undertaken. The formulae for calculating the gap is given as:

$$Gap = \frac{\sum_{ij} C_{ij} \left| T_{ij} - T_{ij}^{'} \right|}{\sum_{ij} C_{ij} T_{ij}^{'}} * 100$$

Where:

C_{ij} is the generalised cost on the previous demand model loop

T_{ij} are the trips on the previous demand model loop

$T_{ij}^{'}$ are the trips on the current demand model loop

For models of this size gaps of less than 0.2 are deemed to be acceptable and below 0.1 is very well converged.

9.3 The Incremental Forecasting Approach

The forecasting procedure for TMfS14 is designed to operate in a multiplicative incremental manner. Before using the TMfS14 model for forecasting, it had to be adjusted to produce trip matrices which reflected the observed or existing travel patterns.

This adjustment was done by generating a set of incremental matrices such that when they were combined with the synthesized matrices produced by the TMfS14 model, the resulting matrices matched the corresponding observed matrices. Thus, the combined synthesised and incremental matrices must adequately match the observed trips or travel patterns.

The cells in the incremental forecast matrices were generated in one of two ways:

Case 1 $$F = S_f + (B - S_b)$$

Case 2 $$F = S_f * \left(\frac{B}{S_b} \right)$$

Where

B Base observed trips

S_b Base modelled (synthesised) trips

S_f Future modelled (synthesised) trips

F Future Trips

The following cases were defined when creating or applying the incremental matrices:

Case 1: Was used where B is zero or where we have high B and low Sb, defined as the case where B/Sb>2

Case 2: Was used in the following circumstances:

- low B, high Sb
- low B low Sb
- high B high Sb

This allowed zero cells in the Base Year to be incremented using Case 1.

The terms in bracket formed the incremental matrices. The equations showed how they were applied in forecasting. Applying these models to estimate incremental changes from a well calibrated base situation removed the reliance on these factors in the forecasting process.

The Base Year matrices were accepted as the best representation of the existing travel pattern.

In this way, the Incremental Matrix remained constant for all applications and the forecast year synthesized trip matrices produced by a forecast run of the Demand Model were adjusted by the Incremental Matrix before assignment.

Once established these incremental matrices are applied to the Road and PT assignment matrices.

9.4 Model Parameters

The need to calculate changes to some of the model parameters for a forecast run of the Demand Model is standard. The parameters for which forecast values are required which have been derived from WebTAG Databook, November 2014 are:

- Generalised cost coefficients for Road assignment
- Occupancy factors to convert from person to vehicle matrices
- Values of time and vehicle operating costs

The mode specific constants calculated for the Base Year are specific to the Base Year distribution of single and multi-car owning households.

9.5 Road and Public Transport Cost Matrices

Generalised cost matrices by mode and at a zone level are required as inputs to start the Demand Model process. Normally, the cost matrices used are those from the Base Year model, but the user can choose to input forecast cost matrices to kick start a demand model run if they so wish.

The Base Year cost matrices by mode are also required for the calculation of the mode specific constants described previously.

Base or Reference Case Generalised Costs are used as the start point of variance case tests within the TMfS.

9.6 Road and Public Transport Networks

As input to a forecast model year run, there must be forecast year Reference Case and/or variant networks. These should be coded up as described by the Road and PT model development reports, by adding any additional schemes directly into the network models.

Consistency between the Road and PT models should be retained at all times.

9.7 Education Matrices

The Education Matrices were built from Census Travel to Work data and are included in the model as add in matrices at the post 'inner loop' stage of a model run.

The Education Matrices are growthed using planning data from TELMoS, the trip ends are forecast in a similar way to the other trip purposes and then the trips are distributed using a simple gravity model.

9.8 Goods Vehicles

Goods vehicle trips are not subjected to the Demand Model process within the TMfS model. Forecast matrices are prepared using growth factors from the TELMoS commodity model.

The Base Year Goods PCU matrices at zonal level, are by hour (AM Peak, Inter Peak, and PM Peak) and by vehicle type, LGV and HGV. The forecasting process applied to these base matrices has the following three steps:

- Calculate percentage growth on a cell by cell basis between TELMoS Base Year and forecast year commodity matrices (these cover internal goods vehicle movements within the TMfS modelled area)
- Apply this percentage growth to the TMfS Base Year goods vehicle matrices
- Apply National Road Traffic Forecasts (NRTF) growth to external movements

9.9 Long Distance Vehicle Matrices

Long Distance, but internal to Scotland, Employers Business and Other trips are forecast separately from the main demand model. There are two long distance models as follows:

Model 1:
Long distance trips are added into the assignment matrices at the same stage as the Goods vehicle matrices (Long Distance trips are those defined as greater than 100km). The forecast procedure for long distance trips uses an elasticity model, based on assumed levels of growth in GDP over time. They are calculated in forecast mode for the full 12hr (07:00 – 19:00) time period and then factored to individual time periods. This process of factoring to the individual time periods uses the Base Year time period splits. Long Distance Trips were not treated differently in the base model. They are only treated differently in forecast mode. This is the default model for long distance trips.

Model 2:
A long distance model including long distance mode and destination choice focussing on the A9/A96 corridor, was calibrated as part of the TMfS12 refresh. It can be invoked to replace Model 1 in the CUBE model code. It is documented in the TMfS12 documentation.

9.10 External Trips

External trips from England and Wales are dealt with as add-on external matrices. In forecast mode these are growthed using NRTF. The model user can, however, include whatever growth assumptions they wish.

10 CONCLUSIONS AND RECOMMENDATIONS

10.1 Conclusions

This document has described the development of the Base Year Demand Model for TMfS14, the Model's sensitivity to a set of example tests and has discussed how the Model will be applied in forecast mode.

The model structure has been defined and implemented for the Base Year. The realism tests undertaken have demonstrated a good overall level of sensitivity. The principal travel purpose of the model, commute trips, has elasticities which fall well within the recommended sensitivity guidelines. Investigation of the elasticities in more detail has shown more variation some of which can be explained by the model structure adopted for this model and it is suggested that this is revisited when the model is next being considered for recalibration.

10.2 Recommendations

SIAS's and PDC's view is that the Demand Model is broadly fit for its intended purpose, i.e. being suitable for supporting the Outline Business Case for improvements on the Inverness to Aberdeen transport corridor and other such schemes.

The model as implemented in CUBE and described in its documentation contains some features where it is not clear that the structure implemented is as intended by its creators. It is recommended that the model architecture be re-structured more in-line with current practice at a suitable time in the model's evolution.

While this report discusses how the model will be applied in forecast mode, it does not include consideration of actual applications of the model in forecast mode. Further experience of these applications gained over time will assist in understanding the sensitivity and performance of the Model.

All model applications should be preceded by an appropriate review of the robustness of the model in the area/corridor of interest.

