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TECHNICAL REPORT

Additional Estimation of the Sydney Strategic Travel Model

James Fox, Andrew Daly, Bhanu Patruni

RAND EUROPE

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Prepared for the Bureau of Transport Statistics, Transport for NSW

RAND EUROPE

The research described in this report was prepared for the Bureau of Transport Statistics, Transport for NSW.

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Preface

RAND Europe was commissioned by the Bureau of Transport Statistics (BTS) of Transport for NSW (New South Wales) to undertake additional estimations for the commute mode–destination model following a detailed spatial validation of the base year model predictions undertaken by BTS in November 2011.

The STM was designed by Hague Consulting Group in 1997. In Stage 1 of model development (1999–2000), Hague Consulting Group developed mode–destination and frequency models for commuting travel, as well as models of licence ownership and car ownership. In addition a forecasting system was developed incorporating these components. In Stage 2 of model development (2001–02), RAND Europe, incorporating Hague Consulting Group, developed mode and destination and frequency models for the remaining home-based (HB) purposes, as well as for non-home-based business (NHBB) travel. Then, during 2003–04, RAND Europe undertook a detailed validation of the performance of the Stage 1 and 2 models. Finally, in 2007 Halcrow undertook Stage 3 of model development, in which they re-estimated the home–work mode–destination models, and at the same time developed models of access mode choice to train for home–work travel.

By 2009, some model parameters dated back to 1999, raising concerns that the model may no longer reflect the current behaviour of residents of Sydney with sufficient accuracy. Furthermore, changes to the zone structure of the model occurred with the area of coverage increased to include Newcastle and Wollongong, and the move to a finer zoning system, and as a result of these changes the number of zones approximately tripled in number. Therefore, BTS commissioned RAND Europe to re-estimate the STM models using more recent information on the travel behaviour of Sydney residents and the new zoning system.

Following the completion of the re-estimation project, RAND Europe was commissioned to undertake three parallel projects to implement the new models, and improve the performance of the pivoting process. These projects delivered a working base year version of the new model to BTS in October 2011, and BTS undertook a detailed spatial validation of the predictions of the commute travel demand model in November 2011. While the overall performance of the model was good, the validation exercise identified a number of specific areas that could be improved. Therefore RAND Europe was commissioned to undertake additional development work for the commute mode–destination model to improve the performance of the model. It is the work to improve the commute mode–destination model, and the subsequent changes to the remainder of the model implementation system that were required to take account of the revised commute mode–destination model specification, that are documented in this report.

This document is intended for a technical audience familiar with transport modelling terminology.

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Abbreviations

BTS: Bureau of Transport Statistics

CBD: Central Business District

HB: Home-Based

HTS: Household Travel Survey

K&R: Kiss-and-Ride

LOS: Level of Service

NHB: Non-Home-Based

NHBB: Non-Home-Based Business

OD: Origin–Destination

P&R: Park-and-Ride

PD: Primary Destination

PT: Public Transport

RMS: Root-Mean-Square

WB: Work-Based

Acknowledgements

The project team acknowledges the contribution of Frank Milthorpe, who has made a substantial contribution to the development of the STM over time. In this project, Frank has run a number of different assignments in the Emme software to enable the model structure to be enhanced to represent separate walk and bus access modes to train, and run supporting analysis to investigate the different walk and bus access assignment options.

The project team would also like to acknowledge the contribution of the two quality assurance reviewers, Charlene Rohr and Dimitris Potoglou, whose comments have improved the clarity and accessibility of the material presented in this report.

CHAPTER 1 Introduction

1.1 Background

In November 2011, BTS undertook a detailed comparison of the outputs from the commute model using data from the Sydney Household Travel Survey (HTS). The comparisons included validation across particular spatial dimensions that were not assessed during the re-estimation work, such as the distance of the home and the workplace from the Central Business District (CBD). While the model performed well overall, this exercise identified a number of specific issues with the base year performance of the home–work travel demand model relative to the HTS data:

- too much bus access to rail
- too little walk access to rail
- too much car travel to the inner areas
- not enough rail journeys originating within the inner areas
- not enough walking in the inner areas, and consequently too much walking in the outer areas.

Furthermore, during the validation process, BTS identified an issue with how they had coded park-and-ride (P&R) and kiss-and-ride (K&R) travel in the sample of HTS data used for model estimation in 2010. Specifically, all rail users who access as car passengers were coded as K&R irrespective of whether or not the car was parked at the station, and thus the true K&R share was over-estimated, and the true P&R share was under-estimated. This additional re-estimation work provided an opportunity to re-estimate the rail access mode and station choice models with corrected data.

1.2 Structure of the remainder of the report

The structure of the remainder of the report is set out as follows.

In Chapter 2, the tests that have been made to enhance the commute mode–destination model in light of BTS's validation findings are documented. The changes to the commute mode–destination model meant that revised commute logsum accessibility measures were calculated for the base year, and these changes necessitated the re-estimation of the commute frequency model, documented in Chapter 3, and the re-estimation of the total car ownership model, documented in Chapter 4. Then Chapter 4 describes the updates to the Population Synthesiser to take account of the changes to the total car ownership model, and the work to create revised base year synthetic populations by segment ready for application in the Travel Demand models. Finally, Chapter 5 documents the changes that have been made to the Travel Demand models to take account of the changes to the commute mode–destination and frequency models, and the re-runs of the Travel Demand models for all purposes to use the revised base year synthetic populations.

CHAPTER 2

Commute mode–destination model enhancements

This chapter summarises the enhancements in the commute mode–destination model during this work. The enhancements are the extension of the commute mode–destination model structure to represent walk and bus access to train separately, and improvements to the model specification to address the issues that BTS identified from a detailed validation of the model outputs against expanded HTS data (these issues are listed in Section 1.1).

Section 2.1 describes how the model structure has been extended to represent walk and bus access to train separately. Then Section 2.2 documents the additional estimation work that has been undertaken to improve the predictive performance of the models following BTS's detailed validation of the existing commute model during November 2011.

2.1 Extending the model structure to represent walk and bus access to train separately

The 2006-base version of the commute mode–destination model developed during 2010 represented three access modes to train:

- P&R, where access is by a car which is parked at the access station
- K&R, where access is by a car which is driven away from the access station
- other access, which includes both pure-walk access, and access where individuals use bus as part of their access leg.

To model the other access mode, zone to zone level-of-service (LOS) data was generated from the Emme assignment package. For a given origin–destination (OD) pair, Emme determined whether or not bus would be used as an access mode during the access leg.

The 2006-base version of the commute mode–destination model has now been implemented, and the model has been run for the base year. BTS has validated the base year model predictions using expanded HTS data, and for train tours using 'other' access the Emme skims have been analysed to compute the use of walk and bus access modes. The results of a comparison of observed and predicted tours by train access mode are shown in Table 1.

Table 1: Validation of train access modes shares

Access mode	Observed (expanded HTS)	STM predicted	Difference	Percentage
Walk	103,600	64,100	−39,400	−38.1 %
Bus	21,700	48,500	26,800	123.5 %
P&R	51,800	48,600	−3,300	−6.2 %
K&R	37,300	36,800	−500	−1.3 %
Total train	214,400	198,000	−18,000	−7.6 %

It can be seen that walk access to rail is substantially under-predicted, while bus access is substantially over-predicted, relative to the expanded HTS data. Therefore the model structure was extended to represent walk and bus access to train separately.

By representing walk and bus access modes separately, access mode constants can be estimated, which ensures that the access mode shares in the unweighted HTS estimation samples are replicated exactly. However, the challenge for model estimation procedure is to generate skims[1] for each of the access modes, which ensure that as many of the observed choices can be modelled as possible; i.e. for those who chose to access train by bus, that the model predicts an access route which includes the use of bus. If, for one of the access modes, a high fraction of chosen observations are excluded from the estimation, then the access mode share will be reduced and when the mode share will be under-estimated relative to the expanded HTS data.

For each of the four access modes represented in the extended approach, separate LOS has been used for the home to first station access legs of the tour, and for the first station to primary destination (PD) train leg of the tour. For P&R and K&R access, the choice between five station alternatives is modelled,[2] whereas for walk and bus access a single access station is modelled for a given OD pair.[3] Table 2 summarises the treatment of the access and train legs for the four access mode options.

Table 2: Treatment of access and train legs, extended approach

Access mode	LOS for access leg	Stations represented per OD pair	LOS for train leg (and egress)
Walk	Home zone to station, PT network with bus removed	1	Station to PD zone wet train[4] skims
Bus	Home zone to station, PT network including bus	1	Station to PD zone wet train skims
P&R	Home zone to station, highway network	5	Station to PD zone wet train skims
K&R	Home zone to station, highway network	5	Station to PD zone wet train skims

Home-zone to station skims for the highway network, and station to PD zone skims from the wet train network, were supplied for the 2010 estimation work and have been retained in the extended approach. However, new skims for the walk and bus access modes were

[1] By ‘skims’ we mean matrices defining in-vehicle and out-of-vehicle LOS measures for those OD pairs for which a public transport path has been identified in the Emme software.

[2] Please refer to Fox, Daly and Patruni (2010) for an explanation of why five station alternatives are modelled for each OD pair.

[3] Different access stations may be identified for the walk and bus access modes.

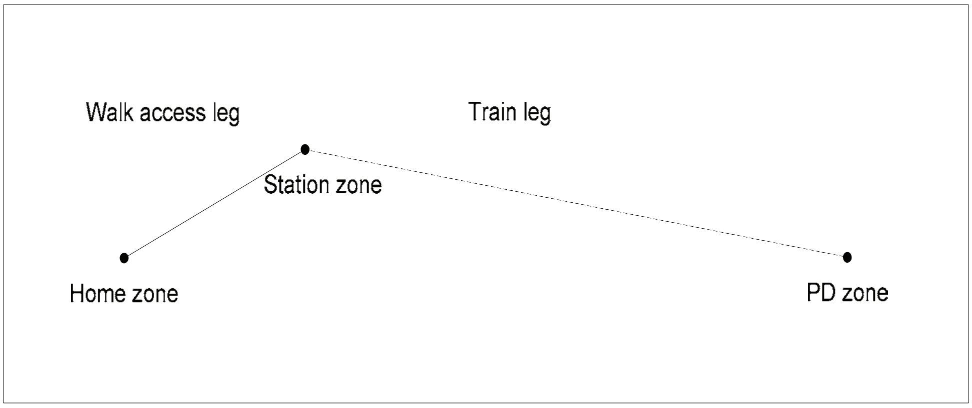
[4] The term ‘wet train’ is used because ferry is a mode in the all-modes public transport network. Light rail is also included in the all-modes public transport network.

required to implement the extended approach. The following sub-sections go on to describe how these skims have been generated.

2.1.1 Generating walk access skims

To model walk access to train, skims have been generated for the home to first station legs of train tours, in some cases using biased networks to ensure that a walk option is available (by biased networks we mean networks where the default assignment parameters have been modified in order to encourage the use of a particular access mode). These skims identify the station used to access the wet train network. Then for the access stations identified by the walk access skims, the *unbiased* station to zone rail LOS supplied for the 2010 estimations has been used to model the train leg of the tour from the access station to the final destination. This approach is illustrated in Figure 1.

Figure 1: Walk access to train



Different sets of walk access skims have been generated by removing the bus mode from the Emme public transport (PT) network, and then testing different biasing assumptions to encourage the use of walk as an access mode for rail. Three different options were tested:

- walk1, which uses the default route choice assumptions
- walk2, where the route choice parameters have been adjusted to encourage as much demand for train services as possible
- walk3, where in addition to the walk2 changes, a very high weight was applied to walk time to encourage as much walking to stations as possible (by reducing the percentage of cases where for shorter journeys a walk path all the way between the origin and the destination is identified – a path that does not use the train network at all)

The assignment parameters used for the three options are summarised in Table 3. Red highlighting is used to show where changes have been made relative to the default route choice assumptions.

Table 3: Walk access skim assignment parameters

Parameter	walk1	walk2	walk3
Boarding time mins	5	1	1
Headway fraction	0.5	0.1	0.1
Wait time weight	2	1	1
Walk time weight	2	2	100

The headway fraction is the proportion of the headway time that someone spends waiting. The default factor of 0.5 assumes random arrivals with trains spaced uniformly. In the walk2 and walk3 tests it is assumed that individuals spend just 10% of the headway time waiting.

The impact of the three different route choice assumptions was assessed by calculating the percentage of OD pairs where walk is used as an access mode to train (it is noted that with the different assumptions above, for some OD pairs, routes are identified where individuals can walk all the way and so there is no use of the train network), and for those OD pairs where a walk access to train skim is identified the average walk access distance. These measures are summarised in Table 4.

Table 4: Performance of walk access skim options

Measure	walk1	walk2	walk3
Percentage of ODs which access a train station	97.6 %	98.1 %	98.4 %
Mean walk access distance (km)	4.44	4.38	4.36

Note: figures are for unweighted OD pairs

The walk2 and walk3 skim options achieve a small increase in the percentage of ODs which have walk access to a train station. The mean walk access distance reduces slightly in the walk2 and walk3 options as individuals tend to walk to stations closer to their home.

Given that the bias introduced in the walk2 and walk3 options only results in a small increase in the percentage of ODs where the skims access a train station, the significant bias introduced in the walk3 option was judged by the study team not to be justified.

To choose between the walk1 and walk2 options, analysis was undertaken using the sample of commuters observed to choose to walk to train for their journeys in the HTS estimation sample. For these commuters, the number of cases where the access assumptions identified the station that was actually chosen were analysed.

There are a total of 439 walk access train tours in the HTS data. In the 2010 estimation work, 95 (21.6%) of these were excluded because no rail path was identified in the zone to zone LOS for the chosen OD pair. The performance of the walk1 and walk2 skims is summarised in Table 5.

Table 5: Performance of walk access skim options for chosen walk access observations

	walk1		walk2	
Total choices	439	100.0 %	439	100.0 %
Chosen station identified	371	84.5 %	369	84.2 %
Different station identified	66	15.0 %	70	15.9 %
No station identified	2	0.5 %	0	0.0 %

Note: figures are for unweighted OD pairs

The walk1 assumptions identify the chosen station in 84.5% of cases, a slightly higher percentage of cases than walk2. For 15% of cases, a different station is identified (it is noted that these observations are retained in estimation assuming use of the predicted station rather than the chosen station). Only two records are excluded with the walk1 assumption because no station was identified (the skim procedure identified a walk path all the way), a substantial improvement on the 95 records excluded when zone to zone LOS was used.

BTS undertook additional analysis to investigate the 66 stations where the chosen and predicted walk access stations differed. Station zone numbers run consecutively along each rail line, so differences of ±1 in the station zone number indicate the predicted station to be an adjacent station along the same rail line. Of the 66 cases where different stations were identified, over half were adjacent stations on the same rail line and therefore observed and predicted behaviour were not too different.

Overall the performance of the walk1 skims, which were generated from an unbiased assignment, was judged to be good and therefore these skims have been used in the modelling.

2.1.2 Generating bus access skims

The approach used to model bus access to rail was similar to that followed for the walk access mode. Different biasing assumptions were tested to encourage the use of bus as an access mode for the zone to access station legs of journeys, and then the wet train LOS for the access station to the final destination leg of journeys has been modelled using *unbiased* station to zone LOS.

Eight different bus skim options were considered, with bus1 representing the unbiased option, and with bus2 to bus8 options using various forms of biasing to the assignment parameters to encourage the use of bus as an access mode. Table 6 summarises the eight different options tested. Red highlighting shows where biases have been applied to the assignment parameters.

Table 6: Bus access skim assignment parameters

Parameter	bus1	bus2	bus3	bus4	bus5	bus6	bus7	bus8
Boarding time mins	5	1	5	1	5	1	5	1
Headway fraction	0.5	0.1	0.5	0.1	0.5	0.1	0.5	0.1
Wait time weight	2	1	2	1	2	1	2	1
Walk time weight	2	2	4	4	2	2	4	4
Train speed factor	1	1	1	1	2	2	2	2

To choose between the different bus skim options, analysis was undertaken for the 86 observations which used bus access to train in the HTS data. Table 7 summarises the number of cases where a bus access to train path is identified for these observations (rather than a walk path all the way, or a path that uses bus but not train), and the number of cases where the bus access station identified corresponds to the chosen station.[5]

Table 7: Performance of bus access skim options for chosen bus access observations

Parameter	bus1	bus2	bus3	bus4	bus5	bus6	bus7	bus8
Cases bus access path identified	74 86%	76 88%	72 84%	62 72%	80 93%	81 94%	76 88%	72 84%
Cases chosen station identified	53 62%	52 60%	48 56%	41 48%	54 63%	51 59%	50 58%	41 48%

Note: figures are for unweighted OD pairs

Comparing the bus1 to bus4 skims options where no adjustment is made to train speeds, the bus2 option performs best at identifying a bus access skim, but bus1 is best at

5 Due to multi-pathing in Emme, in a small fraction of cases more than one access station can exist for a given OD pair. In these cases, the maximum station entry number is taken as the station identified by the skims.

identifying the actual station chosen. Increasing levels of bias in the bus3 and bus4 options noticeably reduces the level of correspondence between skimmed and chosen stations, and these options do no better in identifying any bus access path at all. Given bus1 involves no bias to the assignment parameters, it was decided to test the bus1 skims rather than the bus2 skims in model estimation.

The bus5 to bus8 skim options identify a bus access skim for higher fractions of cases than the bus1 to bus4 options. Thus speeding up train services by a factor of two does lead to more bus access to stations (rather than using bus services all of the way). Of the bus5 to bus8 options, the bus5 option is best at replicating the actual stations chosen, and the bus5 skims will ensure bus is available for a higher fraction of ODs than the bus1 skims. Therefore it was decided to test the bus5 skims as well as the bus1 skims in model estimation.

2.2 Incorporating other improvements

In the brief for this work, BTS summarised a number of issues that emerged from their validation of the 2006-base version of the commute mode–-destination model:

- too much bus access to rail
- too little walk access to rail
- too much car travel in the inner areas
- not enough car travel in the outer areas
- not enough rail journeys originating in the inner areas
- not enough walking in the inner areas
- too much walking in the outer areas.

In addition to these issues, BTS identified an issue with the processing of P&R and K&R from the HTS in the 2010 estimations. Specifically, in the data provided by BTS all rail users who are car passengers were coded as K&R irrespective of whether the car was parked at the station. Corrected HTS data have been supplied for this additional estimation work; as a result the number of P&R observations increases,[6] and the number of K&R observations decreases, relative to the 2010 estimation work.

The first two issues have been addressed by extending the models so bus and walk access to train are represented as separate access modes, as detailed in Section 2.1. To investigate the other issues, special application set-ups have been created to investigate the performance of the models across six different dimensions:

- population density band at the home end
- population density band at the workplace end
- employment density at the home end
- employment density at the workplace end
- distance of the home from the CBD

[6] Note that because P&R includes both drivers and passengers, the availability of the P&R alternatives is not conditioned on individual licence holding. However, for the P&R alternative to be available to an individual their household has to own at least one car.

- distance of the workplace from the CBD.

The first four of these allow the performance of the model to be compared according to measures of land use density, the hypothesis being that car use will be lower in high density areas where parking capacity constraints play a role. The distance from CBD measures provide a proxy measure for similar effects, as the high density areas are located close to the CBD.

Four sets of model runs were therefore undertaken to incorporate the various enhancements:

- tests to improve the predictions for walk
- tests to extend the model structure to represent separate bus and walk modes to train
- tests to improve the predictions for car
- finalisation of the enhanced model

These four sets of tests are documented in the following sub-sections. It should be noted that the comparisons of observed data and model predictions are based on the unweighted samples of HTS data used in model estimation. In application, the model is applied using the full population for the study area generated by the Population Synthesiser, and the model is validated against expanded HTS data. There will be differences between the unweighted model forecasts and those generated in base year application using the base population generated by the Population Synthesiser. The following sub-sections summarise the results from the various tests. Full parameter results for each of the model specifications tested are presented in Appendix A.

2.2.1 Improving the predictions for walk

Comparison of observed and predicted walk tours across each of the four intensity dimensions listed in the first set of bullets above revealed the following patterns:

- a systematic under-prediction of walk tours in higher population density bands measuring population density at the home end
- some under-prediction of walk tours in higher population density bands measuring population density at the workplace end, though the pattern was less clear than the pattern at the home end
- some under-prediction of walk tours in higher employment density bands measuring employment density at the home end
- a relatively good match between observed and predicted data across employment density bands measuring employment density at the workplace end.

More substantial differences between observed and predicted data were observed when the model was assessed according to the distance of home and workplace from the CBD. These comparisons are illustrated in Figure 2 and Figure 3 for the final model specification from the 2010 estimations (model 166).

Figure 2: Fit of walk tours in model 166 by home distance from CBD (km)

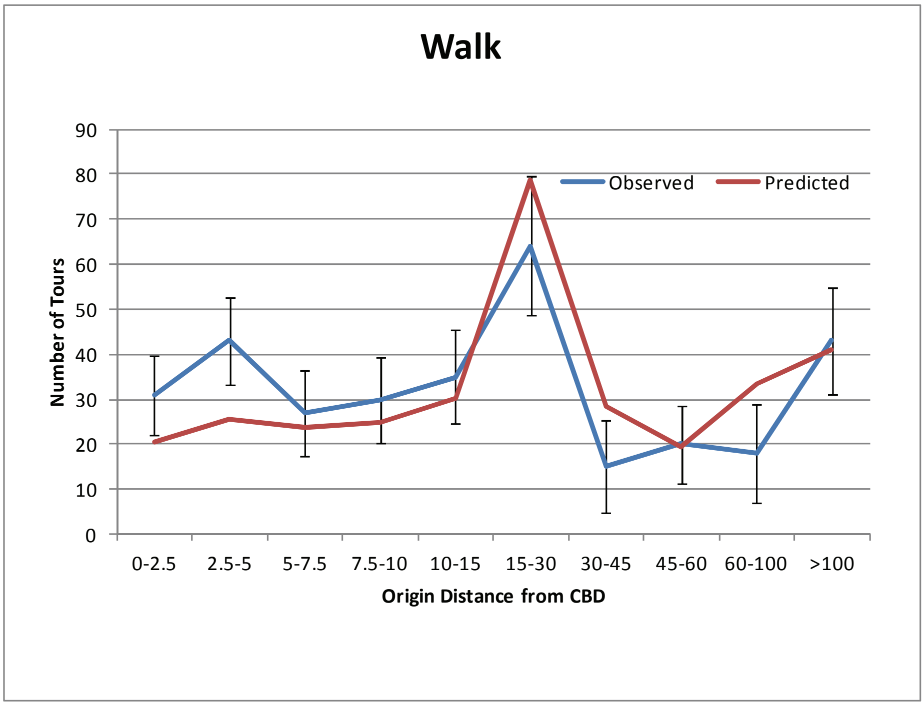
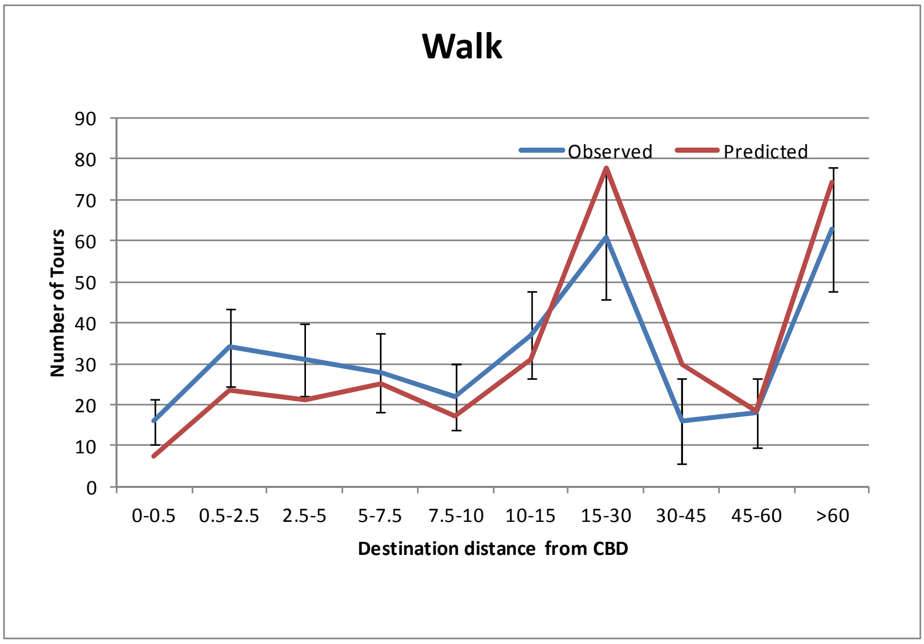


Figure 3: Fit of walk tours in model 166 by workplace distance from CBD (km)



Walk tours are systematically under-predicted for homes and workplaces close to the CBD. As most walk tours are short, similar patterns of difference are observed when measuring distance from the CBD from the home and the workplace. For short distances, a more systematic pattern of difference between observed and predicted data was observed for workplace distance from CBD, with significant differences between observed and predicted data for the first three bands compared with the first two for the home distance from CBD comparison. Therefore, additional model terms were added to the utility equation for walk in terms of workplace distance from the CBD.

Table 8 summarises the additional model runs made to improve the fit to the observed data across the workplace distance from CBD dimension.

Table 8: Additional model runs, workplace distance from CBD terms

Model	Degrees of freedom	Log-likelihood	Description	Result
166	55	−36,883.8	Final model specification from 2010 estimations	n/a
168	56	−36,881.5	As 166, plus linear workplace distance from CBD term	Term significant and negative, indicating lower likelihood of walking for trips with further distance from the CBD
169	57	−36,861.6	As 168, plus log workplace distance from CBD term	Additional log term is negative and significant, significant improvement in likelihood, but linear term turns positive
170	56	−36,871.0	As 169, but dropping positive linear term	Fit to data is better than linear only model (168)
171	58	−36.864.6	As 170, but with distance term re-specified so it only applies to Sydney SD[7] destinations, and with separate walk constants for Newcastle and Wollongong destinations[8]	The log distance from CBD term increases in magnitude and significance, and the separate constants for Newcastle and Wollongong are significant
172	59	−36,864.2	As 171, but re-testing a linear distance from CBD term	The linear term is negative but insignificant, 171 remains the best model

Full parameter results for these models are presented in Table 36 and Table 37 in Appendix A.

To validate the effectiveness of the additional distance-from-CBD terms, each model was analysed across the four intensity and two distance-from-CBD dimensions. The fit of model 171 across the two distance-from-CBD dimensions is shown in Figure 4 and Figure 5.

7 Statistical Division.

8 Newcastle and Wollongong have their own centres, and therefore using distance from the Sydney CBD measure as a proxy for intensity is not appropriate for these areas.

Figure 4: Fit of walk tours in model 171 by home distance from CBD (km), Sydney SD home zones only

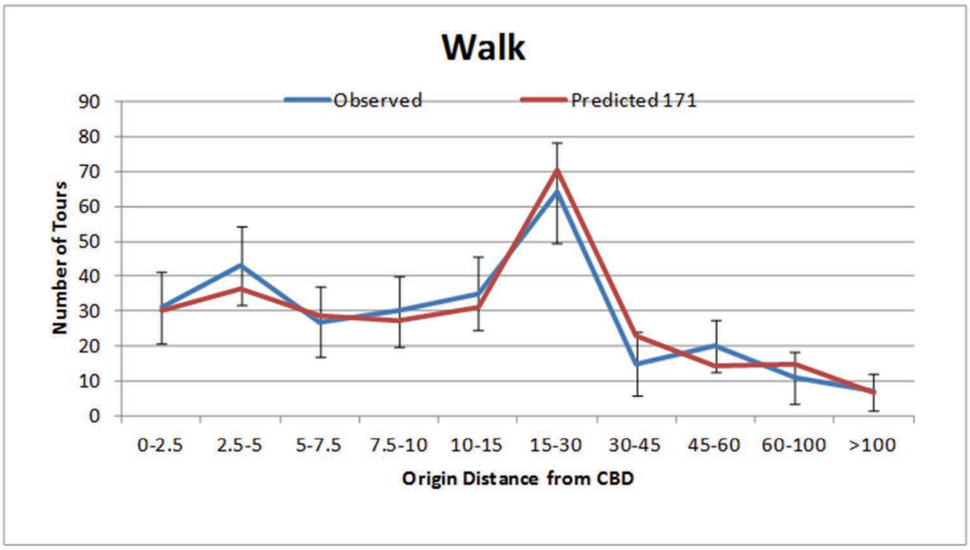
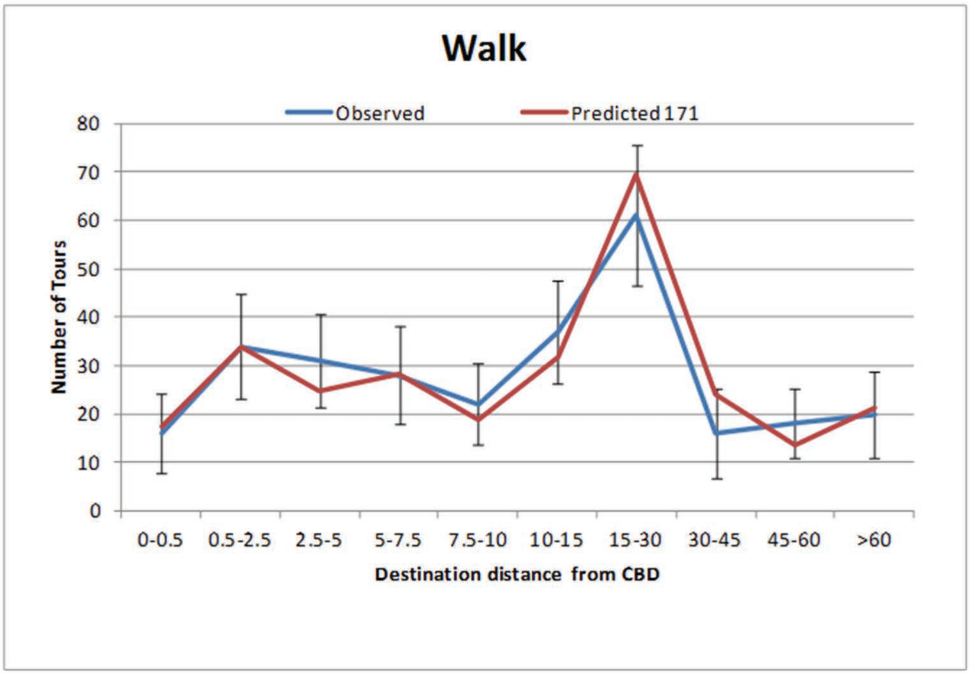


Figure 5: Fit of walk tours in model 171 by workplace distance from CBD (km), Sydney SD workplace zones only



Comparison of these plots with Figure 2 and Figure 3 demonstrates a significant improvement in fit to the observed data, in particular when the home and the workplace are closer to the CBD.

2.2.2 Extending the model to represent separate walk and bus access modes to train

The next set of model tests that were undertaken extended the model structure to represent separate walk and bus access modes to train. Table 9 summarises the results from these tests.

Table 9: Additional model runs, extending the model structure to represent separate walk and bus access modes to train

Model	Degrees of freedom	Log-likelihood	Obs.	Description	Result
171	58	−36,864.6	5689	Best model from workplace distance from CBD tests	n/a
173	59	−37,749.2	5782	Separate walk and bus access modes using walk1 and bus1 skims	Gain 93 observations. Improvements to LOS parameters
174	59	−37,806.2	5788	As 173, but with bus5 skims	Gain an additional 6 observations, little impact on LOS parameters
177	60	−37,802.5	5788	As 174 but with separate bus access time parameter	Bus access time parameter is insignificant, model 174 remains best model

Full parameter results for these models are presented in Table 38 in Appendix A.

In model 173, an additional 93 train observations are incorporated in the model, taking the total number of train observations from 734 to 827. Comparing the model parameters which apply to train between models 171 and 173 (the t-ratios for the parameter estimates are given in brackets):

- there is little impact on the linear cost parameters
- the log cost parameter strengthens from -0.366 (4.5) to -0.398 (4.7)
- rail in-vehicle time strengthens from -0.022 (5.9) to -0.025 (6.2)
- bus in-vehicle time weakens slightly, from -0.041 (6.8) to -0.036 (6.5)
- access and egress time strengthens from -0.063 (6.1) to -0.078 (7.3)
- first wait time strengthens slightly from -0.0105 (5.5) to -0.0106 (5.7)
- other wait time weakens from -0.073 (6.4) to -0.067 (6.3).

Thus a mixed pattern is observed, with some parameters increasing in significance, and others decreasing in significance. It is noteworthy that the access and egress time parameter gains in magnitude and significance when we introduce a separate walk access mode. However, the bus in-vehicle time parameter – which is used both for bus as an access mode to train and for bus as a main mode – weakens.

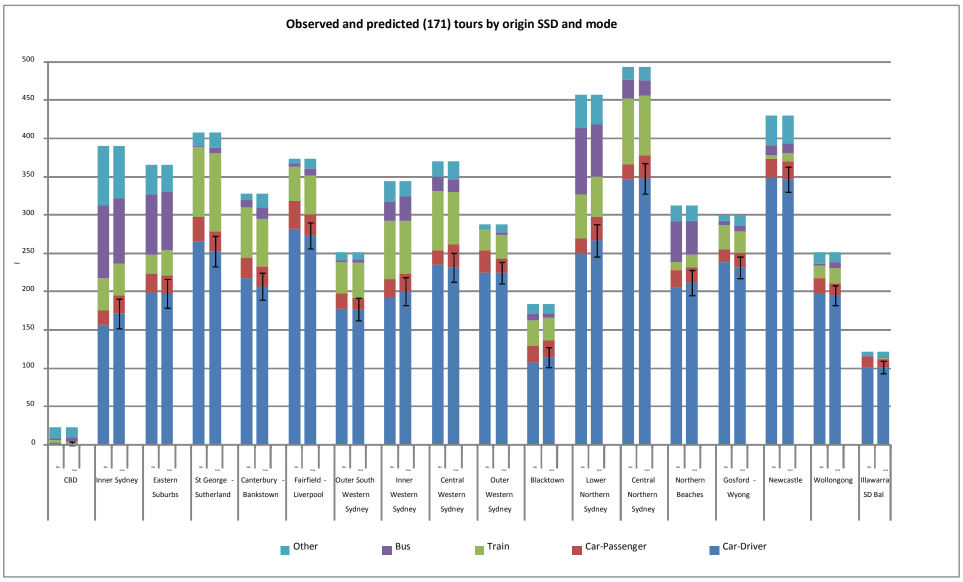
In model 174, the walk1 skims were retained, but the alternative candidate skims for bus access, bus5, were used. With these skims we gain six bus-access observations. Only very marginal impacts on the model parameters that apply to the bus access mode were observed, and therefore it was decided to accept the biasing to the train speeds used to generate the bus5 skims on the basis that the bus5 skims maximise the volume of bus access observations included in the model without introducing bias to the final model parameters. By minimising the loss of observed data we ensure that the access mode shares predicted by the model more closely match those observed in the HTS data.

As noted above, the bus in-vehicle time parameter weakened slightly when the separate walk and bus access modes were introduced. Therefore a test was made in model 177 where a separate bus access time parameter was estimated, with the anticipation that the estimate would be higher than for bus as a main mode. However, the parameter was insignificant with a t-statistic of just −0.5 and therefore we conclude that it is not possible to estimate a separate bus access time parameter. Therefore model 174, which makes the assumption that in-vehicle time for bus as an access mode is valued equally to in-vehicle time for bus as a main mode, remained the best model specification.

2.2.3 Improving the predictions for car

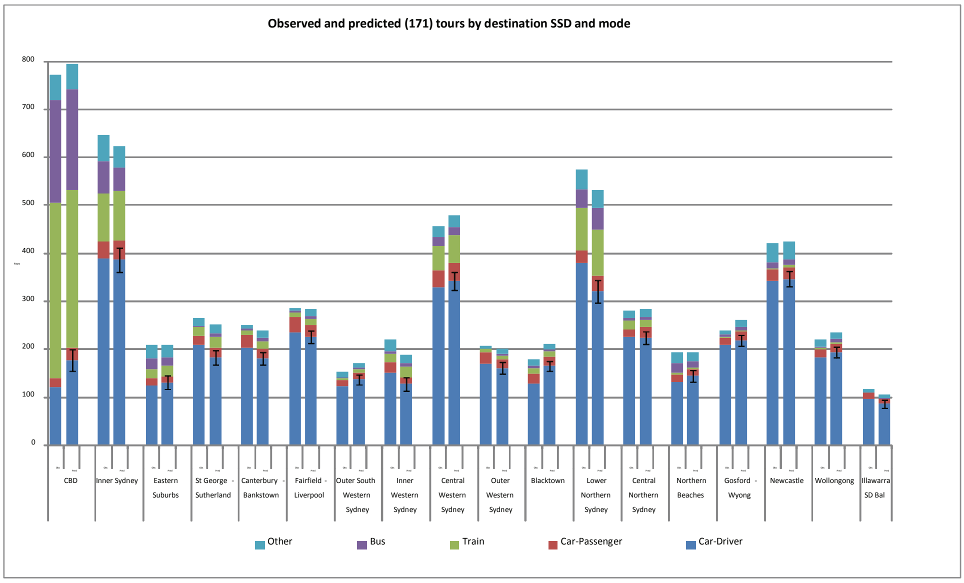
Comparisons of observed and predicted data for car across the six dimensions listed at the start of Section 2.2 did not reveal any significant differences to allow additional model terms to be added to the utility functions for car. Therefore, the predictive performance of the model has also been assessed by comparing observed and predicted tours by aggregate mode (car driver, car passenger, train, bus, other) and home and work Statistical Sub-Division (SSD). It was across these dimensions that BTS identified a pattern of over-prediction of car travel to the inner areas, and under-prediction of car travel to the outer areas. The fit of the model across both home (Figure 6) and workplace (Figure 7) SSD regions was examined for model 171, the best model from the tests to improve the predictions for walk documented in Section 2.2.1.