A PARKING CHARGES

Table A.1 : Destination zones where parking zones are applied

Location	Zones
Aberdeen	625,627,628,632
Glasgow	273,286,290,291,297,298,302,360
Dunfermline	481,482
Perth	539
Stirling	466
Dundee	551,552,555,563
Edinburgh	86,90,94,96,98-100,
Inverness	683,686,687

Table A.2 : Average Charges (£)

	Short Term (HO)	Long Term (HW)
Aberdeen	£2.55	£7.29
Glasgow	£3.77	£11.07
Dunfermline	£1.36	£3.60
Perth	£1.96	£5.25
Stirling	£2.40	£1.99
Dundee	£2.91	£6.14
Edinburgh	£5.43	£13.69
Inverness	£1.69	£4.32

Table A.3 : Parking Charges as a Generalised Cost (Mins)

	Short Term Cost	Long Term Cost
Aberdeen	16.35	26.26
Glasgow	24.14	39.93
Dunfermline	8.70	12.98
Perth	12.59	18.94
Stirling	15.40	7.17
Dundee	18.65	22.12
Edinburgh	34.79	49.34
Inverness	10.84	15.57

B MODEL STRUCTURE

This appendix contains a description of the TMfS 14 Demand Model as a flow diagram for each of the main stages in the process.

This description is intended to be sufficiently detailed to explain the functioning of the demand model and its components.