Figure 6: Fit of model 171, home SSD regions



Note: the error bars are two times the standard errors for the predicted car driver tours

Figure 7: Fit of model 171, workplace SSD regions



Note: the error bars are two times the standard errors for the predicted car driver tours

The fit of model 171 across home SSD regions (Figure 6) was reasonably good. However, a number of significant differences between observed and predicted car driver tours were observed across workplace SSD regions (Figure 7), specifically:

- an over-prediction of car driver tours to the CBD
- an over-prediction of car driver tours to Blacktown
- an under-prediction of car driver tours to St-George Sunderland
- an under-prediction of car driver tours to Canterbury-Bankstown
- an under-prediction of car driver tours to Lower Northern Sydney.

Therefore a series of model tests was undertaken to test additional SSD destination effects on car driver for these five areas. These tests are summarised in Table 10. As noted in the table, the first set of tests were undertaken with bus and walk access to train still represented as a single access mode. Model 172 was used as the starting model from these tests, rather than model 171 (the best model from the workplace distance from CBD tests).

Table 10: Additional model runs, car driver SSD destination effect tests

Model	Degrees of freedom	Log-likelihood	Obs.	Description	Result
172	59	−36,864.2	5689	Model from workplace distance from CBD tests with both linear and log walk distance from workplace terms	Note that walk and bus access to train are still modelled as a single access mode in this model.
175	64	−36,827.1	5689	As 172, plus destination SSD terms on car driver for CBD, Blacktown, St-George Sutherland, Canterbury-Bankstown, Lower Northern Sydney	All five parameters significant. However, adverse impact on key behavioural parameters, in particular cost parameters for higher income bands.
176	60	−36,836.7	5689	As 172, but with a destination SSD term on car driver for CBD destinations only, plus a correction to the definition of the train CBD destination term[9]	The car driver CBD destination parameter remains significant and large in magnitude; however the adverse impacts on key behavioural parameters remain. VOTs are implausibly high.
178	60	−37,766.1	5787	As 176, with separate walk and bus access modes, and revised coding of P&R and K&R	Adverse impacts on key behavioural parameters remain. VOTs are implausibly high.
179	61	−37,756.8	5787	As 178, but releasing Theta_AcMd nest parameter for the train access modes	Theta_AcMd is significantly greater than 1 and is therefore constrained to 1 in subsequent models.
180	59	−37,785.5	5787	As 178, but dropping problematic car driver CBD destination term	Significant loss in likelihood but key behavioural parameters are better estimated.

Full parameter results for these models are presented in Table 39 and Table 40 in Appendix A.

The conclusion from the tests was that it was not possible to add SSD regional terms to the car driver utility without adversely impacting the key behavioural parameters in the model. In particular, the implied values of time (VOTs) were implausibly high if a term for the key effect, the over-prediction of car driver tours to the CBD, was included in the model specification.

If more analysis was undertaken of the available HTS data about the proportion of individuals who have to pay for parking in the CBD, and with more information about the cost of parking in individual CBD zones (rather than averages across groups of zones), then with this improved parking cost information the model might be better able to predict the number of car driver tours to CBD destinations. A dedicated parking survey undertaken in the CBD would be one approach to collecting the parking cost information required. Another approach to improve the predictions of car driver travel to the CBD would be to

[9] In the previous estimations, this train CBD term was mistakenly not applied to the other access mode, which covered walk and bus access. In the new estimations the specification of the term has been corrected so that it is applied to all of the train access modes. This correction was applied in model 176 and model numbers 178 and above.

incorporate parking search time information or to model the choice of parking location relative to the final destination. However, this information was not available for this study and therefore it was decided to accept the over-prediction of car driver tours to the CBD on the basis of the overall quality of the model. A relevant consideration in this decision was that in application the home–work model is pivoted around base matrices generated from the Census journey-to-work information, and these base matrices will ensure that in the base year the correct number of car driver tours will be predicted to CBD destinations.

The fit for model 180 was compared across origin and destination SSDs, both at the main mode level (distinguishing car driver, car passenger, train, bus and other modes) and for the four train access modes (P&R, K&R, walk and other). Figure 8 to 11 present the resulting comparisons.

Figure 8: Fit of model 180, main modes by home SSD regions

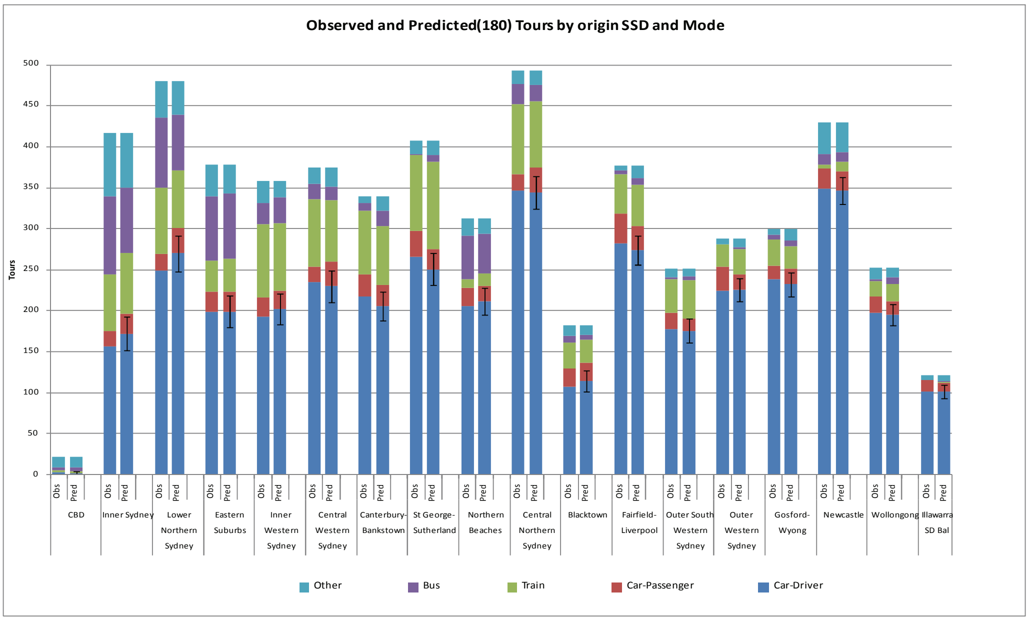
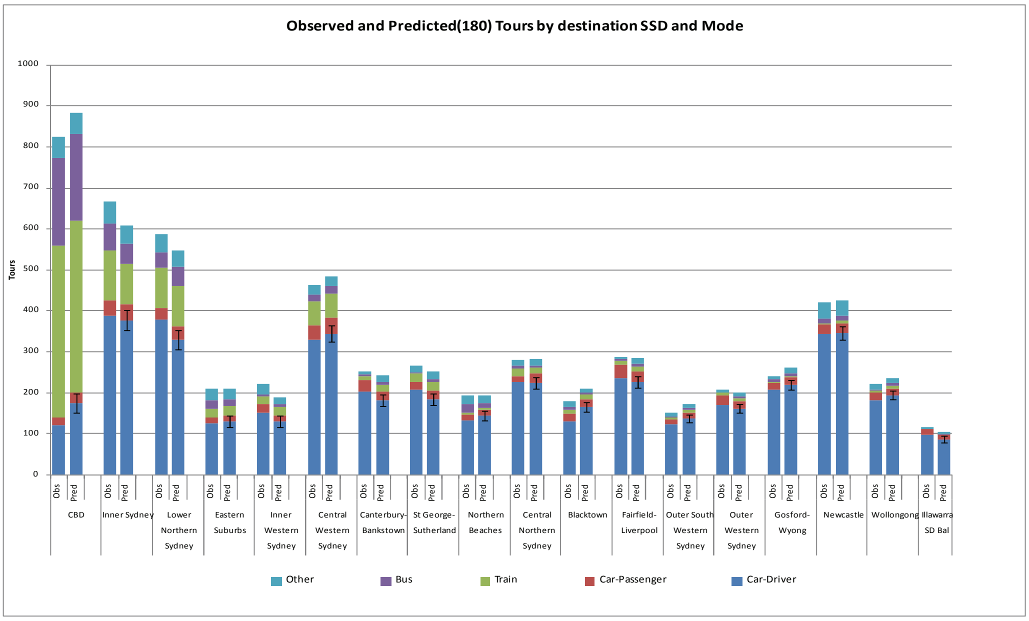


Figure 9: Fit of model 180, main modes by workplace SSD regions



Note: the error bars are two times the standard errors for the predicted car driver tours

At the home end, the fit of model 180 by mode and SSD area is good. In particular, observed and predicted numbers of tours for other modes, which are dominated by walk, now match well as a result of the additional walk distance terms.

At the workplace end, the key differences between observed and predicted data are those for the car driver mode, and in particular the over-prediction of car driver tours to the CBD.

Figure 10: Fit of model 180, train access modes by home SSD regions

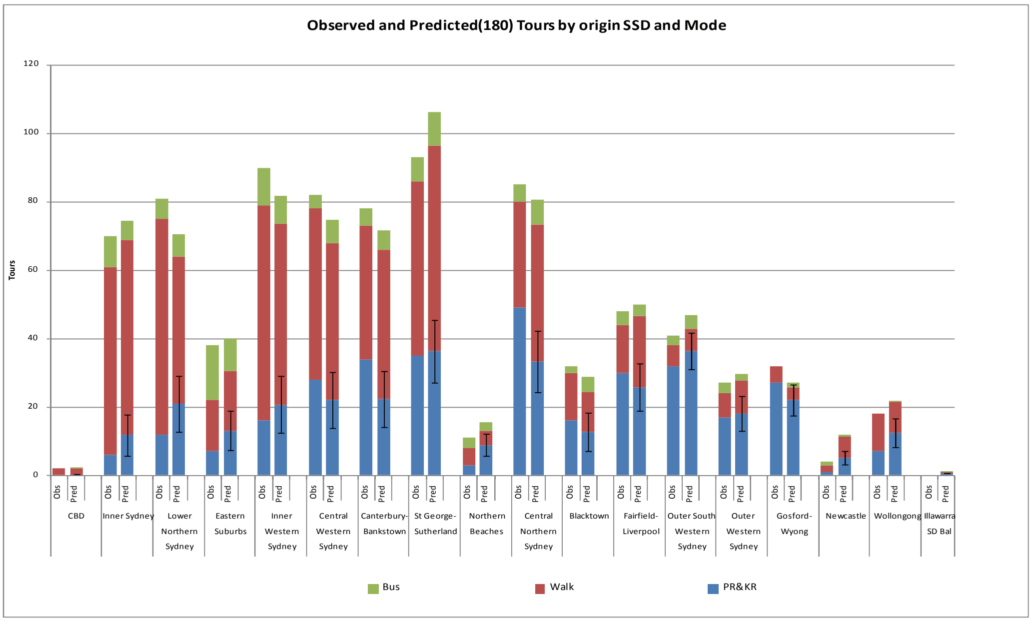
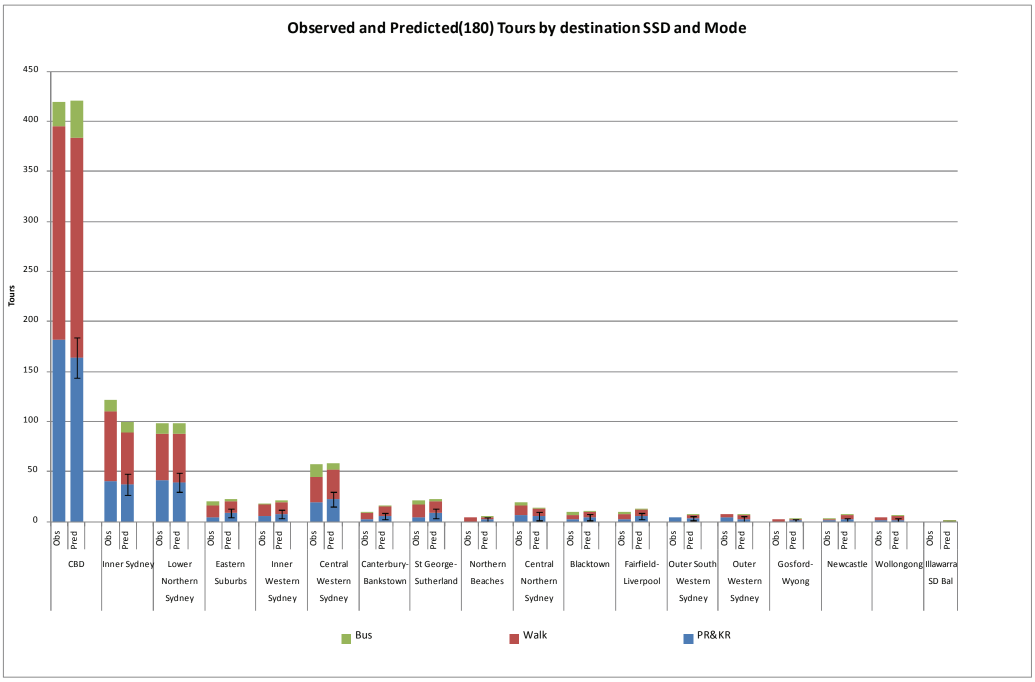


Figure 11: Fit of model 180, train access modes by workplace SSD regions



For the train access modes at the home end, there is some over-prediction of car access (P&R and K&R combined) close to the CBD (Inner Sydney and Lower Northern Sydney), but generally observed and predicted access mode shares match well.

Looking at the access mode shares at the workplace end, the graph is dominated by the CBD, which is the destination for most train tours. Total train tours to the CBD match exactly now following correction to the train CBD destination parameter. Car access to the CBD is under-predicted slightly but the difference is not statistically significant.

2.2.4 Final enhanced model

The final stage in the re-estimation process was to re-process the LOS used to identify the LOS for the top five ranked stations for P&R and K&R access for each OD pair. Models 168 to 180 identified the top ranked stations using parameters from model 166. Model 181 identifies the top ranked stations using parameters from model 180, and so uses enhanced parameters that take account of the improvements to the model specification in the current work. Table 41 in Appendix A compares the results for models 180 and 181.

It can be seen from Table 41 that we gain an additional 15 P&R and K&R observations as a result of using the model 180 parameters, which are better able to identify the P&R and K&R stations actually chosen.[10] A key change between model 180 and 181 is for the car access time parameter, which reduces from -0.077 in model 180 to -0.065 in model 181: the sensitivity per minute of car access time is lower in model 181, which is estimated using the updated LOS for P&R and K&R access.

There are 113 additional train observations included in the enhanced model compared with the final model from the 2010 estimations (model 166). Table 11 summarises the changes in the numbers of observations by train access mode between the two models.

Table 11: Changes in train access mode samples

Access mode	Model 166 Final 2010 model		Model 181 Enhanced model	
P&R	184	25.1 %	209	24.7 %
K&R	137	18.7 %	126	14.9 %
Walk	413	56.3 %	433	51.1 %
Bus			79	9.3 %
Total	734	100.0 %	847	100.0 %

The 113 additional train observations comprise an additional 14 car access records, and an additional 99 walk and bus access records. The number of K&R observations has reduced following the correction to the coding of P&R and K&R so that passengers who arrive in a car that is parked at the access station are coded as P&R rather than K&R.

Table 12 presents a comparison of the ratios of key PT LOS parameters relative to train and ferry in-vehicle time in the final 2010 and enhanced models.

Table 12: Public transport LOS parameters, expressed relative to train in-vehicle time

Parameter	Model 166 Final 2010 model	Model 181 Enhanced model
Train and ferry in-vehicle time	1.00	1.00
Bus in-vehicle time	1.80	1.43
Access/egress time	2.73	2.66
Initial wait time	4.42	3.43
Other wait time	3.30	2.05
Car access time	3.24	2.36

With the inclusion of the 113 additional train observations and the move to representing separate walk and bus access mode observations, the magnitude of the train in-vehicle time parameter has increased by 25% between models 166 and 181. As a result of this increase, the relative valuations of most of the other PT LOS parameters decrease relative to train in-vehicle time between models 166 and 181. An important exception to this pattern is

[10] P&R and K&R choices where the chosen station lies outside the five top ranked stations are excluded from the estimations.

access and egress time, which has a similar ratio in the old and new models because in model 181 it has also increased in magnitude (by 22% between models 166 and 181). The relative valuation of the car access time parameter in model 181 demonstrates that individuals still prefer to minimise the time spent accessing train by car relative to the train leg, but that the relative strength of this preference is not as strong as it was in model 166.

Model 181 is the final enhanced model that has been taken forward for implementation.

CHAPTER 3 Revised commute frequency model

The commute frequency model structure, development and parameter definitions were documented in full in Tsang et al. (2010). The final commute frequency model estimated in 2011 incorporated a logsum accessibility parameter for the zero/one-plus tours decision. This term reflects higher frequency of commute tour making for individuals with higher accessibility: accessibility varies between different home zones and between different person segments.

The following models are compared in this chapter:

- COMFR_v13: final model from 2011
- COMFR_v14: as per model v13, but with revised logsums from the enhanced commute mode–destination model (model 181)
- COMFR_v15: as per model v14, but re-testing a logsum term on the stop alternatives in the multiple tour component of the model.

Table 13 compares the parameter estimates for the three models.

Table 13: Commute frequency models

File	COMFR_v13.F12		COMFR_v14.F12		COMFR_v15.F12	
Observations	12720		12720		12720	
Final log (L)	-8495.2		-8494.8		-8494.1	
D.O.F.	20		20		21	
Rho²(0)	0.657		0.657		0.657	
Rho²(c)	0.129		0.129		0.130	
Estimated	25 May 11		10 May 12		10 May 12	
theta	0	(*)	0	(*)	0	(*)
Terms on zero/one-plus model						
Constant	-0.1499	(-1.1)	-0.1562	(-1.1)	-0.1562	(-1.1)
ageo39	0.1667	(3.9)	0.1655	(3.8)	0.1655	(3.8)
ageo59	0.3125	(4.0)	0.3135	(4.1)	0.3135	(4.1)
manufac	-0.6971	(-9.7)	-0.6983	(-9.7)	-0.6983	(-9.7)
males	0.5262	(12.1)	0.5263	(12.1)	0.5263	(12.1)
compcar	0.6763	(14.8)	0.6778	(14.8)	0.6778	(14.8)
carcompet	-0.2321	(-4.6)	-0.2274	(-4.5)	-0.2274	(-4.5)
fted	2.152	(21.7)	2.151	(21.7)	2.152	(21.7)
pted	1.609	(11.7)	1.608	(11.7)	1.608	(11.7)
ptwk	0.6948	(11.2)	0.6934	(11.1)	0.6934	(11.1)
caswk	0.8856	(10.7)	0.8841	(10.7)	0.8841	(10.7)
volwk	1.666	(11.4)	1.664	(11.4)	1.664	(11.4)
incge67.6k	-0.1188	(-2.3)	-0.1172	(-2.2)	-0.1172	(-2.2)
incpu20.8k	0.4535	(7.1)	0.4517	(7.0)	0.4517	(7.0)
access	-0.1202	(-6.3)	-0.1194	(-6.4)	-0.1194	(-6.4)
Terms in stop/go model						
Constant2	3.396	(34.0)	3.396	(34.0)	2.900	(6.6)
compcar2	-0.5000	(-3.4)	-0.5000	(-3.4)	-0.5451	(-3.6)
manufac2	0.5342	(2.0)	0.5342	(2.0)	0.5425	(2.1)

inpu20.8k2	-0.4098	(-2.3)	-0.4098	(-2.3)	-0.3640	(-2.0)
inge67.6k2	0.4903	(2.5)	0.4903	(2.5)	0.4488	(2.3)
StopLogsum					0.07330	(1.1)

Comparing models 13 and 14, the logsum accessibility parameter 'access' increases in significance slightly (the t-ratio increases from 6.3 to 6.4), and the overall model fit also increases slightly (by 0.4 log-likelihood points). Thus the accessibility parameters from the enhanced commute mode–destination model are slightly better able to explain observed commute tour making behaviour. The changes to the other model parameters are relatively small. Note that the 'access' term is negative because it is placed on the zero tours alternative – individuals with higher accessibility are less likely to make zero tours.

In model 15 an accessibility term was tested on the 'stop' alternatives in the multiple tour model named 'StopLogsum'. A positive parameter indicates that an individual is more likely to stop – less likely to make multiple tours. We would expect multiple tour making to increase as accessibility increases, which would imply a negative accessibility parameter. However, the accessibility term is positive and insignificant and therefore it was not possible to identify a significant accessibility effect in the multiple tour component of the model.

Model 14 is the updated commute frequency model that has been taken forward for implementation.

CHAPTER 4 Revised total car ownership model

The total car ownership model estimated in 2011 incorporates a logsum for commute travel that reflects the fact that households are more likely to own one or more cars in areas where the *improvement* in accessibility for commuting relative to not owning a car is greatest. Accessibility is measured through logsums for an 'average' individual for each household, specifically a full-time worker in the middle personal income band ($32,000–41,599 p.a. in 2006 prices).

Table 14 compares the final total car ownership model estimated in 2011 (hhcar_2006base_v35) with the updated model re-estimated with the updated commute mode–destination model logsums (hhcar_2006base_v36). The model parameter definitions are detailed in Tsang et al. (2010).

Table 14: Total car ownership models

File	hhcar_2006base_v35.F12		hhcar_2006base_v36.F12	
Observations	22677		22677	
Final log (L)	-15967.9		-15971.1	
D.O.F.	32		32	
$Rho^2(0)$	0.462		0.461	
$Rho^2(c)$	0.362		0.361	
Estimated	9 Feb 11		10 May 12	
Constants				
1carowned	-3.774	(-19.6)	-3.508	(-19.5)
2carowned	-9.020	(-27.2)	-8.527	(-27.8)
3+carowned	-14.87	(-36.2)	-14.32	(-36.4)
Income				
HHInc1	0.1468	(8.5)	0.1502	(8.7)
HhInc23	0.2019	(14.8)	0.2028	(14.9)
Gender				
FmHdHH2	-0.1745	(-4.2)	-0.1757	(-4.2)
FmHdHH3	-0.3003	(-4.3)	-0.3023	(-4.3)
Work status				
FtTmWrk1	0.3854	(5.2)	0.3917	(5.3)
FtTmWrk2	0.6346	(8.0)	0.6407	(8.1)
FtTmWrk3	0.8727	(9.9)	0.8776	(10.0)
PrTmWrk1	0.4544	(3.9)	0.4574	(3.9)
PrTmWrk2	0.7311	(6.0)	0.7344	(6.0)
PrTmWrk3	0.9114	(6.9)	0.9148	(6.9)
Age related				
D1age35	0.03131	(10.9)	0.03120	(10.9)
D2age35	0.07205	(15.4)	0.07187	(15.3)
D3age35	0.08441	(16.1)	0.08422	(16.0)
D23age50	-0.06341	(-10.1)	-0.06354	(-10.1)
Household characteristics				

NChildCof	0.3195	(5.0)	0.3130	(4.9)
Numlics1	1.476	(14.1)	1.400	(13.7)
Numlics2	2.628	(18.4)	2.509	(18.2)
Numlics3	3.365	(23.8)	3.280	(23.8)
D2LIC_CAR	-0.8181	(-6.2)	-0.9277	(-7.4)
D3LIC_CAR	-0.8776	(-7.3)	-0.9073	(-7.6)
CmpCar1_2	1.191	(20.2)	1.193	(20.3)
CmpCar1_3	1.649	(20.6)	1.654	(20.7)
CmpCar2_3	1.445	(15.9)	1.446	(16.0)
couple1	0.1498	(3.4)	0.1417	(3.2)
CBDdist	0.5429	(24.9)	0.5220	(23.1)
Migrant status				
Naus_1	0.09819	(2.4)	0.09548	(2.3)
Naus_2	0.2755	(6.4)	0.2744	(6.4)
Naus_3	0.3505	(7.7)	0.3508	(7.7)
Accessibility				
m_d_access	0.6885	(12.3)	0.6400	(12.1)

In contrast to the commute frequency model, the significance of the accessibility parameter in the total car ownership model reduces slightly when the model is re-estimated with the updated commute mode–destination model logsums. Furthermore, we observe a slight reduction in model fit (3.2 log-likelihood points).

The changes to the logsum term have a noticeable impact on a number of the other model parameters, specifically the constants on the 1, 2 and 3+ car alternatives, and the parameters relating to licence holding. Analysis of the LOG file for the model run confirmed that the parameters which show greater changes between models 35 and 36 are those which have higher correlations with the accessibility parameter.

Model 36 is the updated car ownership model that has been taken forward for implementation.

CHAPTER 5 Updates to the Population Synthesiser

The development of the 2006-base Population Synthesiser was documented in full in Fox, Daly, Patruni and Tsang (2012). The first stage in the updating task was to implement the revised total car ownership model parameters in the Population Synthesiser; this stage is documented in Section 5.1. Note that no changes were made to the company car ownership model and therefore the implementation of the company car ownership model in the Population Synthesiser is unchanged. The next stage was to recalibrate the car ownership pivot process, which ensures that the model predicts the levels of car ownership observed in the 2006 Census for each model zone. The car ownership recalibration is documented in Section 5.2. The final stage was to re-run the 'ACCUM' process to generate the population weights by zone for each HB purpose for the 2006 base year. This final step is documented in Section 5.3.

5.1 Total car ownership model implementation

The total car ownership is implemented in ALOGIT using a file named TOTCARO_2006.ALO. Two changes have been made to the code to take account of the changes to the total car ownership model in Task 3:

- The code has been updated to reference the parameters of the new total car ownership model (model version 36).
- New commute mode–destination model logsums have been created to implement the influence of accessibility.

No other changes were required.

5.2 Zonal car ownership pivot recalibration

The zonal car ownership pivot was incorporated into the Population Synthesiser during the recent project to create the 2006 base version of the Population Synthesiser. The car ownership pivot was added because the earlier 2004 STM validation project had revealed that the total car ownership model was not able to fully replicate the spatial variation in car ownership levels observed in the 2006 Census data.

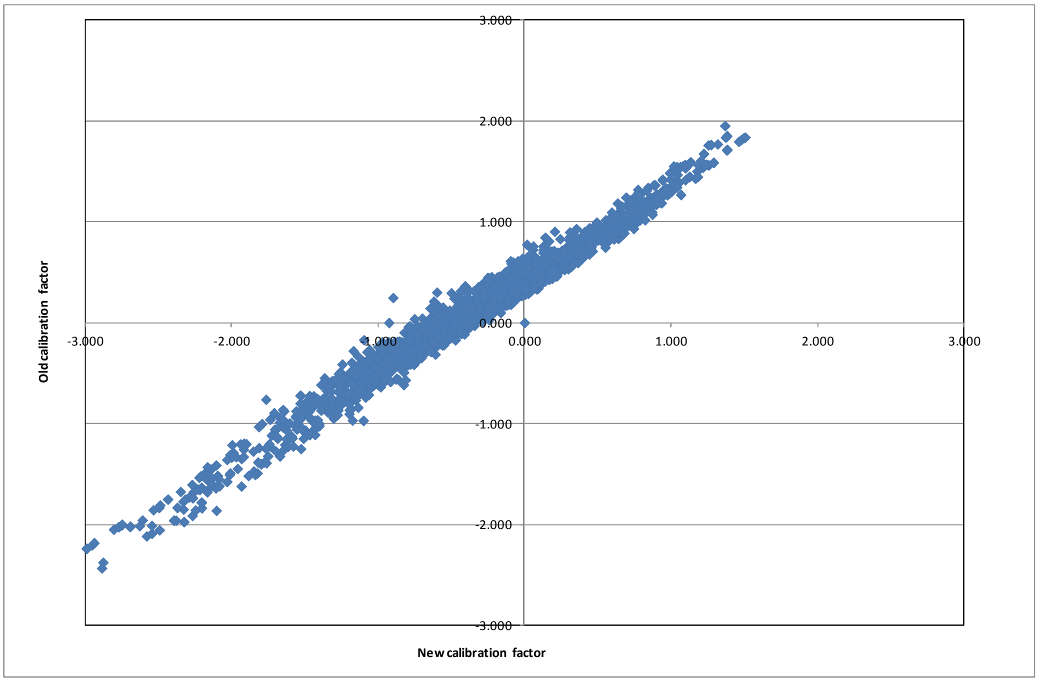
The implementation of the zonal car ownership pivot is described in detail in Chapter 4 of Fox, Daly, Patruni and Tsang (2012). In summary, the total car ownership model is recalibrated for each zone in the study area so that the total numbers of cars predicted matches the levels observed in the 2006 Census.

The recalibration of the updated total car ownership model was undertaken using the following steps:

1. The ALOGIT recalibration code was updated to use the new total car ownership model parameters (model 36), and to reference logsums from the updated commute mode–destination model (model 181).
2. The iterative process was re-run to recalibrate the total car ownership model to the Census targets for each of the 2,690 zones in the model study area.

The output from the process is a calibration factor for each model zone, which ensures that the predicted number of cars matches the values observed in the 2006 Census data. Figure 12 presents a scatter plot comparison of the calibration factors from the original recalibration and the new calibration factors.

Figure 12: Scatter plot comparison, old and new total car ownership model calibration factors



The scatter plot demonstrates that the mean value of the new calibration factors is lower (the scatter crosses the x-axis around −0.5), although there is a strong positive correlation between the old and new calibration factors, as we would expect.

The systematic difference between the old and new calibration factors, however, was a cause for concern, as it suggests a difference in the mean prediction of the model before calibration. Detailed investigations were therefore undertaken to better understand the cause of the systematic difference, and the problem was tracked down to differences in the input files used for the old and new recalibrations. The input to the recalibration process is a household file enumerating each possible combination of licence holding and company car ownership state, and during the original work in 2011 to create the 2006 base Population Synthesiser. A problem with the calculation of the company car ownership probabilities was discovered and corrected. Although the problem was corrected in the main Population Synthesiser setup, unfortunately the file used in the recalibrations was not updated. As a result, the original calibration was based on an input file with artificially low company car ownership probabilities, which resulted in lower predictions of total car ownership before calibration. As a result, *higher* calibration factors were needed in the old calibration than in the new calibration using the correct input file, hence the systematic difference of 0.5 between the two sets of calibration factors.

To confirm that the new process was working correctly, validation checks have been re-run for selected zones to verify that the post-calibration predictions match the Census target values. Table 15 summarises the results from these validation checks.

Table 15: Validation of new total car ownership model calibration

STM zone	Census hhlds	Target cars	Predicted pre-pivot	Error	Predicted post-pivot	Error
1289	752	864	1,060	22.7 %	864	0.0 %
1290	830	1,458	1,507	3.4 %	1,458	0.0 %
1291	115	222	200	−10.1 %	222	0.1 %
1292	33	68	56	−17.4 %	68	−0.2 %
1293	1,330	1,524	1,811	18.8 %	1,524	0.0 %
1294	1,292	1,833	2,034	11.0 %	1,833	0.0 %
1295	1,254	2,175	2,266	4.2 %	2,175	0.0 %
1297	11	9	13	47.5 %	9	−1.7 %
1298	176	260	193	−25.9 %	260	0.0 %
1299	1,519	2,157	2,420	12.2 %	2,157	0.0 %
1300	1,447	2,943	2,896	−1.6 %	2,943	0.0 %

The validation tests summarised in Table 1 confirm that the new calibration is working correctly.

5.3 Re-running the ACCUM process

The ‘ACCUM’ process generates the population weights by zone and model segment for each of the seven home-based (HB) travel purposes represented in the STM. No changes to the ACCUM process itself have been made during this work, but the process has been re-run to take account of the impact of the changes to the total car ownership model, and then the car ownership pivot applied to the ACCUM output has been re-run using the new calibration factors.

To validate the re-run of the ACCUM process, analysis has been undertaken to compare the distributions of the old and new ACCUM output for the commute model after the application of the total car ownership pivot. We expect some changes in the distribution of the commute population over car availability segments following on from the changes to the total car ownership model, and in particular from the correction to the zonal car ownership pivot, but no changes are expected across the two other commute mode–destination segmentations: job classification and household income band. It is noted that the commute population only includes adults (persons aged 15 and above) who are workers.[11]

The comparisons of the old and new ACCUM commute populations are presented in Table 16 to Table 18.

Table 16: Commute populations by car availability segmentation (a)

a	Definition	Previous population		Updated population	
1	No car	157,058	5.2 %	217,354	7.1 %
2	No licence	410,615	13.5 %	396,908	13.0 %
3	Competition for car, no company car	448,928	14.8 %	601,278	19.8 %
4	Free car use, one car, no company car	317,993	10.5 %	297,596	9.8 %
5	Free car use, several licences, no comp. car	945,472	31.1 %	766,884	25.2 %
6	Competition for car, 1+ company car	79,074	2.6 %	124,905	4.1 %
7	Free car use, one car, 1+ company car	66,191	2.2 %	66,191	2.2 %
8	Free car use, several licences, 1+ company car	616,314	20.3 %	570,483	18.8 %
	Total	3,041,646	100.0 %	3,041,599	100.0 %

Following the correction to the recalibration of the total car ownership model, we observe significant changes in the distribution of population over the car availability segments. Specifically, we observe a significant increase in the proportion of the population in the no car segment, and an increase in the proportion of the population in car competition segments. These changes are consistent with the correction to the car ownership pivot process, which results in lower predicted levels of car ownership.[12] When the revised populations are fed into the travel demand models we would expect declines in the car driver shares. It is noted that the total commute population decreases very slightly due to rounding of the outputs from the category segment process (by 46.4 persons, a –0.002% reduction).

Table 17: Commute population by personal income (b)

b	Definition	Previous population		Updated population	
1	< $20,799 p.a.	820,715	26.98 %	820,693	26.98 %
2	$20,800–31,999 p.a.	393,704	12.94 %	393,695	12.94 %
3	$31,200–41,559 p.a.	422,710	13.90 %	422,702	13.90 %
4	$41,600–67,599 p.a.	811,519	26.68 %	811,513	26.68 %
5	> $67,599 p.a.	592,998	19.50 %	592,997	19.50 %
	Total	3,041,646	100.00 %	3,041,600	100.00 %

The populations by each personal income band segment show a very slight decrease due to rounding, but there is no change in the distributions over segments (reported to two decimal places).

[11] Specifically, persons with adult status codes 1 to 6 inclusive.

[12] Previously the process was re-calibrated using a file which under-estimated car ownership levels pre-pivot, and then applied to a file which correctly calculated car ownership levels pre-pivot. The effect of this was that car ownership was *over*-predicted after application of the car ownership pivot.

Table 18: Commute population by employment status (c)

c	Definition	Previous population		Updated population	
1	Full time worker	1,860,621	61.17 %	1,860,602	61.17 %
2	Other worker	1,181,025	38.83 %	1,180,998	38.83 %
	Total	3,041,646	100.00 %	3,041,600	100.00 %

Again, there are very slight decreases in the population by each employment status band due to rounding, but no change to the distribution over the two segments.

Similar validation has been undertaken for the six other HB purposes, and the same patterns of changes were observed – substantial changes in the distribution of the populations over car availability segments reflecting lower predicted car ownership levels, but no perceptible changes in the distribution over the other segments, and very slight changes in the population totals due to rounding of the category segment process outputs.

CHAPTER 6 Travel Demand model updates

Section 6.1 summarises the updates that have been made to the commute TravDem to implement the enhanced commute mode–destination model specification. Section 6.2 presents a summary of the revised base year TravDem outputs for all home-based (HB) and non-home-based (NHB) purposes, and documents a recalibration of the frequency models for the NHB purposes to achieve a better match to the volume of NHB travel observed in the HTS. Finally, Section 6.3 documents the recalibration of the car availability adjustment procedure.

6.1 Updates to the commute TravDem files

A number of files had to be updated to incorporate the revised commute mode–destination and frequency models.

The first file that was updated is the pre-processing step that creates the station choice logsums for the P&R and K&R alternatives before the main TravDem is run (HW_PR_KR_LOS.alo). The only update that was required in this file was to read in the parameters from the enhanced commute mode–destination model (COM_181).