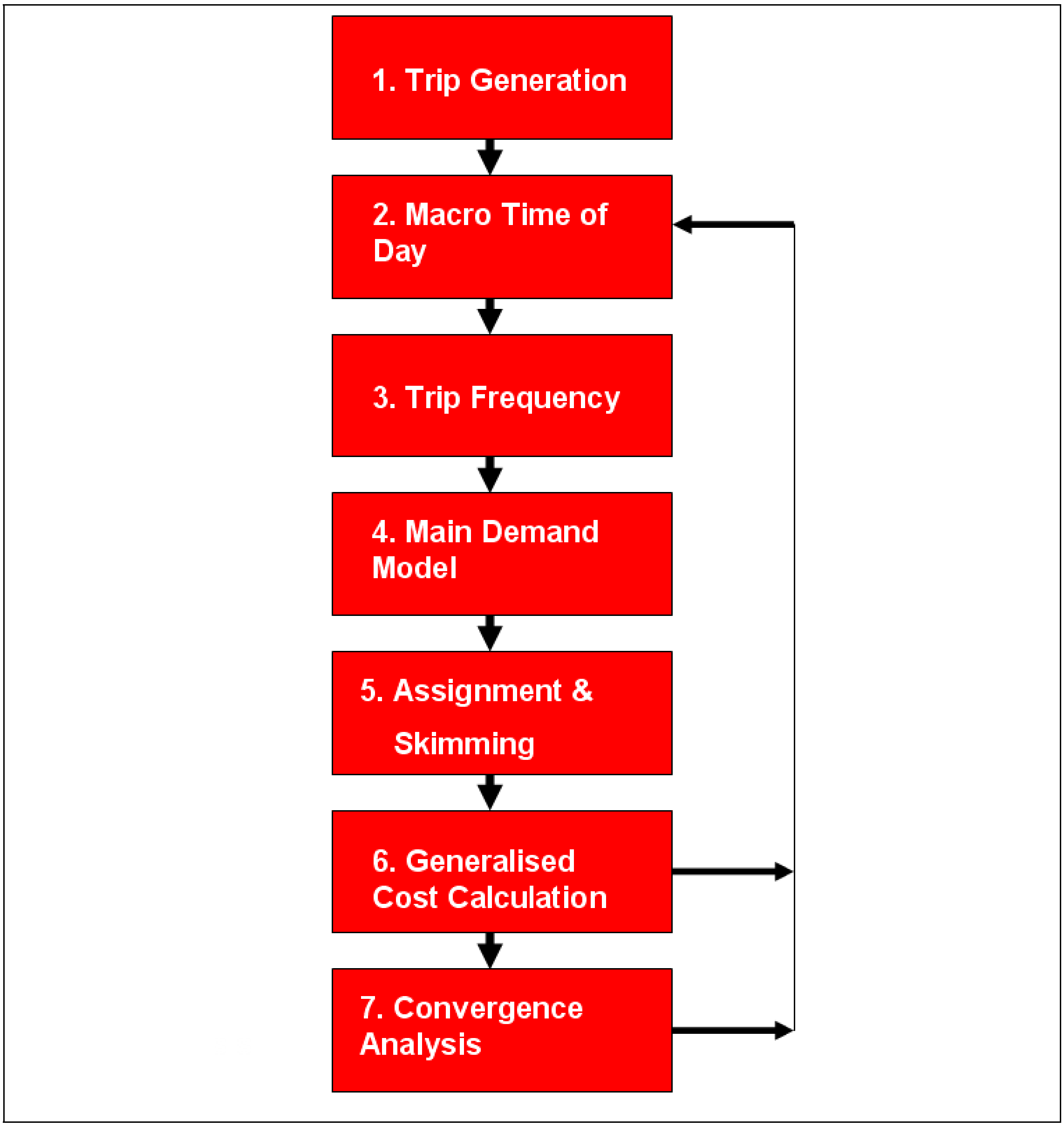


Figure B.1 : Overall Model Architecture

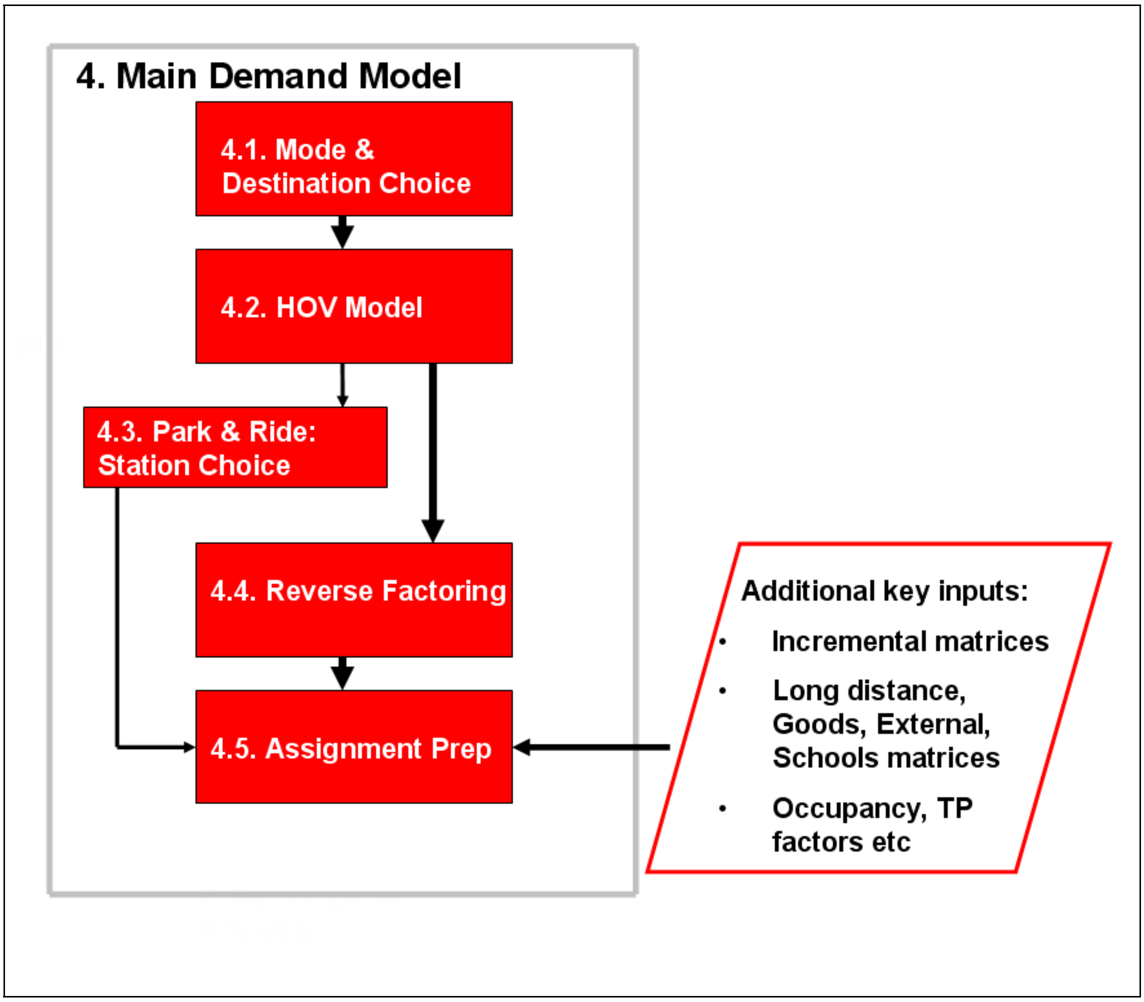