A number of changes have been made to the main commute TravDem file (HW_TravDem.alo). First, the file has been updated to read in the parameters from the enhanced commute mode–destination model (COM_181), and the updated commute frequency model (COM_v14). Second, the structure has been changed to reflect the use of separate modes for walk and bus access to train in the enhanced model. This necessitated changes so that separate home to access station LOS skims were read in for the two access modes, as well as requiring changes to the model transformations, availability calculations and utility calculations to reflect the additional access alternatives. Table 19 summarises the additional model terms that have been added to the utilities.

Table 19: Additional commute mode–destination utility terms

Term	Mode	Description
TrainWk	Train, walk access	Constant for the new walk access alternative to train (defined relative to train, bus access)
LWdistCBD	Walk	Log of destination distance from the CBD, applied for destinations within the Sydney Statistical Division only
WNcast	Walk	Constant applied for all destinations within the Newcastle Statistical Sub-Division
WWng	Walk	Constant applied for all destinations within the Illawarra Statistical Division (which includes Wollongong)

Finally, modifications have been made to the outputs generated by the TravDem so that predicted demand for walk and bus access for train alternatives is output separately. There are three files where demand for walk and bus access is output. A definition of the items output on these three files is provided in Table 20 and Table 21.

Table 20: Definition of HW_Tours.dat file

Matrix name	Definition
TrCrDT	Matrix of demand for car driver toll alternative
TrCrDNT	Matrix of demand for car driver no toll alternative
TrCrP	Matrix of demand for car passenger alternative
TrTrnPR	Matrix of demand for train, P&R access
TrTrnKR	Matrix of demand for train, K&R access
TrTrnW	Matrix of demand for train, walk access
TrTrnB	Matrix of demand for train, bus access
TrBus	Matrix of demand for bus as a main mode
TrBike	Matrix of demand for bike
TrWalk	Matrix of demand for walk
TrTaxi	Matrix of demand for taxi

Table 21: Definition of Wrk_DEM.csv and Wrk_KM.csv files

Wrk_DEM.csv		Wrk_KM.csv	
TOLLDEM	Total tours, car driver toll	TOLLKM	Total kms, car driver toll
NTOLLDEM	Total tours, car driver no toll	NTOLLKM	Total kms, car driver no toll
CARPDEM	Total tours, car passenger	CARPKM	Total kms, car passenger
TRPRDEM	Total tours, train P&R access	TRPRKM	Total kms, train P&R access
TRKRDEM	Total tours, train K&R access	TRKRKM	Total kms, train K&R access
TRWDEM	Total tours, train walk access	TRWKM	Total kms, train walk access
TRBDEM	Total tours, train bus access	TRBKM	Total kms, train bus access
TRBUSDEM	Total tours, bus main mode	TRBUSKM	Total kms, bus main mode
TRBKDEM	Total tours, bike	TRBKKM	Total kms, bike
TRWKDEM	Total tours, walk	TRWKKM	Total kms, walk
TRTXDEM	Total tours, taxi	TRTXKM	Total kms, taxi

6.2 Validation of base year TravDem results

Modifications to the Population Synthesiser to take account of the updates to the total car ownership model meant that revised base year inputs were generated for all of the HB purposes. Because the NHB TravDems are run using outputs from the commute and home-business TravDems, this meant that all the HB and NHB TravDems needed to be re-run for the 2006 base year.

In the final report from the 2011 study to create the new ALOGIT application system (Fox, Patruni and Daly, 2012), a number of validation tables were presented to compare the base year TravDem predictions to the unweighted estimation samples and to weighted HTS data using five waves of data covering 2004–2009. The following sub-sections replicate that analysis, and allow comparison of the validation from the first application of the 2006 base TravDems in 2011 with the revised results generated during the current study.

Appendix B presents detailed validation of the TravDem results for each of the nine model purposes.

6.2.1 Tour rates

The first check is on the mean tour rate, defined as the number of tours made per person per average workday, compared with the rate observed in the unweighted HTS estimation sample. This check validates that the frequency model from the re-estimation work has been implemented correctly in the TravDem.

The results from the tour frequency rate checks for HB purposes are presented in Table 22.

Table 22: Tour frequency rate validation, HB purposes

Purpose	HTS unweighted estimation sample tour rate	Original TravDem 2006 base tour rate		Revised TravDem 2006 base tour rate	
Home–work	0.502	0.499	−0.67 %	0.499	−0.58 %
Home–business	0.104	0.105	0.82 %	0.103	−1.05 %
Home–primary education	0.719	0.669	−6.98 %	0.669	−7.03 %
Home–secondary educ.	0.665	0.648	−2.60 %	0.648	−2.61 %
Home–tertiary education	0.026	0.027	4.76 %	0.027	3.58 %
Home–shopping	0.177	0.179	1.03 %	0.177	−0.24 %
Home–other travel	0.615	0.616	0.09 %	0.609	−1.10 %

As expected, the mean tour rates predicted by the revised TravDems are very similar to those predicted in the original TravDem, except for home–other, where the mean predicted tour rate has decreased slightly in the revised implementation. Slight changes to the tour frequency rates come about as a result of changes in the distribution of the base population over car availability segments following the correction to the car ownership recalibration. Following the correction to the car ownership recalibration, there has been a shift towards segments with lower car ownership levels, which will have lower mean tour rates. This is consistent with the observed reduction to the tour rates in Table 22 for home–other travel, and also with the smaller reductions to the tour rates for home–business and home–shopping travel.

The results from the tour frequency rate checks for NHB purposes are presented in Table 23. In this table, NHBB denotes NHB business, WB denotes work-based, PD denotes primary destination, and ret. denotes return.

Table 23: Tour frequency rate validation, NHB purposes

Purpose	HTS estimation sample tour rate	Original TravDem 2006 base tour rate		Revised TravDem 2006 base tour rate	
WB business tours	0.097	0.097	0.12 %	0.096	−1.25 %
NHBB detours, PD work, out	0.029	0.026	−11.87 %	0.025	−12.70 %
NHBB detours, PD work, ret.	0.033	0.031	−6.97 %	0.030	−8.41 %
NHBB detours, PD bus., out	0.243	0.230	−5.50 %	0.229	−5.61 %
NHBB detours, PD bus., ret.	0.281	0.278	−1.30 %	0.278	−1.37 %

All of the tour and detour rates have decreased in the revised TravDems, with larger decreases observed for the two WB detour models. Higher detour frequency rates are predicted if the HB tour mode is car driver; therefore these decreases in detour frequency rate are consistent with the changes to the distribution of population over car availability segments following the correction to the car ownership recalibration, which have resulted in a reduction in the use of car driver for HB tours.

The second check is on the total number of tours predicted, which have been compared with the weighted HTS data in Table 24. It is noted that the weighted HTS tour totals include half tours as well as full tours: they include all observed travel. The frequency models are consistent with this definition, because they too include half-tours.[13]

Table 24: Total tours validation, HB purposes

Purpose	HTS data (2004–2009)	Original TravDem 2006 base		Revised TravDem 2006 base	
Home–work	1,524,033	1,556,841	2.2 %	1,558,278	2.2%
Home–business	421,964	436,541	3.5 %	428,453	1.5%
Home–primary education	329,878	310,326	−5.9 %	310,156	−6.0%
Home–secondary educ.	266,722	244,125	−8.5 %	244,118	−8.5%
Home–tertiary education	103,566	106,331	2.7 %	105,863	2.2%
Home–shopping	930,090	911,782	−2.0 %	906,484	−2.5%
Home–other travel	3,175,979	3,162,373	−0.4 %	3,124,925	−1.6%
Total HB	6,752,232	6,728,319	−0.4 %	6,678,277	−1.1%

As per the results from the original TravDem, we observe over-predictions of home–work and home–business travel, despite the fact that the observed and predicted tour rates match closely. Differences in the number of workers between the expanded base year population and the weighted HTS data explain the differences in total tours.

As per the original TravDem runs, primary and secondary education travel is under-predicted relative to the weighted HTS data. These differences come about from a combination of lower tours rates in application, and differences between the expanded population of children from the Population Synthesiser and the population of children in the weighted HTS data.

Shopping travel is under-predicted by 2.5% relative to the 2004–2009 HTS data, but other travel is predicted accurately and this accounts for 47% of the total number of trips.

[13] In the frequency model estimation, each outward half tour was taken to be equivalent to one full tour, whereas return half tours were dropped as they were judged to be more susceptible to coding errors.

The over-predictions of travel for home–work, home–business and home–tertiary education travel are balanced by under predictions of travel for home–primary education, home–secondary education and home–shopping travel. As a result the overall volume of HB travel is predicted with an error of just over 1%.

Table 25 presents validation of total trips for the two NHBB purposes. Note that in calculating the total NHBB trips, each WB business tour is counted as two trips, whereas each NHBB detour is counted as a single trip.

Table 25: Total trips validation, NHBB purposes

Purpose	HTS data (2004–2009)	Original TravDem 2006 base		Revised TravDem 2006 base	
WB business tours	138,457	151,355	9.32 %	149,301	7.83 %
NHBB detours	311,053	308,314	−0.88 %	301,072	−3.21 %
Total NHBB trips	587,967	611,024	3.92 %	599,674	1.99 %

Total NHB trips are over-predicted by 2%, and WB business tours are over-predicted by 8%. The NHB models are applied using the outputs from the home–work and home–business models, and as observed in Table 24 total travel for these purposes is over-predicted relative to the HTS data. Therefore it was decided to recalibrate the NHB frequency models so that they matched the volume of NHB travel in the 2004–2009 HTS data exactly. Table 26 summarises the adjustment factors that have been applied. For the two frequency models for NHB detours made in the course of PD business tours, the original model matched the weighted HTS data well and so no recalibration was applied.

Table 26: Non-home-based frequency calibration factors

Purpose	HTS data (2004–2009)	TravDem, prior to recalib.	Calibration factor	TravDem, after recalib.	Diff. relative to HTS
WB business tours	138,457	149,301	0.927	138,457	0.00 %
NHB detours, out legs of PD work tours	41,641	39,254	1.061	41,641	0.00 %
NHB detours, return legs of PD work tours	53,237	46,417	1.147	53,237	0.00 %
NHB detours, out legs of PD business tours	99,162	97,405	none applied	97,405	1.80 %
NHB detours, return legs of PD business tours	117,013	117,996	none applied	117,996	−0.83 %
Total NHBB trips	587,967	599,674	n/a	587,193	−0.13 %

Following the application of the recalibration factors, the total volume of NHBB travel is predicted to within 0.13%.

6.2.2 Mode share

To calculate a summary measure of the replication of mode share to the weighted HTS data, a root-mean-square (RMS) measure has been used. The measure, *RMS(MF)*, provides an RMS measure for each of the detailed modes represented in the TravDems including the car toll and train access mode alternatives:

$$RMS(MF) = \sqrt{\frac{\sum_{mf}\left(HTS_{mf} - TD_{mf}\right)^2}{MF}} \qquad (6.1)$$

where: *mf* are the detailed (full) modes

MF is the total number of detailed modes

HTS_{mf} are the mode shares from the expanded HTS data

TD_{mf} are the mode shares predicted by the TravDems

Table 27 summarises the measures obtained for each of the HB travel purposes. For consistency with the mode–destination model estimation, the weighted HTS validation figures include full tours only.

Table 27: Mode share validation, HB purposes

Purpose	RMS(MF) original TravDem 2006 base	RMS(MF) revised TravDem 2006 base
Home–work	0.59 %	1.29 %
Home–business	0.66 %	1.00 %
Home–primary education	1.01 %	1.04 %
Home–secondary education	1.39 %	1.39 %
Home–tertiary education	1.56 %	1.06 %
Home–shopping	0.92 %	1.32 %
Home–other travel	0.51 %	0.56 %
Total HB	0.66 %	0.92 %

The fit to the observed mode shares remains good, with an overall RMS value of less than 1%. For five of the seven purposes, the fit is slightly worse for the revised TravDems, and so the changes to the mode shares were investigated further. For home–work, the main discrepancy is for the 'car driver no toll' alternative, which is under-predicted by 3.4%; previously this error was just 0.2%. The shares for all other modes are correct to within 1%. For other HB purposes where we observe deterioration in the RMS, the match to the observed car driver share has also worsened. In general, with the revised 2006 base Population Synthesiser outputs, which have lower levels of car ownership than the original versions (following the correction to the car ownership recalibration), there is a tendency to under-predict the car driver no toll share relative to the expanded HTS data.

Table 28 summarises the RMS measures obtained for the NHBB purposes.

Table 28: Mode share validation, NHBB purposes

Purpose	RMS(MF) Original TravDem 2006 base	RMS(MF) Revised TravDem 2006 base
WB business tours	0.56 %	0.69 %
NHBB detours	0.56 %	0.70 %
Total NHBB	0.56 %	0.70 %

The mode share validation for the NHBB models remains very good, though it has deteriorated slightly compared with the previous validation. The small deterioration is driven by under-predictions of the car driver share when working with outputs from the revised and home–work HB TravDems.

6.2.3 Tour lengths

The mean tour lengths predicted for each HB purpose are compared with weighted HTS data in Table 29.

Table 29: Overall tour lengths (km), HB purposes

Purpose	HTS data (2004–2009)	Original TravDem 2006 base		Revised TravDem 2006 base	
Home–work	31.9	30.0	−5.7 %	30.2	−5.1 %
Home–business	44.1	36.1	−18.1 %	36.1	−18.1 %
Home–primary education	7.3	6.6	−10.0 %	6.5	−10.1 %
Home–secondary educ.	14.9	13.7	−7.8 %	13.7	−8.3 %
Home–tertiary education	31.3	33.5	6.8 %	33.4	6.7 %
Home–shopping	10.6	8.6	−18.6 %	8.6	−18.8 %
Home–other travel	13.8	12.3	−11.1 %	12.2	−11.3 %
Total home−based	19.0	17.6	−7.4 %	17.6	−7.2 %

For all purposes, the mean tour lengths have changed little compared with the original validation, and in general the fit to the observed tour lengths remains disappointing, with tour lengths under-predicted for all purposes except home–tertiary education.

NHB tour and detour lengths are compared with weighted HTS data in Table 30.

Table 30: Overall tour and detour lengths (km), NHBB purposes

Purpose	HTS data (2004–2009)	Original TravDem 2006 base		Revised TravDem 2006 base	
WB business tours	15.3	15.6	2.2 %	15.4	0.5 %
NHBB detours	14.6	13.8	−5.8 %	13.7	−6.5 %
Total NHBB trips	11.3	10.8	−4.5 %	10.9	−4.3 %

For both NHB purposes, predicted tour and detour lengths are slightly lower in the revised TravDem because the car driver share has declined slightly, and car driver tour and detour lengths are higher than average. For WB business, the slight decline in mean tour length means the overall mean matches the HTS data slightly better; for NHBB detours the reduction in detour length results in a slight worsening in the fit to the weighted HTS data. The WB business tour distances have been converted into trip distances to allow the overall NHBB trip distances to be calculated. These demonstrate a slight improvement to the overall fit to the HTS data for the revised TravDem.

To summarise the match to observed tour lengths by mode, RMS measures have been calculated over modes, using a weighted RMS formula where the weighting is by observed mode share, and the term in brackets defines the proportional error in the predicted tour length relative to the observed:

$$RMS = \sqrt{\sum_{mf} SO_{mf} \left(\frac{O_{mf} - P_{mf}}{O_{mf}} \right)^2} \tag{6.2}$$

where: SO_{mf} is the observed mode share (noting these sum to 1 over the modes)

O_{mf} is the observed tour length for mode *mf*

P_{mf} is the predicted tour length for mode *mf*

The RMS measures calculated for each HB purpose are presented in Table 31.

Table 31: Root-mean-square measures of tour length fit over modes, HB purposes

Purpose	Original TravDem 2006 base	Revised TravDem 2006 base
Home–work	11.25 %	7.05 %
Home–business	17.20 %	16.93 %
Home–primary education	26.66 %	26.64 %
Home–secondary education	12.10 %	12.02 %
Home–tertiary education	17.16 %	17.25 %
Home–shopping	17.60 %	17.47 %
Home–other travel	17.75 %	17.50 %
Total	16.39 %	15.24 %

The fit to modal tour lengths has improved for the home–work model, as a result of improvements to the fit for train (walk and bus access) and bus main mode. For all other purposes, the fit remains very similar. As per the original TravDem the fit to mean tour lengths by mode is disappointing compared with the tour generation and mode share validation.

The RMS measures of fit are presented for the two NHBB purposes in Table 32.

Table 32: Root-mean-square measures of tour/detour length fit over modes, NHBB purposes

Purpose	Original TravDem 2006 base	Revised TravDem 2006 base
WB business tours	8.01 %	7.67 %
NHBB detours	7.56 %	7.41 %
Total	7.78 %	7.53 %

The RMS measures of tour and detour fit at the modal level are slightly improved for both NHB models, though they remain disappointing overall.

6.3 Car availability adjustment procedure

The car availability adjustment procedure adjusts total car ownership and thus the availability of cars at the person level to take account of changes in home–work accessibility in the forecast year relative to the base year. In the travel demand models, car availability segments are defined using information on car ownership together with individual and household licence holding, and these car availability segments govern the availability and attractiveness of the car alternatives in the travel demand models.

The car availability adjustment process is designed to be applied as part of the standard iteration between the travel demand models and the Emme assignments. Because of this link to the assignment process, it is implemented as part of the travel demand models, and not as part of the Population Synthesiser.

The procedure employs a simple pivot-point model[14] to predict changes in the probability of car availability states as a function of the change in home–work accessibility relative to the base year. More information on the car availability adjustment procedure, including specification of the pivot-point model, is provided in Chapter 3 of HCG and ITS (2002).

[14] A 'pivot-point' model predicts changes from a known base situation on the basis of differences in utility between the forecast and base cases.

The new pivot point parameters for the 2006 base version of the STM have been calibrated by making a series of runs of the base home–work Travel Demand model with 10% changes applied to the home–work accessibility for particular car availability segments. By assessing the predicted changes in the distribution of persons across the extended car availability segments (*aext2*), the new pivot-point parameters can be calculated. The *aext2* segments are defined in full in Fox, Daly, Patruni and Tsang (2012).

Table 33 presents a comparison of the previous and revised car availability adjustment parameters.

Table 33: Car availability adjustment parameter comparison

Base aext2	Coeff	STM 2006 original	STM 2006 revised	abs (revised / original)
3	c05_1	−0.47808	−0.44419	0.929
	c05_3	−0.44948	−0.41777	0.929
	c05_4	0.18295	0.17056	0.932
	co5_5	−0.09532	−0.08832	0.927
	c11_1	0.38720	0.35961	0.929
	c11_3	0.36046	0.33481	0.929
	c11_4	−0.10072	−0.09367	0.930
	c11_5	0.17104	0.15957	0.933
10	c16_6	−0.25807	−0.24102	0.934
	c16_8	0.24995	0.23398	0.936
2	c07_1	−0.52490	−0.48515	0.924
	c07_3	0.00283	0.00262	0.928
	c07_4	0.51813	0.47913	0.925
	c07_5	0.00078	0.00072	0.923
4	c06_1	−0.44801	−0.41646	0.930
	c06_3	0.60794	0.56608	0.931
	c06_4	0.00615	0.00570	0.927
	c06_5	−0.17520	−0.16322	0.932
	c12_1	−0.43259	−0.40221	0.930
	c12_3	0.46258	0.43032	0.930
	c12_4	0.00585	0.00542	0.927
	c12_5	−0.04036	−0.03745	0.928
	c13_1	−0.43737	−0.40656	0.930
	c13_3	0.02751	0.02598	0.945
	c13_4	0.00588	0.00546	0.927
	c13_5	0.39596	0.36818	0.930
8	c14_6	−0.20740	−0.19353	0.933
	c14_8	0.20969	0.19549	0.932
	c15_6	−0.61478	−0.57220	0.931
	c15_8	0.61686	0.57400	0.931

It can be seen from Table 33 that the car availability adjustment parameters have consistently declined in magnitude by a factor of around 0.93. This decline in parameter magnitude is a result of the change in the scale of the home–work logsums generated from the original and enhanced commute mode–destination models. The enhanced model has additional alternatives relative to the original model and would be expected to generate different logsums.

CHAPTER 7 Summary

Commute mode–destination model enhancements

The structure of the commute mode–destination model has been extended to represent walk access and bus access to train separately. In the revised approach, for both the walk and bus access mode alternatives separate LOS is used from the home to the first access train station, and from the first access train station to the workplace. The LOS from the first access station to the workplace is the same data that are used to model the station to workplace legs of car access train tours.

Three different sets of skims were tested to model walk access to train, two of which incorporated bias relative to the default assignment parameters in order to maximise the number of OD pairs where walk access to train is modelled as available. In all cases, bus was removed from the network as a possible access mode. In the end, walk access skims generated with no biasing performed well, identifying a walk access to station skim for 97.6% of OD pairs, and for replicating the actual station chosen for walk access in 84.5% of cases. Cases where a different station to the chosen was identified were analysed by BTS, and in over half of these cases the station identified in the skim was an adjacent station on the same rail line. Overall, the walk access skims were judged to perform well at replicating the stations actually chosen.

To generate skims for bus access to train, eight different sets of skims have been tested for modelling the trip from the origin to the first access train station. In the skim option selected for the modelling, train speeds were doubled to maximise the use of bus access to train, rather than travelling by bus all the way, but no other bias was applied relative to the default skimming parameters. This skim option performed best in identifying the stations actually chosen for bus access (63% of cases).

To develop the enhanced commute mode–destination specification, the predictive performance of different model specifications was assessed across population density, employment density and distance from the CBD dimensions. A number of parameters were identified to improve the fit of the models for the car driver mode at the workplace end of the tours, but retaining these parameters in the model had an adverse impact on a number of the key behaviour parameters in the model, which resulted in implausibly high values of time, and therefore these parameters were not retained in the final specification.

The final enhanced specification included the following additional parameters:

- a constant for the new walk access alternative to train, ensuring that the model replicates the observed walk access shares (the term is defined relative to the bus access alternative, and therefore the shares for that alternative will also be replicated in the enhanced model)

- a log of distance from the CBD term for walk, applied for destinations within the Sydney Statistical Division only, which ensures that the model predicts higher walk use in inner areas
- separate walk constants for the Newcastle Statistical Sub-Division, and the Illawarra Statistical Division.

Revised commute frequency model

The commute frequency model has been re-estimated using revised commute logsum accessibility measures calculated from the enhanced commute mode–destination model. Only slight changes to the parameter values were observed, and the revised commute frequency model gives a slightly better fit to the observed data.

Revised total car ownership model

The total car ownership model has been re-estimated using revised commute logsum accessibility measures calculated from the enhanced commute mode–destination model. In contrast to the commute frequency model, more substantial changes to some of the model parameters were observed when the model was re-estimated with the revised logsums, and the overall fit of the model reduced slightly.

Updates to the Population Synthesiser

The Population Synthesiser has been updated to use the revised total car ownership model. The zonal car ownership pivot procedure was recalibrated so that the updated model replicates the total car ownership levels by zone observed in the 2006 Census. Checks of the new calibration parameters identified a problem with the earlier recalibration. It has been verified that the new recalibration is working correctly.

The impact of the correction to the car ownership recalibration is that lower levels of car ownership are predicted in the base year relative to the 2011 version of the Population Synthesiser.

Travel Demand model updates

The Travel Demand models have been updated to take account of the enhancements to the commute mode destination model specification, and then the models for all purposes have been re-run using the revised 2006 base Population Synthesiser outputs. The revised predictions of the Travel Demand models for the 2006 base year have been validated against expanded 2004–2009 HTS data.

The total volume of HB travel is predicted to within just over 1% of the HTS total, though there were larger differences for individual purposes. The total volume of HB travel predicted has reduced slightly as a consequence of the shift in the distribution of the base population towards lower car ownership segments. The volume of NHB travel predicted by the models was lower than the levels observed in the HTS data, and therefore some of the frequency models have been recalibrated so that the predictions match the HTS totals.

The mode share validation shows a slight deterioration in fit to the HTS data for both HB and NHB purposes. This deterioration is explained by a reduction in the predicted car driver share as a result of the lower levels of car ownership that are predicted by the revised 2006 base Population Synthesiser.

The fit to the observed tour lengths by mode for the commute model has significantly improved following the enhancements made to the mode–destination model specification during this work. There is little change to the tour length fit for the other HB and NHB purposes, and overall the fit to observed tour lengths is not as good as the fit for travel frequency and mode share.

REFERENCES

Reference list

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APPENDICES

Appendix A: Commute mode–destination model parameter values

This section presents the full parameter results for each of the commute mode–destination model specifications tested during this work. The models are summarised in Table 34, before presenting the full parameter results.

Table 34: Summary of commute mode–destination model tests

Model	Predecessor	Description	Separate train and walk access modes for train?	Use of corrected P&R and K&R choice data?
166	n/a	Final model specification from 2010 estimations	No	No
168	166	Test of linear workplace distance from CBD term for walk	No	No
169	168	Test of log workplace distance from CBD term for walk	No	No
170	169	Dropping linear workplace distance from CBD term for walk	No	No
171	170	Distance from CBD term re-specified to only apply to Sydney SD destinations, and separate walk constants for Newcastle and Wollongong destinations	No	No
172	171	Retesting linear distance from CBD term for walk	No	No
173	171	Separate walk and bus access modes, walk1 and bus1 skims	Yes	No
174	173	bus5 skims used instead of bus1 to model bus access to train	Yes	No
175	172	Additional car driver destination terms for CBD, Blacktown, St-George Sutherland, Canterbury-Bankstown, Lower Northern Sydney	No	No
176	172	Additional car driver destination term for CBD destinations only, correction to definition of train CBD term	No	No
177	174	Test of separate bus access time parameter	Yes	No
178	176	Move to separate walk and bus access modes (with walk1 and bus5 skims) plus use of corrected P&R and K&R data	Yes	Yes
179	178	Test where the Theta_AcMd nest parameter is released from 1	Yes	Yes
180	178	Dropping car driver CBD destination term	Yes	Yes

At the top of each of the model comparisons, summary statistics are provided; they are defined in Table 35.

Table 35: Model summary statistics

Statistic	Definition
File	This defines the name of the model run.
Observations	The number of observations included in the model estimation.
Final log (L)	This indicates the value of the log-likelihood at convergence. The log-likelihood is defined as the sum of the log of the probabilities of the chosen alternatives, and is the function that is maximised in model estimation. The value of log-likelihood for a single model has no obvious meaning. However, comparing the log-likelihood of two models with different specifications allows the statistical significance of new model parameters to be assessed properly.
D.O.F.	Degrees of freedom – the number of parameters estimated in this model. Note that if a parameter is constrained to a fixed value (indicated by(*)) then it is not a degree of freedom.
$Rho^2(0)$	The rho-squared measure compares the log-likelihood (LL(final)) to the log-likelihood of a model with all parameters restricted to zero (LL(0)): $Rho^2(0) = 1 – LL(final)/LL(0)$ A higher value indicates a better fitting model.

Table 36: Workplace distance from CBD tests (1)

File	COM_166.F12		COM_168.F12		COM_169.F12		COM_170.F12	
Observations	5689		5689		5689		5689	
Final log (L)	−36883.8		−36881.5		−36868.6		−36871.0	
D.O.F.	55		56		57		56	
Rho²(0)	0.393		0.393		0.393		0.393	
Estimated	16 Aug 10		19 Mar 12		21 Mar 12		28 Mar 12	
Cost and LOS terms								
cost13	−0.00248	(−6.8)	−0.00248	(−6.8)	−0.00252	(−6.8)	−0.00251	(−6.8)
cost4	−0.00189	(−6.8)	−0.00189	(−6.9)	−0.00188	(−6.8)	−0.00189	(−6.8)
cost5	−0.00160	(−6.8)	−0.00160	(−6.8)	−0.00158	(−6.7)	−0.00158	(−6.7)
cost67	−0.00122	(−6.7)	−0.00122	(−6.7)	−0.00119	(−6.6)	−0.00120	(−6.7)
cost810	−0.00105	(−6.5)	−0.00104	(−6.5)	−0.00101	(−6.3)	−0.00101	(−6.4)
cost	−0.00368	(−3.9)	−0.00369	(−3.9)	−0.00368	(−3.9)	−0.00369	(−3.9)
LogCost	−0.3683	(−4.5)	−0.3658	(−4.5)	−0.3682	(−4.5)	−0.3654	(−4.5)
CarTime	−0.05956	(−7.9)	−0.05946	(−8.0)	−0.05958	(−7.9)	−0.05947	(−7.9)
RlTime	−0.02207	(−5.9)	−0.02206	(−5.9)	−0.02214	(−5.9)	−0.02210	(−5.9)
BusTime	−0.03977	(−6.8)	−0.03979	(−6.8)	−0.04069	(−6.8)	−0.04044	(−6.8)
FWaitTm	−0.09765	(−5.3)	−0.09873	(−5.4)	−0.1042	(−5.5)	−0.1036	(−5.4)
OWaitTm	−0.07280	(−6.4)	−0.07267	(−6.4)	−0.07297	(−6.4)	−0.07282	(−6.3)
AcEgTm	−0.06018	(−6.1)	−0.06049	(−6.1)	−0.06252	(−6.1)	−0.06221	(−6.1)
CrAcEgTm	−0.07144	(−6.1)	−0.07123	(−6.2)	−0.07255	(−6.2)	−0.07210	(−6.1)
CarPDist	−0.04651	(−5.4)	−0.04656	(−5.5)	−0.04657	(−5.4)	−0.04662	(−5.4)
BikeDist	−0.3194	(−5.7)	−0.3188	(−5.7)	−0.3202	(−5.7)	−0.3194	(−5.7)
WalkDist	−1.125	(−7.5)	−1.112	(−7.5)	−1.155	(−7.5)	−1.130	(−7.4)
Toll choice terms								
TollBonus	−0.7381	(−4.3)	−0.7384	(−4.3)	−0.7387	(−4.3)	−0.7389	(−4.3)
CarTDist	0.01370	(5.4)	0.01368	(5.4)	0.01353	(5.3)	0.01356	(5.3)
Train access mode distance fit terms								
OrigGW	4.436	(5.3)	4.428	(5.3)	4.464	(5.3)	4.450	(5.3)
OrigSWS	0.8710	(1.6)	0.8560	(1.6)	0.9029	(1.7)	0.8830	(1.6)
TRnOthG75	−2.722	(−4.9)	−2.726	(−4.9)	−2.708	(−4.9)	−2.717	(−4.9)
Car availability terms								
CarComp	−3.948	(−7.0)	−3.888	(−7.1)	−4.029	(−7.0)	−3.960	(−7.0)
CmpCrDr	1.745	(5.3)	1.725	(5.3)	1.799	(5.3)	1.770	(5.3)
PassOpts	4.004	(5.3)	3.968	(5.3)	4.076	(5.3)	4.034	(5.3)
Prfr2pcar	0.5896	(1.3)	0.5763	(1.3)	0.6162	(1.4)	0.5994	(1.4)
Prcarcomp	−2.389	(−3.9)	−2.383	(−3.9)	−2.374	(−3.9)	−2.371	(−3.9)
KRPassopts	4.016	(2.7)	4.013	(2.7)	4.024	(2.7)	4.020	(2.7)
PRLicence	2.544	(4.2)	2.529	(4.2)	2.585	(4.2)	2.561	(4.2)
Other socio-economic terms								
MaleCrDr	0.4846	(2.6)	0.4843	(2.6)	0.5019	(2.6)	0.4974	(2.6)
MaleBike	5.378	(3.9)	5.313	(4.0)	5.555	(4.0)	5.457	(4.0)
FTwrkdist	0.01214	(4.5)	0.01190	(4.5)	0.01181	(4.4)	0.01168	(4.4)

Mode constants								
CarP	-11.23	(-7.1)	-11.10	(-7.1)	-11.48	(-7.0)	-11.32	(-7.0)
Train	-1.545	(-3.7)	-1.447	(-3.5)	-1.453	(-3.4)	-1.392	(-3.4)
TrainPR	-9.205	(-7.1)	-9.199	(-7.2)	-9.315	(-7.1)	-9.282	(-7.1)
TrainKR	-11.78	(-5.8)	-11.79	(-5.8)	-11.84	(-5.8)	-11.83	(-5.8)
Bus	-2.114	(-4.7)	-2.018	(-4.6)	-2.022	(-4.5)	-1.966	(-4.4)
Bike	-16.33	(-6.5)	-16.11	(-6.5)	-16.74	(-6.5)	-16.46	(-6.4)
Walk	-3.236	(-4.6)	-2.928	(-4.3)	-1.674	(-2.6)	-1.869	(-2.9)
Taxi	-9.707	(-6.3)	-9.536	(-6.3)	-10.09	(-6.3)	-9.858	(-6.3)
Destination constants								
Pmatta	1.055	(4.6)	1.050	(4.6)	1.041	(4.5)	1.040	(4.5)
Cwood	1.333	(4.3)	1.329	(4.3)	1.316	(4.3)	1.316	(4.3)
SLC	1.156	(4.5)	1.150	(4.5)	1.139	(4.4)	1.138	(4.4)
NSyd	1.747	(5.9)	1.738	(5.9)	1.702	(5.8)	1.704	(5.8)
ISyd	0.9182	(6.2)	0.9132	(6.2)	0.8668	(6.0)	0.8766	(6.0)
Esub	1.010	(4.9)	1.005	(4.9)	1.002	(4.9)	0.9985	(4.9)
Nbeach	0.6903	(3.3)	0.6884	(3.2)	0.6953	(3.3)	0.6920	(3.3)
CBDRail	1.643	(5.2)	1.642	(5.2)	1.657	(5.2)	1.651	(5.2)
CBDBus	1.002	(4.0)	1.016	(4.0)	1.089	(4.2)	1.078	(4.2)
Intrazonal constants								
CrDNoTllIZ	-0.6883	(-2.0)	-0.6923	(-2.0)	-0.7049	(-2.1)	-0.7034	(-2.1)
CarPIZ	0.1050	(0.2)	0.07004	(0.1)	0.04958	(0.1)	0.03079	(0.0)
WalkIZ	1.184	(3.5)	1.364	(3.8)	1.398	(3.9)	1.522	(4.2)
BikeIZ	0.5615	(0.4)	0.5030	(0.3)	0.4745	(0.3)	0.4419	(0.3)
Attraction term								
TotEmp	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Structural parameters								
Theta_MD	0.8082	(19.0)	0.8174	(19.1)	0.7844	(19.3)	0.7971	(19.3)
Theta_PT	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Toll	0.5116	(8.0)	0.5118	(8.1)	0.5126	(8.0)	0.5126	(8.0)
Theta_dum	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Walk distance from workplace terms								
WdistCBD			-0.00774	(-2.0)	0.01179	(2.1)	0	(*)
LWdistCBD					-0.7629	(-4.4)	-0.5299	(-4.3)

Table 37: Workplace distance from CBD tests (2)

File	COM_170.F12		COM_171.F12		COM_172.F12	
Converged	True		True		True	
Observations	5689		5689		5689	
Final log (L)	-36871.0		-36864.6		-36864.2	
D.O.F.	56		58		59	
Rho²(0)	0.393		0.393		0.393	
Rho²(c)	0.129		0.129		0.129	
Estimated	28 Mar 12		4 Apr 12		10 Apr 12	
Scaling	1.0000		1.0000		1.0000	
Cost and LOS terms						
cost13	-0.00251	(-6.8)	-0.00252	(-6.8)	-0.00252	(-6.8)
cost4	-0.00189	(-6.8)	-0.00189	(-6.8)	-0.00189	(-6.8)
cost5	-0.00158	(-6.7)	-0.00158	(-6.7)	-0.00158	(-6.7)
cost67	-0.00120	(-6.7)	-0.00119	(-6.6)	-0.00119	(-6.6)
cost810	-0.00101	(-6.4)	-0.00101	(-6.3)	-0.00101	(-6.3)
cost	-0.00369	(-3.9)	-0.00368	(-3.9)	-0.00369	(-3.9)
LogCost	-0.3654	(-4.5)	-0.3663	(-4.5)	-0.3648	(-4.5)
CarTime	-0.05947	(-7.9)	-0.05956	(-7.9)	-0.05952	(-7.9)
RlTime	-0.02210	(-5.9)	-0.02213	(-5.9)	-0.02212	(-5.9)
BusTime	-0.04044	(-6.8)	-0.04062	(-6.8)	-0.04054	(-6.8)
FWaitTm	-0.1036	(-5.4)	-0.1051	(-5.5)	-0.1051	(-5.5)
OWaitTm	-0.07282	(-6.3)	-0.07296	(-6.4)	-0.07291	(-6.4)
AcEgTm	-0.06221	(-6.1)	-0.06271	(-6.1)	-0.06267	(-6.1)
CrAcEgTm	-0.07210	(-6.1)	-0.07256	(-6.2)	-0.07246	(-6.2)