Figure B.2 : Main Demand Model Architecture

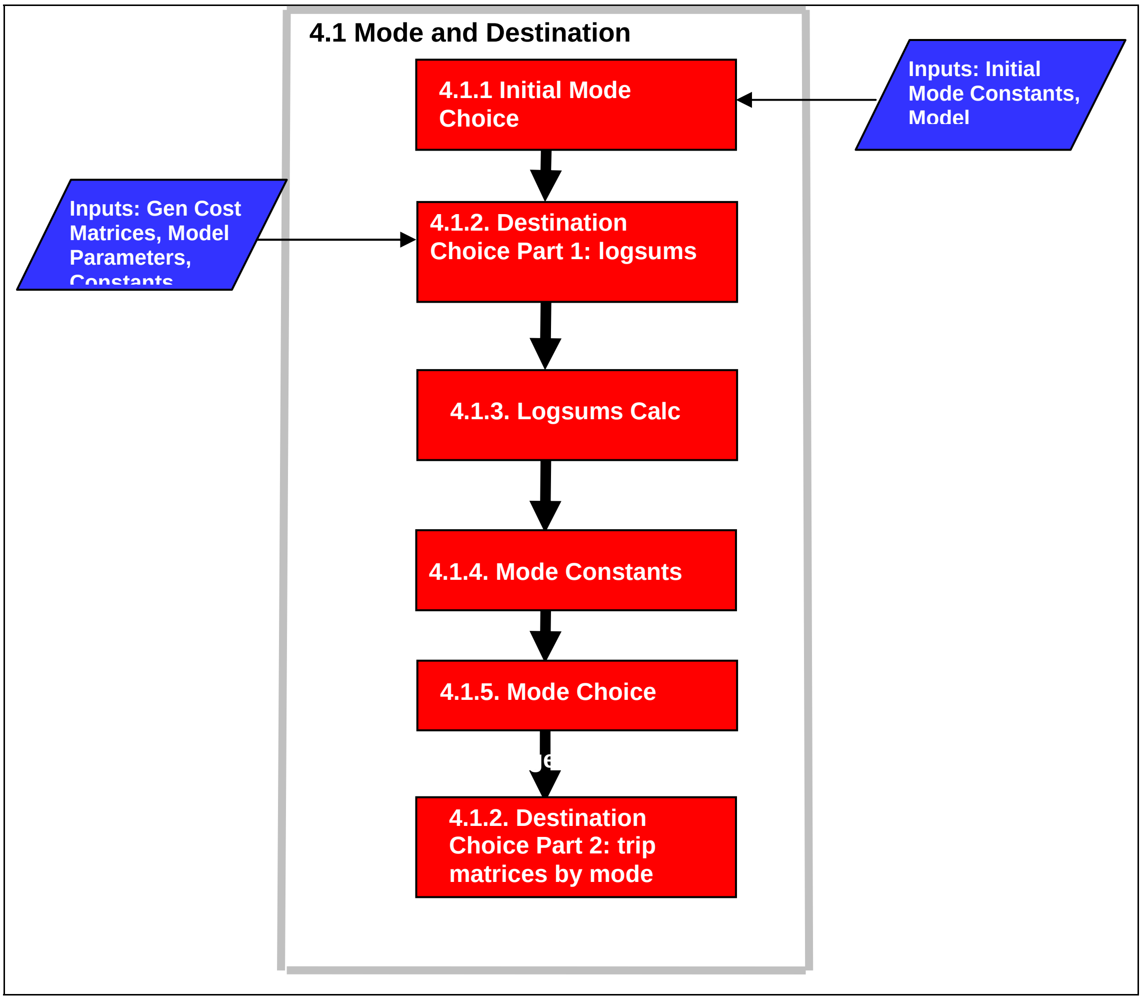
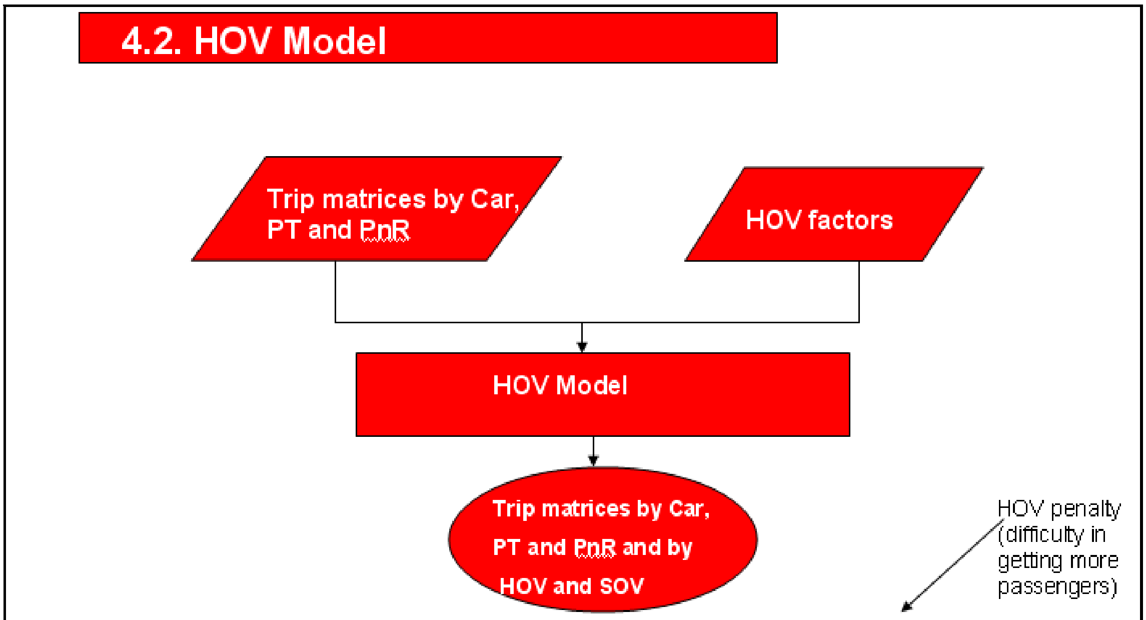


Figure B.3 : Mode & Destination Module



$$U_{ij(SOV)} = \beta(GC_{ij(SOV)}) \qquad U_{ij(HOV)} = \beta(GC_{ij(HOV)} + \partial)$$

$$P_{ij(SOV)} = \frac{\exp(U_{ij(SOV)})}{\exp(U_{ij(SOV)}) + \exp(U_{ij(HOV)})}$$

$$T_{ij(SOV)} = T_{ij} * P_{ij(SOV)}$$

Figure B.4 : HOV Model

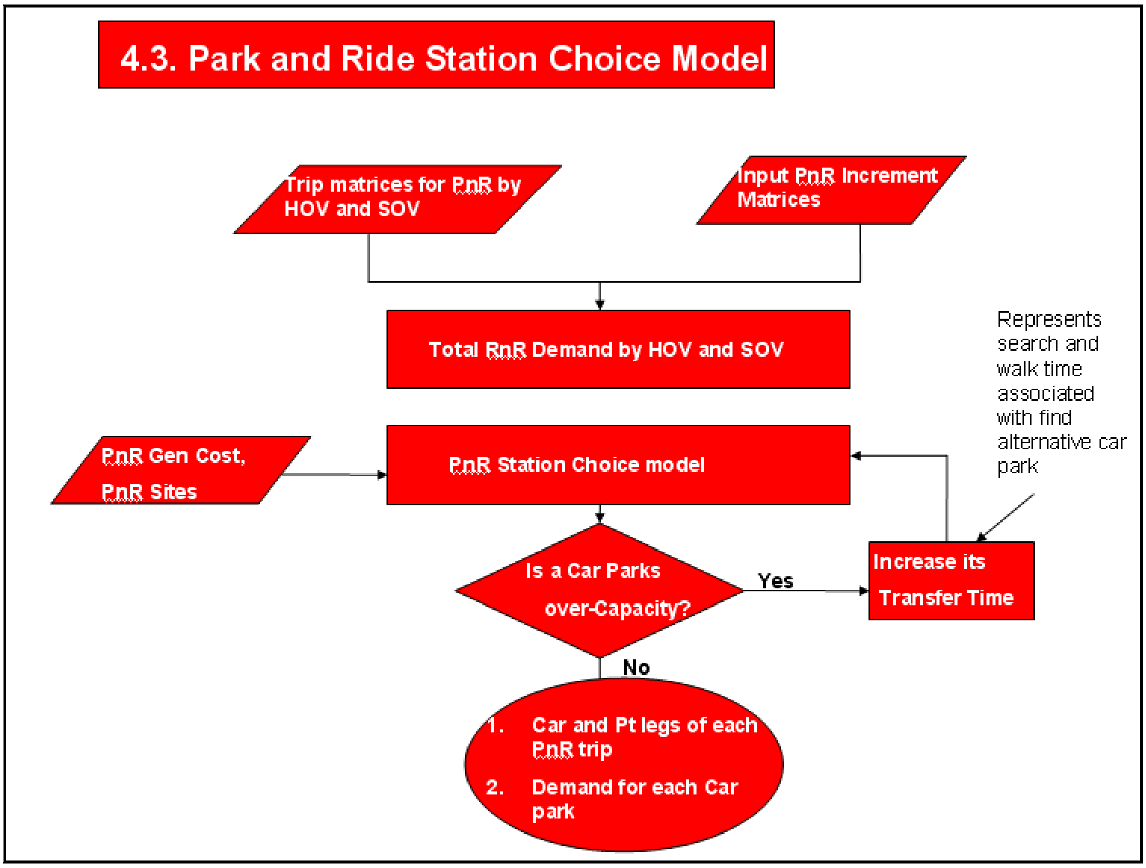


Figure B.5 : Park & Ride Station Choice Model

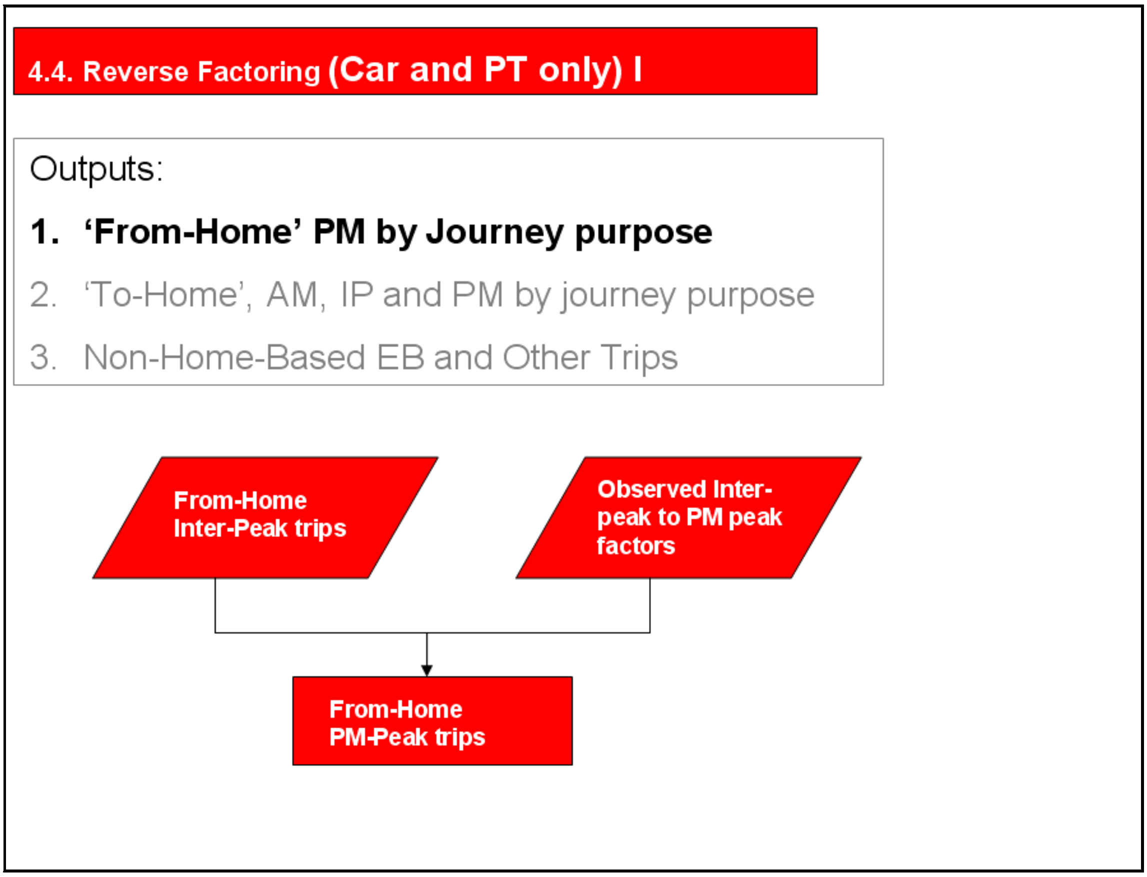


Figure B.6 : Reverse Factoring (Output 1)

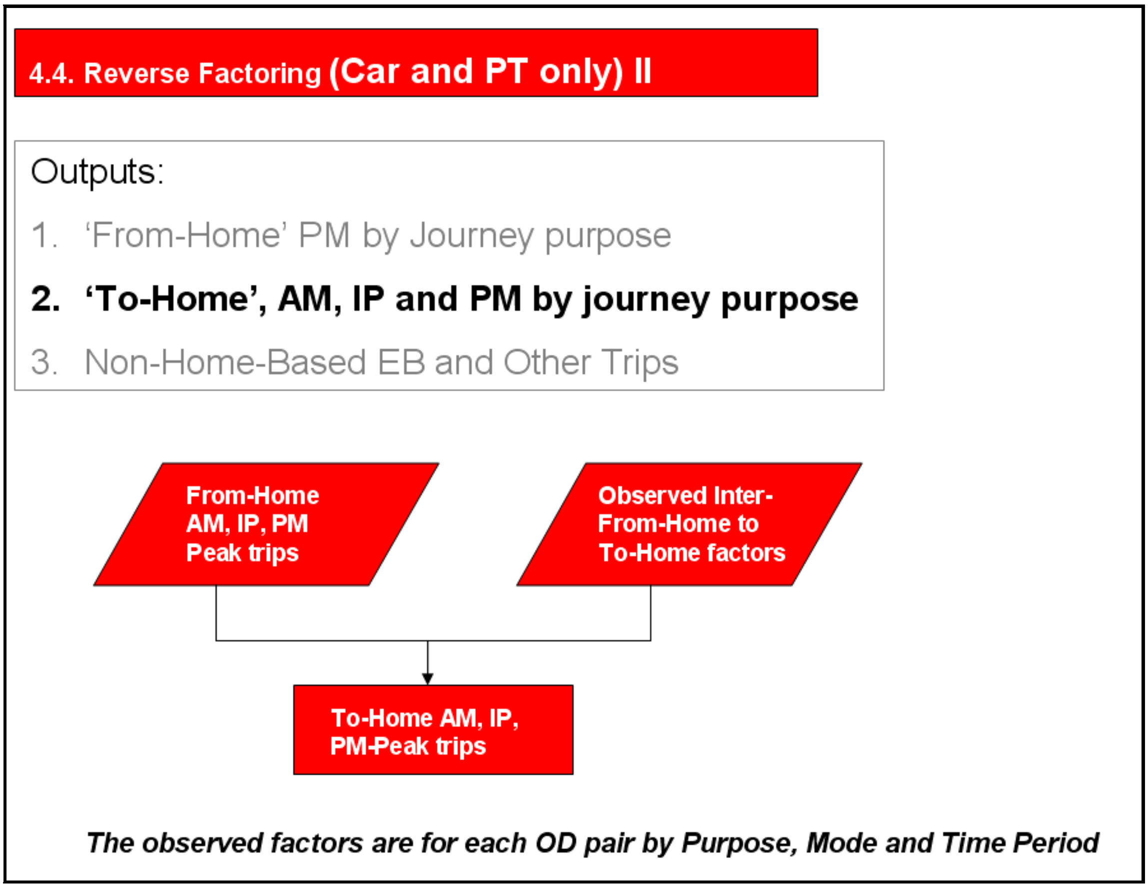


Figure B.7 : Reverse Factoring (Output 2)