CarPDist	-0.04662	(-5.4)	-0.04663	(-5.4)	-0.04666	(-5.4)
BikeDist	-0.3194	(-5.7)	-0.3200	(-5.7)	-0.3196	(-5.7)
WalkDist	-1.130	(-7.4)	-1.143	(-7.4)	-1.132	(-7.4)
Toll choice terms						
TollBonus	-0.7389	(-4.3)	-0.7386	(-4.3)	-0.7387	(-4.3)
CarTDist	0.01356	(5.3)	0.01352	(5.3)	0.01353	(5.3)
Train access mode distance fit terms						
OrigGW	4.450	(5.3)	4.449	(5.2)	4.440	(5.2)
OrigSWS	0.8830	(1.6)	0.8958	(1.6)	0.8880	(1.6)
TRnOthG75	-2.717	(-4.9)	-2.721	(-4.9)	-2.727	(-4.9)
Car availability terms						
CarComp	-3.960	(-7.0)	-4.031	(-7.0)	-4.014	(-7.0)
CmpCrDr	1.770	(5.3)	1.803	(5.3)	1.798	(5.3)
PassOpts	4.034	(5.3)	4.097	(5.3)	4.085	(5.3)
Prfr2pcar	0.5994	(1.4)	0.6172	(1.4)	0.6134	(1.4)
Prcarcomp	-2.371	(-3.9)	-2.376	(-3.9)	-2.375	(-3.9)
KRPassopts	4.020	(2.7)	4.020	(2.7)	4.018	(2.7)
PRLicence	2.561	(4.2)	2.592	(4.2)	2.589	(4.2)
Other socio-economic terms						
MaleCrDr	0.4974	(2.6)	0.5015	(2.6)	0.5003	(2.6)
MaleBike	5.457	(4.0)	5.566	(4.0)	5.542	(4.0)
FTwrkdist	0.01168	(4.4)	0.01178	(4.4)	0.01174	(4.4)
Mode constants						
CarP	-11.32	(-7.0)	-11.50	(-7.0)	-11.46	(-7.0)
Train	-1.392	(-3.4)	-1.437	(-3.4)	-1.419	(-3.4)
TrainPR	-9.282	(-7.1)	-9.320	(-7.1)	-9.312	(-7.1)
TrainKR	-11.83	(-5.8)	-11.84	(-5.8)	-11.83	(-5.8)
Bus	-1.966	(-4.4)	-2.006	(-4.4)	-1.988	(-4.4)
Bike	-16.46	(-6.4)	-16.74	(-6.4)	-16.67	(-6.4)
Walk	-1.869	(-2.9)	-1.691	(-2.6)	-1.750	(-2.7)
Taxi	-9.858	(-6.3)	-10.09	(-6.3)	-10.04	(-6.3)
Destination constants						
Pmatta	1.040	(4.5)	1.039	(4.5)	1.037	(4.5)
Cwood	1.316	(4.3)	1.313	(4.3)	1.312	(4.3)
SLC	1.138	(4.4)	1.136	(4.4)	1.133	(4.4)
NSyd	1.704	(5.8)	1.697	(5.8)	1.695	(5.8)
ISyd	0.8766	(6.0)	0.8662	(6.0)	0.8683	(6.0)
Esub	0.9985	(4.9)	0.9976	(4.9)	0.9946	(4.8)
Nbeach	0.6920	(3.3)	0.6935	(3.3)	0.6920	(3.3)
CBDRail	1.651	(5.2)	1.653	(5.2)	1.650	(5.2)
CBDBus	1.078	(4.2)	1.086	(4.2)	1.082	(4.2)
Intrazonal constants						
CrDNoTllIZ	-0.7034	(-2.1)	-0.7066	(-2.1)	-0.7062	(-2.1)
BikeIZ	0.4419	(0.3)	0.4421	(0.3)	0.4221	(0.3)
WalkIZ	1.522	(4.2)	1.480	(4.1)	1.537	(4.1)
CarPIZ	0.03079	(0.0)	0.03413	(0.1)	0.02462	(0.0)
Attraction term						
TotEmp	1.000	(*)	1.000	(*)	1.000	(*)
Structural parameters						
Theta_MD	0.7971	(19.3)	0.7841	(19.2)	0.7868	(19.0)
Theta_PT	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Toll	0.5126	(8.0)	0.5129	(8.0)	0.5131	(8.0)
Walk distance from workplace and workplace location terms						
WdistCBD	0	(*)	0	(*)	-0.00791	(-0.8)
LWdistCBD	-0.5299	(-4.3)	-0.6822	(-4.7)	-0.5901	(-3.3)
WWng			-3.426	(-3.2)	-3.386	(-3.2)
WNcast			-1.253	(-2.0)	-1.223	(-1.9)

Table 38: Extending structure to represent separate walk and bus access modes to train tests

File	COM_171.F12		COM_173.F12		COM_174.F12		COM_177.F12	
Observations	5689		5782		5788		5788	
Final log (L)	-36864.6		-37749.2		-37806.2		-37802.5	
D.O.F.	58		59		59		60	
Rho²(0)	0.393		0.391		0.391		0.391	
Estimated	4 Apr 12		20 Apr 12		19 Apr 12		23 Apr 12	
Cost and LOS terms								
cost13	-0.00252	(-6.8)	-0.00252	(-6.8)	-0.00252	(-6.8)	-0.00250	(-6.8)
cost4	-0.00189	(-6.8)	-0.00187	(-6.8)	-0.00188	(-6.8)	-0.00187	(-6.8)
cost5	-0.00158	(-6.7)	-0.00155	(-6.6)	-0.00155	(-6.7)	-0.00156	(-6.7)
cost67	-0.00119	(-6.6)	-0.00117	(-6.6)	-0.00117	(-6.6)	-0.00118	(-6.6)
cost810	-0.00101	(-6.3)	-0.00100	(-6.3)	-0.00100	(-6.3)	-0.00101	(-6.4)
cost	-0.00368	(-3.9)	-0.00365	(-3.9)	-0.00366	(-3.9)	-0.00363	(-3.9)
LogCost	-0.3663	(-4.5)	-0.3978	(-4.7)	-0.3967	(-4.7)	-0.3858	(-4.6)
CarTime	-0.05956	(-7.9)	-0.05983	(-7.9)	-0.05985	(-7.9)	-0.06018	(-8.0)
RlTime	-0.02213	(-5.9)	-0.02451	(-6.2)	-0.02455	(-6.3)	-0.02587	(-6.4)
BusTime	-0.04062	(-6.8)	-0.03565	(-6.5)	-0.03585	(-6.5)	-0.03811	(-6.6)
BusAccTime							-0.00503	(-0.5)
FWaitTm	-0.1051	(-5.5)	-0.1059	(-5.7)	-0.1076	(-5.8)	-0.1048	(-5.7)
OWaitTm	-0.07296	(-6.4)	-0.06763	(-6.3)	-0.06713	(-6.3)	-0.06447	(-6.2)
AcEgTm	-0.06271	(-6.1)	-0.07770	(-7.3)	-0.07751	(-7.3)	-0.07729	(-7.3)
CrAcEgTm	-0.07256	(-6.2)	-0.07480	(-6.2)	-0.07481	(-6.2)	-0.07416	(-6.2)
CarPDist	-0.04663	(-5.4)	-0.04624	(-5.4)	-0.04625	(-5.4)	-0.04620	(-5.4)
BikeDist	-0.3200	(-5.7)	-0.3224	(-5.7)	-0.3225	(-5.7)	-0.3221	(-5.7)
WalkDist	-1.143	(-7.4)	-1.153	(-7.4)	-1.153	(-7.5)	-1.149	(-7.5)
Toll choice terms								
TollBonus	-0.7386	(-4.3)	-0.7223	(-4.2)	-0.7229	(-4.2)	-0.7246	(-4.2)
CarTDist	0.01352	(5.3)	0.01324	(5.2)	0.01324	(5.2)	0.01322	(5.2)
Train access mode distance fit terms								
OrigGW	4.449	(5.2)	4.604	(5.3)	4.603	(5.3)	4.631	(5.4)
OrigSWS	0.8958	(1.6)	0.9229	(1.7)	0.9200	(1.7)	0.9260	(1.7)
TRnOthG75	-2.721	(-4.9)	-2.534	(-4.6)	-2.519	(-4.6)	-2.487	(-4.6)
Car availability terms								
CarComp	-4.031	(-7.0)	-4.002	(-7.0)	-3.980	(-7.0)	-3.947	(-7.1)
CmpCrDr	1.803	(5.3)	1.849	(5.4)	1.856	(5.4)	1.844	(5.5)
PassOpts	4.097	(5.3)	4.017	(5.2)	4.004	(5.2)	3.975	(5.3)
Prfr2pcar	0.6172	(1.4)	0.6519	(1.5)	0.6640	(1.5)	0.6573	(1.5)
Prcarcomp	-2.376	(-3.9)	-2.353	(-3.9)	-2.333	(-3.9)	-2.328	(-3.9)
KRPassopts	4.020	(2.7)	4.063	(2.7)	4.080	(2.7)	4.060	(2.7)
PRLicence	2.592	(4.2)	2.607	(4.2)	2.601	(4.2)	2.582	(4.2)
Other socio-economic terms								
MaleCrDr	0.5015	(2.6)	0.5018	(2.6)	0.4935	(2.6)	0.4887	(2.6)
MaleBike	5.566	(4.0)	5.508	(3.9)	5.492	(3.9)	5.447	(4.0)
FTwrkdist	0.01178	(4.4)	0.01214	(4.5)	0.01217	(4.5)	0.01286	(4.7)
Mode constants								
CarP	-11.50	(-7.0)	-11.43	(-7.0)	-11.39	(-7.0)	-11.29	(-7.1)
Train	-1.437	(-3.4)	-1.654	(-3.4)	-1.636	(-3.4)	-2.435	(-4.0)
TrainWk			0.8284	(2.5)	0.8232	(2.6)	1.618	(3.5)
TrainPR	-9.320	(-7.1)	-8.765	(-6.9)	-8.774	(-6.9)	-7.941	(-6.6)
TrainKR	-11.84	(-5.8)	-11.29	(-5.6)	-11.31	(-5.6)	-10.48	(-5.4)
Bus	-2.006	(-4.4)	-1.928	(-4.5)	-1.896	(-4.4)	-1.834	(-4.4)
Bike	-16.74	(-6.4)	-16.78	(-6.5)	-16.73	(-6.5)	-16.54	(-6.5)
Walk	-1.691	(-2.6)	-1.744	(-2.7)	-1.709	(-2.7)	-1.627	(-2.6)
Taxi	-10.09	(-6.3)	-9.987	(-6.3)	-9.950	(-6.3)	-9.848	(-6.4)
Destination constants								
Pmatta	1.039	(4.5)	1.065	(4.7)	1.065	(4.7)	1.060	(4.7)
Cwood	1.313	(4.3)	1.288	(4.2)	1.288	(4.2)	1.299	(4.3)
SLC	1.136	(4.4)	1.104	(4.4)	1.121	(4.4)	1.134	(4.5)
NSyd	1.697	(5.8)	1.689	(5.9)	1.698	(5.9)	1.712	(5.9)
ISyd	0.8662	(6.0)	0.9163	(6.2)	0.9124	(6.2)	0.9249	(6.2)
Esub	0.9976	(4.9)	0.9765	(4.8)	0.9698	(4.8)	0.9808	(4.8)
Nbeach	0.6935	(3.3)	0.6904	(3.3)	0.6926	(3.3)	0.7011	(3.3)

CBDRail	1.653	(5.2)	1.592	(5.1)	1.598	(5.1)	1.609	(5.2)
CBDBus	1.086	(4.2)	0.9887	(4.0)	0.9880	(4.0)	1.024	(4.1)
Intrazonal constants								
CrDNoTllIZ	-0.7066	(-2.1)	-0.8130	(-2.3)	-0.8103	(-2.3)	-0.7751	(-2.2)
CarPIZ	0.03413	(0.1)	-0.06453	(-0.1)	-0.06188	(-0.1)	-0.03071	(-0.0)
BikeIZ	0.4421	(0.3)	0.4369	(0.3)	0.4338	(0.3)	0.4317	(0.3)
WalkIZ	1.480	(4.1)	1.455	(4.0)	1.453	(4.0)	1.453	(4.0)
Attraction term								
TotEmp	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Structural parameters								
Theta_MD	0.7841	(19.2)	0.7901	(19.7)	0.7917	(19.8)	0.7954	(19.8)
Theta_PT	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Toll	0.5129	(8.0)	0.5110	(8.0)	0.5111	(8.0)	0.5129	(8.1)
Walk distance from workplace and workplace location terms								
Wwng	-3.426	(-3.2)	-3.380	(-3.2)	-3.389	(-3.2)	-3.370	(-3.2)
WNcast	-1.253	(-2.0)	-1.203	(-1.9)	-1.215	(-1.9)	-1.216	(-1.9)
LWdistCBD	-0.6822	(-4.7)	-0.6801	(-4.7)	-0.6815	(-4.7)	-0.6790	(-4.7)

Table 39: Car driver destination SSD tests (1)

File	COM_172.F12		COM_175.F12		COM_176.F12	
Observations	5689		5689		5689	
Final log (L)	-36864.2		-36827.1		-36836.7	
D.O.F.	59		64		60	
Rho²(0)	0.393		0.394		0.394	
Estimated	10 Apr 12		20 Apr 12		25 Apr 12	
Cost and LOS terms						
cost13	-0.00252	(-6.8)	-0.00223	(-6.1)	-0.00222	(-6.1)
cost4	-0.00189	(-6.8)	-0.00154	(-5.8)	-0.00150	(-5.7)
cost5	-0.00158	(-6.7)	-0.00119	(-5.3)	-0.00115	(-5.2)
cost67	-0.00119	(-6.6)	-7.71e-4	(-4.5)	-7.22e-4	(-4.3)
cost810	-0.00101	(-6.3)	-5.35e-4	(-3.4)	-4.80e-4	(-3.1)
cost	-0.00369	(-3.9)	-0.00345	(-3.5)	-0.00346	(-3.5)
LogCost	-0.3648	(-4.5)	-0.3750	(-4.3)	-0.3967	(-4.5)
CarTime	-0.05952	(-7.9)	-0.06853	(-7.7)	-0.06929	(-7.8)
RlTime	-0.02212	(-5.9)	-0.02387	(-5.9)	-0.02466	(-5.9)
BusTime	-0.04054	(-6.8)	-0.04419	(-6.7)	-0.04448	(-6.7)
FWaitTm	-0.1051	(-5.5)	-0.1150	(-5.5)	-0.1135	(-5.4)
OWaitTm	-0.07291	(-6.4)	-0.08017	(-6.3)	-0.07516	(-6.1)
AcEgTm	-0.06267	(-6.1)	-0.06932	(-6.1)	-0.06407	(-5.9)
CrAcEgTm	-0.07246	(-6.2)	-0.08331	(-6.2)	-0.08573	(-6.3)
CarPDist	-0.04666	(-5.4)	-0.04220	(-4.9)	-0.04195	(-4.8)
BikeDist	-0.3196	(-5.7)	-0.3337	(-5.6)	-0.3367	(-5.6)
WalkDist	-1.132	(-7.4)	-1.185	(-7.2)	-1.201	(-7.2)
Toll choice terms						
TollBonus	-0.7387	(-4.3)	-0.8665	(-4.9)	-0.8818	(-5.0)
CarTDist	0.01353	(5.3)	0.01189	(4.6)	0.01177	(4.6)
Train access mode distance fit terms						
OrigGW	4.440	(5.2)	4.618	(5.1)	4.780	(5.2)
OrigSWS	0.8880	(1.6)	0.8718	(1.5)	0.9624	(1.7)
TRnOthG75	-2.727	(-4.9)	-2.903	(-4.9)	-3.012	(-4.9)
Car availability terms						
CarComp	-4.014	(-7.0)	-4.175	(-6.8)	-4.289	(-6.8)
CmpCrDr	1.798	(5.3)	1.865	(5.2)	1.924	(5.2)
PassOpts	4.085	(5.3)	4.258	(5.2)	4.398	(5.2)
Prfr2pcar	0.6134	(1.4)	0.6394	(1.4)	0.6808	(1.5)
Prcarcomp	-2.375	(-3.9)	-2.494	(-3.9)	-2.518	(-3.9)
PRLicence	2.589	(4.2)	2.698	(4.2)	2.818	(4.3)
KRPassopts	4.018	(2.7)	4.207	(2.7)	4.272	(2.7)
Other socio-economic terms						

MaleCrDr	0.5003	(2.6)	0.5117	(2.5)	0.5306	(2.6)
MaleBike	5.542	(4.0)	5.754	(3.9)	5.921	(3.9)
FTwrkdist	0.01174	(4.4)	0.01020	(3.8)	0.00993	(3.7)
Mode constants						
CarP	-11.46	(-7.0)	-11.82	(-6.8)	-12.26	(-6.9)
Train	-1.419	(-3.4)	-1.447	(-3.3)	-2.453	(-4.6)
TrainPR	-9.312	(-7.1)	-9.669	(-6.9)	-8.991	(-6.8)
TrainKR	-11.83	(-5.8)	-12.33	(-5.7)	-11.61	(-5.5)
Bus	-1.988	(-4.4)	-1.900	(-4.1)	-2.417	(-4.7)
Bike	-16.67	(-6.4)	-17.21	(-6.3)	-17.87	(-6.3)
Walk	-1.750	(-2.7)	-1.733	(-2.6)	-1.983	(-2.8)
Taxi	-10.04	(-6.3)	-11.48	(-6.3)	-12.05	(-6.4)
Destination constants						
Pmatta	1.037	(4.5)	0.9270	(3.9)	0.9041	(3.8)
Cwood	1.312	(4.3)	1.003	(3.3)	1.214	(3.8)
SLC	1.133	(4.4)	0.7808	(3.0)	0.9594	(3.6)
NSyd	1.695	(5.8)	1.284	(4.5)	1.449	(4.9)
ISyd	0.8683	(6.0)	1.109	(6.1)	0.8869	(5.6)
Esub	0.9946	(4.8)	1.159	(5.0)	1.010	(4.6)
Nbeach	0.6920	(3.3)	0.8708	(3.7)	0.7149	(3.2)
CBDRail	1.650	(5.2)	1.502	(4.7)	1.324	(5.2)
CBDBus	1.082	(4.2)	0.9141	(3.5)	1.130	(4.0)
Intrazonal constants						
CrDNoTllIZ	-0.7062	(-2.1)	-0.6901	(-1.9)	-0.7397	(-2.0)
CarPIZ	0.02462	(0.0)	0.03100	(0.0)	-0.00239	(-0.0)
WalkIZ	1.537	(4.1)	1.595	(4.1)	1.623	(4.1)
BikeIZ	0.4221	(0.3)	0.4232	(0.3)	0.4589	(0.3)
Attraction term						
TotEmp	1.000	(*)	1.000	(*)	1.000	(*)
Structural parameters						
Theta_MD	0.7868	(19.0)	0.7947	(18.9)	0.7833	(19.0)
Theta_PT	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Toll	0.5131	(8.0)	0.4894	(7.7)	0.4827	(7.7)
Walk distance from workplace and workplace location terms						
WdistCBD	-0.00791	(-0.8)	-0.01050	(-1.0)	-0.00892	(-0.9)
LWdistCBD	-0.5901	(-3.3)	-0.5648	(-3.0)	-0.6119	(-3.2)
WNcast	-1.223	(-1.9)	-1.260	(-1.9)	-1.255	(-1.8)
Wwng	-3.386	(-3.2)	-3.475	(-3.1)	-3.567	(-3.1)
Car driver destination constants						
CarDCB			0.3770	(2.2)	0	(*)
CarDSGS			0.4696	(2.5)	0	(*)
CarDLNS			0.4684	(3.0)	0	(*)
CarDBT			-0.5002	(-2.4)	0	(*)
CarDCBD			-1.589	(-4.7)	-1.651	(-4.8)