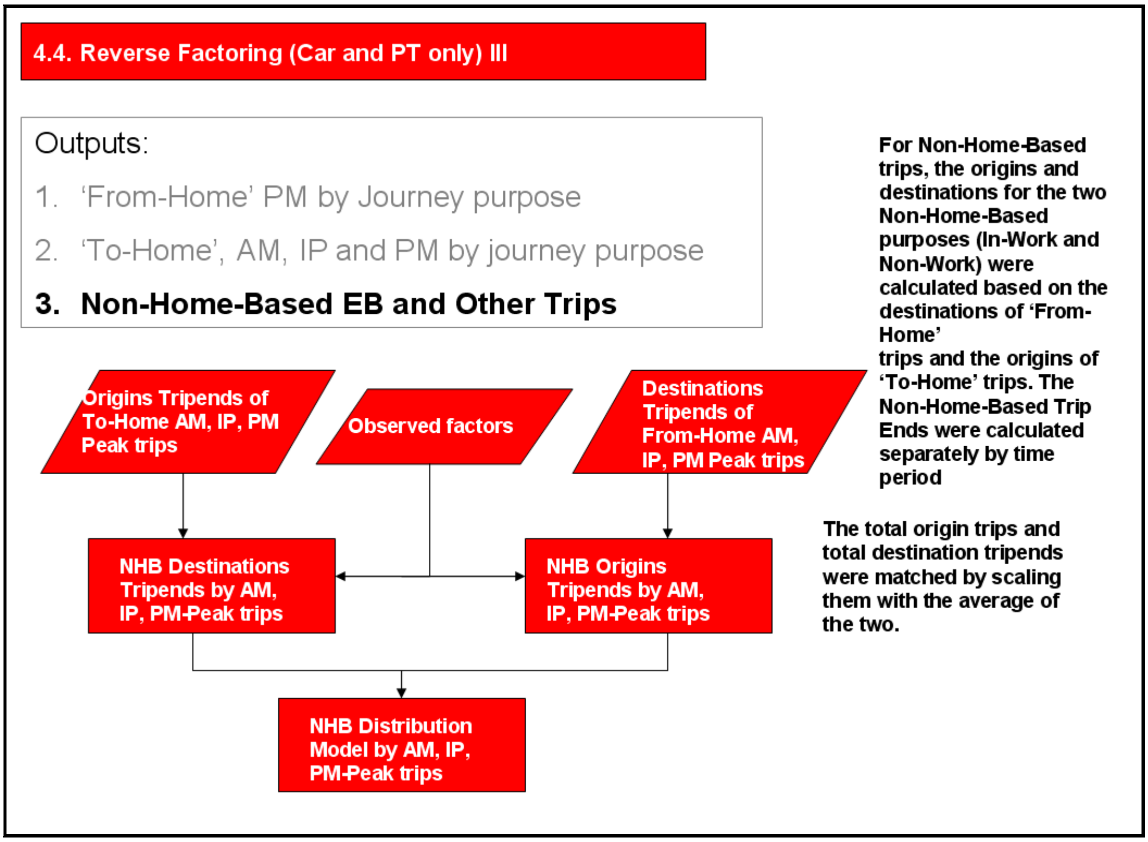


Figure B.8 : Reverse Factoring (Output 3)

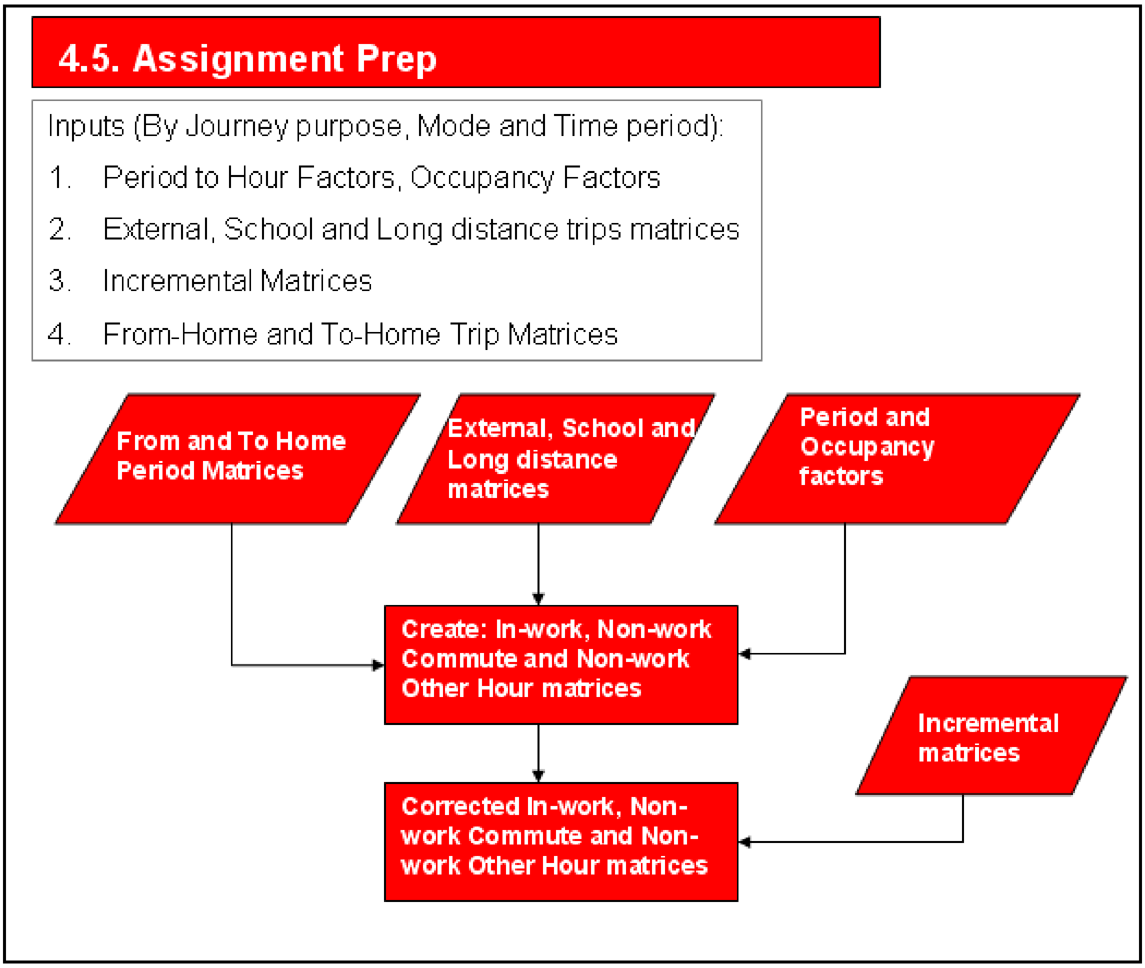


Figure B.9 : Assignment Prep Module

C NTEM TRIP RATE ASSUMPTIONS

Trip rates from the National Trip End Model (NTEM) version 6.2 are used in the TMfS trip end model.

The NTEM person type categories are split into a matrix of eleven person types and eight household types generating 88 categories in total.

The eleven person types are:

1 Children (0 to 15)
2 Males in full time employment (16 to 64)
3 Females in full time employment (16 to 64)
4 Male students (16 to 64)
5 Female students (16 to 64)
6 Males in part time employment (16 to 64)
7 Females in part time employment (16 to 64)
8 Male not employed/students (16 to 64) – unemployed plus other inactive
9 Female not employed/students (16 to 64) – unemployed plus other inactive
10 Male 65+
11 Female 65+

The eight household types are:

1 1 adult household with no access to a Car
2 1 adult household with access to one or more Cars
3 2 adult households with no access to a Car
4 2 adult households with access to one Car
5 2 adult households with access to two or more Cars
6 3+ adult households with no access to a Car
7 3+ adult households with access to one Car
8 3+ adult households with access to two or more Cars

The specific travel modes included in NTEM are:

1 Walk
2 Cycle
3 Car driver
4 Car passenger
5 Bus;
6 Rail (including underground)

The walk and cycle modes are not included within the TMfS trip end model. Car trip rates are the sum of car drivers and car passengers. PT trip rates are the sum of bus and rail.

Production trip rates for these 88 categories are obtained from the NTEM databases. The IBETAhsr table is used to provide the weekly trip rates by purpose, traveller type and area type. The IRhomdhsr table is used to split these trip rates by time period and mode.

For TMfS12, Area Type 5 (Urban Medium) trip rates are applied as this was considered to be the most appropriate assumption or average set of trip rates for the TMfS coverage area. For TMfS12A the trip end model has been improved to use all area types so that, for example, modelled trip rates in cities will be different to rural locations.

The trip rates are constant over all modelled years.

D PARK & RIDE CALIBRATION

Table D.1 : Park & Ride by Local Authority

Local Authority	Sites
Aberdeen City	Aberdeen
	Bridge of Don
	Dyce
	Kingswell
Aberdeenshire	Ellon
	Huntly
	Insch
	Inverurie
	Laurencekirk*
	Portlethen
	Stonehaven
Angus	Arbroath
	Carnoustie
	Montrose
Argyll and Bute	Cardross
	Craigendoran*
	Garelochhead*
	Helensburgh Central
	Oban
Clackmannanshire	Alloa*
Dumfries and Galloway	Dumfries
	Gretna
	Kirkconnel
	Lockerbie
Dundee City	Broughty Ferry*
	Dundee
East Ayrshire	Auchinleck
	Dunlop*
	Kilmarnock
	Kilmaurs
	New Cumnock
	Stewarton
East Dunbartonshire	Bearsden
	Bishopbriggs
	Hillfoot
	Lenzie
	Milngavie
	Westerton
East Lothian	Drem
	Dunbar
	Longniddry
	Musselburgh
	North Berwick
	Prestonpans
	Wallyford

*Park&Ride sites added to TMfS14

Table D.2 : Park & Ride by Local Authority (Cont.)

East Renfrewshire	Barrhead
	Clarkston
	Giffnock
	Neilston
	Patterton
	Thornliebank
	Whitecraigs
	Williamwood
Edinburgh, City of	Brunstane
	Curriehill
	Dalmeny
	Edinburgh Park
	Haymarket
	Hermiston
	Ingilston
	Newcraighall
	South Gyle
	Waverley
	Wester Hailes
Falkirk	Camelon
	Falkirk Grahamston
	Falkirk High
	Larbert
	Polmont
Fife	Aberdour
	Burntisland
	Cardenden
	Cowdenbeath*
	Cupar
	Dalgety Bay
	Dunfermline Queen Margaret
	Dunfermline Town
	Ferrytoll
	Glenrothes
	Halbeath*
	Inverkeithing
	Kincardine*
	Kirkcaldy
	Ladybank
	Leuchars
	Markinch
	North Queensferry
	Rosyth

*Park&Ride sites added to TMfS14

Table D.3 : Park & Ride by Local Authority (Cont.)

Glasgow City	Anniesland
	Bellgrove
	Bridge Street Subway*
	Bridgeton
	Cardonald
	Cathcart
	Charing Cross
	Drumchapel
	Easterhouse
	Garrowhill
	Glasgow Central
	Glasgow Queen St
	High Street Glasgow
	Hyndland
	Jordanhill*
	Kelvinbridge
	Kelvinbridge Subway
	Kinross (Govanhill)*
	Muirend
	Partick
	Scotstounhill
	Shettleston
	Shield Rd
	Shieldmuir*
	Silverburn*
Highland	Aviemore
	Fort William
	Inverness
	Kingussie
	Kirkhill*
	Kyle of Lochalsh
	Nairn
	Stromeferry
Inverclyde	Branchton
	Fort Matilda
	Gourock
	Greenock Central
	Greenock West
	Inverkip*
	Port Glasgow
	Wemyss Bay
Midlothian	Sheriffhall*
	Straiton*
Moray	Elgin
	Forres
	Keith

*Park&Ride sites added to TMfS14

Table D.4 : Park & Ride by Local Authority (Cont.)

North Ayrshire	Ardrossan South Beach
	Dalry
	Fairlie*
	Glengarnock
	Irvine
	Kilwinning
	Largs*
	Saltcoats
	West Kilbride*
North Lanarkshire	Airbles
	Airdrie
	Bargeddie
	Bellshill
	Blairhill
	Caldercruix*
	Carfin*
	Cleland
	Coatbridge Central*
	Coatbridge Sunnyside
	Coatdyke
	Croy
	Cumbernauld
	Drumgelloch
	Gartcosh
	Greenfaulds
	Harthill*
	Hartwood*
	Holytown
	Kirkwood*
	Motherwell
	Newhouse*
	Shotts
	Stepps
	Whifflet
	Wishaw
Perth and Kinross	Broxden Perth
	Dunkeld & Birnam
	Gleneagles
	Kinross (Perthshire)
	Perth
	Pitlochry
	Rannoch
	Scone*

*Park&Ride sites added to TMfS14

Table D.5 : Park & Ride by Local Authority (Cont.)

Renfrewshire	Bishopton
	Hawkhead
	Howwood
	Johnstone
	Lochwinnoch*
	Paisley Canal
	Paisley Gilmour
South Ayrshire	Ayr
	Barassie*
	Girvan
	Maybole*
	Prestwick
	Troon
South Lanarkshire	Blantyre
	Cambuslang
	Carluke
	Chatelherhault*
	Croftfoot
	East Kilbride
	Hairmyres
	Hamilton Cent
	Hamilton West
	Lanark
	Larkhall
	Merryton
	Newton
	Rutherglen
	Thorntonhall*
	Uddingston
Stirling	Bridge of Allan
	Castleview*
	Dunblane
	Springkerse
	Stirling
	Upper Tyndrum
West Dunbartonshire	Alexandria
	Balloch
	Bowling*
	Clydebank
	Dalmuir
	Dalreoch
	Drumry
	Dumbarton Central
	Dumbarton East
	Kilbowie*
	Singer
West Lothian	Armadale*
	Bathgate
	Kirknewton
	Linlithgow
	Livingston North
	Livingston South
	Uphall
	West Calder

*Park&Ride sites added to TMfS14

Table D.6 : Park & Ride Calibration by site (Vehs)

Site	Observed	Modelled	GEH
Aberdeen	165	197	2.38
Bridge of Don	354	260	5.36
Dyce	30	110	9.56
Kingswell	172	89	7.27
Ellon	163	114	4.16
Huntly	8	13	1.54
Insch	18	4	4.22
Inverurie	49	225	15.04
Portlethen	4	9	1.96
Stonehaven	149	33	12.16
Arbroath	39	33	1.00
Carnoustie	29	17	2.50
Montrose	98	60	4.28
Cardross	21	8	3.41
Helensburgh Cent	218	135	6.25
Oban	9	6	1.10
Dumfries	10	101	12.22
Gretna	0	7	3.74
Kirkconnel	8	8	0.00
Lockerbie	16	36	3.92
Dundee	129	45	9.01
Auchinleck	26	24	0.40
Kilmarnock	103	88	1.53
Kilmaurs	19	21	0.45
New Cumnock	7	24	4.32
Stewarton	44	40	0.62
Bearsden	156	45	11.07
Bishopbriggs	111	115	0.38
Hillfoot	52	17	5.96
Lenzie	253	266	0.81
Milngavie	191	158	2.50
Westerton	128	135	0.61
Drem	102	56	5.18
Dunbar	64	58	0.77
Longniddry	42	47	0.75
Musselburgh	10	83	10.71
N Berwick	75	57	2.22
Prestonpans	90	149	5.40
Wallyford	32	196	15.36
Barrhead	51	12	6.95
Clarkston	135	457	18.72
Giffnock	130	113	1.54
Neilston	101	13	11.66
Patterton	86	75	1.23
Thornliebank	8	9	0.34
Whitecraigs	133	147	1.18
Williamwood	28	30	0.37
Brunstane	41	53	1.75
Curriehill	10	36	5.42
Dalmeny	94	157	5.62

Table D.7 : Park & Ride Calibration by site (Vehs) (Cont.)

Site	Observed	Modelled	GEH
Edinburgh Park	59	87	3.28
Haymarket	53	34	2.88
Hermiston	440	367	3.63
Ingilston	499	465	1.55
Newcraighall	132	293	11.04
S Gyle	15	18	0.74
Waverley	122	88	3.32
Wester Hailes	0	4	2.83
Camelon	37	59	3.18
Falkirk Grahamston	18	364	25.04
Falkirk High	550	408	6.49
Larbert	183	375	11.49
Polmont	273	261	0.73
Aberdour	9	34	5.39
Burntisland	28	37	1.58
Cardenden	12	10	0.60
Cupar	30	65	5.08
Dalgety Bay	128	203	5.83
Dunfermline Q Margaret	31	158	13.06
Dunfermline Town	58	318	18.96
Ferrytoll	452	716	10.92
Glenrothes	8	10	0.67
Inverkeithing	657	359	13.22
Kirkcaldy	418	620	8.87
Ladybank	14	28	3.06
Leuchars	42	228	16.01
Markinch	61	92	3.54
N Queensferry	23	28	0.99
Rosyth	21	178	15.74
Anniesland	23	17	1.34
Bellgrove	23	21	0.43
Bridgeton	14	13	0.27
Cardonald	36	34	0.34
Cathcart	44	41	0.46
Charing Cross	5	3	1.00
Drumchapel	7	29	5.19
Easterhouse	43	33	1.62
Garrowhill	25	20	1.05
Glasgow Cent	82	139	5.42
Glasgow Queen St	178	213	2.50
High Street Glasgow	18	16	0.49
Hyndland	55	63	1.04
Kelvinbridge	0	16	5.66
Muirend	118	110	0.75
Partick	66	52	1.82
Scotstounhill	9	14	1.47
Shettleston	143	54	8.97
Shield Rd	0	173	18.60
Aviemore	7	6	0.39
Fort William	2	9	2.98
Inverness	73	66	0.84

Table D.8 : Park & Ride Calibration by site (Vehs) (Cont.)

Site	Observed	Modelled	GEH
Kingussie	3	5	1.00
Kyle of Lochalsh	5	1	2.31
Nairn	14	23	2.09
Stromeferry	0	0	0.00
Branchton	7	8	0.37
Fort Matilda	11	14	0.85
Gourock	108	94	1.39
Greenock Cent	34	29	0.89
Greenock W	15	16	0.25
Port Glasgow	78	53	3.09
Wemyss Bay	9	190	18.15
Elgin	29	20	1.82
Forres	31	14	3.58
Keith	11	12	0.29
Ardrossan South Beach	27	27	0.00
Dalry	7	21	3.74
Glengarnock	41	71	4.01
Irvine	155	127	2.36
Kilwinning	186	166	1.51
Saltcoats	21	20	0.22
West Kilbride	7	8	0.37
Airdrie	366	205	9.53
Bargeddie	9	12	0.93
Bellshill	143	29	12.29
Blairhill	84	322	16.70
Cleland	13	15	0.53
Coatbridge Sunnyside	128	56	7.51
Coatdyke	76	63	1.56
Croy	460	15	28.88
Cumbernauld	60	119	6.24
Drumgelloch	49	209	14.09
Gartcosh	28	30	0.37
Greenfaulds	22	18	0.89
Holytown	13	16	0.79
Motherwell	194	331	8.46
Shotts	17	173	16.01
Stepps	60	35	3.63
Whifflet	32	36	0.69
Wishaw	88	109	2.12
Broxden Perth	179	196	1.24
Dunkeld Birnam	4	11	2.56
Gleneagles	15	22	1.63
Kinross (Perthshire)	0	80	12.65
Perth	130	148	1.53
Pitlochry	7	5	0.82
Rannoch	0	11	4.69
Bishopton	92	42	6.11
Hawkhead	31	179	14.44
Howwood	1	15	4.95
Johnstone	320	301	1.08
Paisley Canal	77	80	0.34

Table D.9 : Park & Ride Calibration by site (Vehs) (Cont.)

Site	Observed	Modelled	GEH
Paisley Gilmour	283	276	0.42
Ayr	353	316	2.02
Girvan	9	3	2.45
Prestwick	35	78	5.72
Troon	117	96	2.03
Blantyre	90	91	0.11
Cambuslang	204	183	1.51
Carluke	100	93	0.71
Croftfoot	29	25	0.77
East Kilbride	260	154	7.37
Hairmyres	195	197	0.14
Hamilton Cent	45	41	0.61
Hamilton W	369	51	21.94
Lanark	84	68	1.84
Larkhall	0	2	2.00
Merryton	0	2	2.00
Newton	89	146	5.26
Rutherglen	59	50	1.22
Uddingston	185	183	0.15
Bridge of Allan	66	200	11.62
Dunblane	150	31	12.51
Springkerse	228	129	7.41
Stirling	274	341	3.82
Upper Tyndrum	0	4	2.83
Alexandria	12	12	0.00
Balloch	50	34	2.47
Clydebank	14	7	2.16
Dalmuir	288	205	5.29
Dalreoch	80	39	5.32
Drumry	11	6	1.71
Dumbarton Cent	126	320	12.99
Dumbarton E	13	75	9.35
Singer	26	3	6.04
Bathgate	357	345	0.64
Kirknewton	18	5	3.83
Linlithgow	340	205	8.18
Livingston N	196	185	0.80
Livingston S	85	180	8.25
Uphall	68	211	12.11
West Calder	0	80	12.65
	17,760	19,714	4.78