Table 40: Car driver destination SSD tests (2)

File	COM_176.F12		COM_178.F12		COM_179.F12		COM_180.F12	
Observations	5689		5787		5787		5787	
Final log (L)	-36836.7		-37766.1		-37756.8		-37787.5	
D.O.F.	60		60		61		59	
Rho²(0)	0.394		0.391		0.391		0.391	
Estimated	25 Apr 12		27 Apr 12		30 Apr 12		2 May 12	
Cost and LOS terms								
cost13	-0.00222	(-6.1)	-0.00222	(-6.0)	-0.00221	(-6.0)	-0.00253	(-6.8)
cost4	-0.00150	(-5.7)	-0.00149	(-5.6)	-0.00149	(-5.6)	-0.00187	(-6.8)
cost5	-0.00115	(-5.2)	-0.00110	(-5.0)	-0.00113	(-5.1)	-0.00154	(-6.6)
cost67	-7.22e-4	(-4.3)	-6.80e-4	(-4.1)	-7.07e-4	(-4.2)	-0.00115	(-6.5)
cost810	-4.80e-4	(-3.1)	-4.58e-4	(-3.0)	-4.83e-4	(-3.2)	-9.81e-4	(-6.2)
cost	-0.00346	(-3.5)	-0.00344	(-3.5)	-0.00345	(-3.5)	-0.00368	(-3.9)
LogCost	-0.3967	(-4.5)	-0.4255	(-4.6)	-0.4018	(-4.5)	-0.3985	(-4.7)
CarTime	-0.06929	(-7.8)	-0.06951	(-7.8)	-0.06982	(-7.8)	-0.05985	(-7.9)
RlTime	-0.02466	(-5.9)	-0.02655	(-6.2)	-0.02759	(-6.2)	-0.02496	(-6.3)
BusTime	-0.04448	(-6.7)	-0.04115	(-6.5)	-0.04146	(-6.5)	-0.03768	(-6.6)
FWaitTm	-0.1135	(-5.4)	-0.1116	(-5.6)	-0.1206	(-5.6)	-0.1014	(-5.6)
OWaitTm	-0.07516	(-6.1)	-0.06730	(-5.9)	-0.06771	(-6.0)	-0.05851	(-5.9)
AcEgTm	-0.06407	(-5.9)	-0.08068	(-7.1)	-0.08872	(-7.1)	-0.07469	(-7.3)
CrAcEgTm	-0.08573	(-6.3)	-0.08907	(-6.3)	-0.09360	(-6.1)	-0.07690	(-6.2)
CarPDist	-0.04195	(-4.8)	-0.04145	(-4.8)	-0.04179	(-4.8)	-0.04634	(-5.4)
BikeDist	-0.3367	(-5.6)	-0.3395	(-5.6)	-0.3362	(-5.6)	-0.3230	(-5.7)
WalkDist	-1.201	(-7.2)	-1.222	(-7.2)	-1.224	(-7.3)	-1.156	(-7.5)
Toll choice terms								
TollBonus	-0.8818	(-5.0)	-0.8753	(-5.0)	-0.8713	(-5.0)	-0.7310	(-4.3)
CarTDist	0.01177	(4.6)	0.01154	(4.5)	0.01148	(4.5)	0.01329	(5.2)
Train access mode distance fit terms								
OrigGW	4.780	(5.2)	5.001	(5.3)	6.395	(5.4)	4.728	(5.4)
OrigSWS	0.9624	(1.7)	1.311	(2.3)	1.708	(2.5)	1.236	(2.3)
TRnOthG75	-3.012	(-4.9)	-2.666	(-4.5)	-3.057	(-4.4)	-2.588	(-4.7)
Car availability terms								
CarComp	-4.289	(-6.8)	-4.206	(-6.8)	-4.471	(-6.8)	-3.975	(-7.1)
CmpCrDr	1.924	(5.2)	1.967	(5.3)	2.052	(5.3)	1.860	(5.4)
PassOpts	4.398	(5.2)	4.282	(5.2)	4.527	(5.2)	4.036	(5.3)
Prfr2pcar	0.6808	(1.5)	0.8286	(1.8)	0.6426	(1.2)	0.7787	(1.8)
Prcarcomp	-2.518	(-3.9)	-1.839	(-3.1)	-2.688	(-3.5)	-1.740	(-3.2)
PRLicence	2.818	(4.3)	2.385	(4.0)	2.928	(3.9)	2.267	(4.0)
KRPassopts	4.272	(2.7)	4.057	(2.6)	4.993	(2.4)	3.840	(2.6)
Other socio-economic terms								
MaleCrDr	0.5306	(2.6)	0.5225	(2.6)	0.5428	(2.5)	0.5003	(2.6)
MaleBike	5.921	(3.9)	5.844	(3.9)	6.132	(3.9)	5.524	(4.0)
FTwrkdist	0.00993	(3.7)	0.00976	(3.7)	0.01144	(4.1)	0.01142	(4.3)
Mode constants								
CarP	-12.26	(-6.9)	-12.10	(-6.8)	-12.73	(-6.9)	-11.44	(-7.1)
Train	-2.453	(-4.6)	-2.783	(-4.6)	-3.483	(-4.7)	-2.506	(-4.5)
TrainPR	-8.991	(-6.8)	-7.999	(-6.6)	-9.365	(-6.4)	-7.654	(-6.8)
TrainKR	-11.61	(-5.5)	-10.96	(-5.3)	-13.44	(-4.9)	-10.45	(-5.4)
TrainWk			0.9719	(2.8)	1.675	(3.5)	0.8186	(2.6)
Bus	-2.417	(-4.7)	-2.244	(-4.7)	-2.242	(-4.6)	-2.138	(-4.8)
Bike	-17.87	(-6.3)	-17.79	(-6.3)	-18.66	(-6.3)	-16.78	(-6.5)
Walk	-1.983	(-2.8)	-1.822	(-2.7)	-2.078	(-2.9)	-1.654	(-2.6)
Taxi	-12.05	(-6.4)	-11.91	(-6.4)	-12.74	(-6.4)	-10.01	(-6.4)
Destination constants								
Pmatta	0.9041	(3.8)	0.9401	(4.0)	0.9260	(4.0)	1.104	(4.8)
Cwood	1.214	(3.8)	1.192	(3.7)	1.163	(3.7)	1.358	(4.4)
SLC	0.9594	(3.6)	0.9626	(3.7)	0.9620	(3.7)	1.157	(4.5)
NSyd	1.449	(4.9)	1.488	(5.0)	1.454	(5.0)	1.802	(6.0)
ISyd	0.8869	(5.6)	0.9236	(5.7)	0.9243	(5.8)	0.7855	(5.6)
Esub	1.010	(4.6)	0.9881	(4.6)	0.9802	(4.6)	0.9582	(4.7)
Nbeach	0.7149	(3.2)	0.7126	(3.2)	0.6952	(3.1)	0.6790	(3.2)
CBDRail	1.324	(5.2)	1.235	(5.2)	1.143	(5.0)	1.320	(5.6)

CBDBus	1.130	(4.0)	1.100	(4.0)	1.038	(3.9)	1.215	(4.5)
Intrazonal constants								
CrDNoTllIZ	-0.7397	(-2.0)	-0.8323	(-2.2)	-0.7707	(-2.1)	-0.8083	(-2.3)
CarPIZ	-0.00239	(-0.0)	-0.07489	(-0.1)	-0.04830	(-0.1)	-0.06257	(-0.1)
WalkIZ	1.623	(4.1)	1.540	(4.0)	1.481	(3.9)	1.481	(4.1)
BikeIZ	0.4589	(0.3)	0.4625	(0.3)	0.4595	(0.3)	0.4299	(0.3)
Attraction term								
TotEmp	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Structural parameters								
Theta_MD	0.7833	(19.0)	0.7925	(19.8)	0.7454	(18.7)	0.7937	(19.9)
Theta_PT	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)	1.373	(13.4)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)	1.000	(*)	1.000	(*)
Theta_Toll	0.4827	(7.7)	0.4809	(7.7)	0.3542	(6.8)	0.5079	(8.0)
Walk distance from workplace and workplace location terms								
WdistCBD	-0.00892	(-0.9)	0	(*)	0	(*)	0	(*)
LWdistCBD	-0.6119	(-3.2)	-0.7249	(-4.7)	-0.7655	(-4.8)	-0.7055	(-4.8)
WNcast	-1.255	(-1.8)	-1.314	(-2.0)	-1.320	(-1.9)	-1.303	(-2.1)
WWng	-3.567	(-3.1)	-3.624	(-3.2)	-3.807	(-3.2)	-3.496	(-3.3)
Car driver destination constants								
CarDCBD	-1.651	(-4.8)	-1.699	(-4.9)	-1.662	(-4.8)	0	(*)

Table 41: Tests with the final P&R and K&R station logsums

File	COM_180.F12		COM_181.F12	
Observations	5787		5802	
Final log (L)	-37787.5		-37935.0	
D.O.F.	59		59	
Rho²(0)	0.391		0.390	
Estimated	2 May 12		5 May 12	
Cost and LOS terms				
cost13	-0.00253	(-6.8)	-0.00247	(-6.7)
cost4	-0.00187	(-6.8)	-0.00187	(-6.8)
cost5	-0.00154	(-6.6)	-0.00155	(-6.7)
cost67	-0.00115	(-6.5)	-0.00117	(-6.6)
cost810	-9.81e-4	(-6.2)	-1.00e-3	(-6.3)
cost	-0.00368	(-3.9)	-0.00364	(-3.9)
LogCost	-0.3985	(-4.7)	-0.3825	(-4.6)
CarTime	-0.05985	(-7.9)	-0.06045	(-7.9)
RlTime	-0.02496	(-6.3)	-0.02756	(-6.5)
BusTime	-0.03768	(-6.6)	-0.03941	(-6.7)
FWaitTm	-0.1014	(-5.6)	-0.09456	(-5.5)
OWaitTm	-0.05851	(-5.9)	-0.05662	(-5.8)
AcEgTm	-0.07469	(-7.3)	-0.07336	(-7.2)
CrAcEgTm	-0.07690	(-6.2)	-0.06515	(-5.8)
CarPDist	-0.04634	(-5.4)	-0.04596	(-5.4)
BikeDist	-0.3230	(-5.7)	-0.3218	(-5.7)
WalkDist	-1.156	(-7.5)	-1.143	(-7.4)
Toll choice terms				
TollBonus	-0.7310	(-4.3)	-0.7263	(-4.3)
CarTDist	0.01329	(5.2)	0.01315	(5.2)
Train access mode distance fit terms				
OrigGW	4.728	(5.4)	4.695	(5.4)
OrigSWS	1.236	(2.3)	1.026	(2.0)
TRnOthG75	-2.588	(-4.7)	-2.529	(-4.6)
Car availability terms				
CarComp	-3.975	(-7.1)	-3.878	(-7.0)
CmpCrDr	1.860	(5.4)	1.834	(5.5)
PassOpts	4.036	(5.3)	3.943	(5.3)
PRfr2pcar	0.7787	(1.8)	0.8306	(1.9)
PRCarComp	-1.740	(-3.2)	-1.744	(-3.2)

PRLicence	2.267	(4.0)	2.279	(4.1)
KRPassopts	3.840	(2.6)	3.903	(2.6)
Other socio-economic terms				
MaleCrDr	0.5003	(2.6)	0.5173	(2.8)
MaleBike	5.524	(4.0)	5.401	(4.0)
FTwrkdist	0.01142	(4.3)	0.01317	(4.8)
Mode constants				
CarP	-11.44	(-7.1)	-11.14	(-7.0)
Train	-2.506	(-4.5)	-3.024	(-5.2)
TrainPR	-7.654	(-6.8)	-7.082	(-6.7)
TrainKR	-10.45	(-5.4)	-9.922	(-5.3)
TrainWk	0.8186	(2.6)	1.401	(4.0)
Bus	-2.138	(-4.8)	-2.052	(-4.7)
Bike	-16.78	(-6.5)	-16.29	(-6.4)
Walk	-1.654	(-2.6)	-1.492	(-2.4)
Taxi	-10.01	(-6.4)	-9.642	(-6.3)
Destination constants				
Pmatta	1.104	(4.8)	1.105	(4.8)
Cwood	1.358	(4.4)	1.368	(4.4)
SLC	1.157	(4.5)	1.173	(4.6)
NSyd	1.802	(6.0)	1.847	(6.1)
ISyd	0.7855	(5.6)	0.8117	(5.7)
ESub	0.9582	(4.7)	1.002	(4.9)
Nbeach	0.6790	(3.2)	0.6996	(3.3)
CBDRail	1.320	(5.6)	1.315	(5.6)
CBDBus	1.215	(4.5)	1.241	(4.6)
Intrazonal constants				
CrDNoTllIZ	-0.8083	(-2.3)	-0.7612	(-2.2)
CarPIZ	-0.06257	(-0.1)	-0.01779	(-0.0)
BikeIZ	0.4299	(0.3)	0.4272	(0.3)
WalkIZ	1.481	(4.1)	1.482	(4.1)
Attraction term				
TotEmp	1.000	(*)	1.000	(*)
Structural parameters				
Theta_MD	0.7937	(19.9)	0.8072	(19.9)
Theta_PT	1.000	(*)	1.000	(*)
Theta_Acmd	1.000	(*)	1.000	(*)
sta_ch	1.000	(*)	1.000	(*)
Theta_Toll	0.5079	(8.0)	0.5126	(8.0)
Walk distance from workplace and workplace location terms				
LWdistCBD	-0.7055	(-4.8)	-0.6868	(-4.8)
WWng	-3.496	(-3.3)	-3.431	(-3.3)
WNcast	-1.303	(-2.1)	-1.294	(-2.1)

Appendix B: Detailed TravDem model validation

In these sections, two RMS measures of fit to observed tour lengths have been calculated using the RMS formula defined in Equation 6.2 (see Section 6.2.3). The RMS1 measure was calculated using tour lengths from the expanded 2004–2009 HTS data as the observed data. The RMS2 measure was calculated using the unweighted tour lengths observed in the HTS estimation samples as the observed data.

Home–work

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver toll	79,703	4,787,880	4.1%	4.2%	5.1%	0.95%
Car driver no toll	907,032	24,427,328	60.5%	61.8%	58.2%	-3.60%
Car passenger	109,320	2,390,491	6.7%	6.4%	7.0%	0.64%
Train, P&R	55,563	4,204,369	3.6%	3.4%	3.6%	0.14%
Train, K&R	37,561	2,345,831	2.2%	2.5%	2.4%	-0.07%
Train, walk	122,966	5,120,022	7.5%	8.4%	7.9%	1.02%
Train, bus	23,766	1,228,701	1.4%		1.5%	
Bus	115,028	2,166,279	7.4%	6.5%	7.4%	0.90%
Bike	8,522	95,624	0.7%	0.7%	0.5%	-0.16%
Walk	93,016	290,331	5.6%	5.5%	6.0%	0.49%
Taxi	5,801	59,553	0.3%	0.7%	0.4%	-0.30%
Total	1,558,278	47,116,410	100.0%	100.0%	100.0%	0.00%
					RMS:	1.29%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver toll	30.9	29.6	-4.26%	66.7	60.1	-9.89%
Car driver no toll				28.7	26.9	-6.29%
Car oassenger	21.7	21.9	0.55%	22.5	21.9	-2.67%
Train, P&R	71.3	75.7	6.06%	70.8	75.7	6.87%
Train, K&R	58.0	62.5	7.61%	54.7	62.5	14.24%
Train, bus & walk	37.5	43.3	15.25%	37.7	43.3	14.76%
Bus	18.7	18.8	0.91%	17.9	18.8	5.05%
Bike	10.0	11.2	11.79%	11.3	11.2	-0.52%
Walk	3.3	3.1	-5.25%	3.1	3.1	0.34%
Taxi	18.3	10.3	-43.81%	10.2	10.3	0.52%
Total	31.9	30.2	-5.13%	30.3	30.2	-0.28%
		RMS:	7.05%		RMS:	7.26%

Home–business

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver toll	28,493	2,188,559	8.1%	8.1%	6.7%	-1.48%
Car driver no toll	317,341	10,480,973	75.5%	75.9%	74.1%	-1.86%
Car passenger	31,358	1,154,634	6.7%	5.8%	7.3%	1.49%
Train, P&R	6,830	510,482	1.5%	1.6%	1.6%	-0.04%
Train, K&R	2,243	138,396	0.5%	0.7%	0.5%	-0.21%
Train, other	12,198	633,973	2.4%	3.2%	2.8%	-0.32%
Bus	11,727	227,656	2.1%	1.8%	2.7%	0.96%
Bike	3,296	25,738	0.6%	0.4%	0.8%	0.37%
Walk	12,429	54,028	2.2%	2.0%	2.9%	0.91%
Taxi	2,538	62,929	0.5%	0.4%	0.6%	0.18%
Total	428,453	15,477,370	100.0%	100.0%	100.0%	0.00%
					RMS:	1.00%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver toll	44.2	36.6	-17.09%	88.3	85.2	-3.56%
Car driver no toll				36.5	36.5	-0.08%
Car Passenger	46.9	36.8	-21.47%	39.2	38.8	-1.09%
Train, P&R	84.3	74.7	-11.37%	77.7	76.9	-0.97%
Train, K&R	59.2	61.7	4.25%	51.2	60.8	18.73%
Train, other	55.4	52.0	-6.14%	44.8	48.4	8.13%
Bus	23.7	19.4	-18.08%	20.8	19.4	-6.59%
Bike	7.2	7.8	8.18%	8.8	8.0	-9.35%
Walk	5.0	4.3	-13.52%	3.8	4.4	16.22%
Taxi	21.6	24.8	14.78%	17.6	25.8	47.14%
Total	44.1	36.1	-18.05%	40.4	40.3	-0.28%
		RMS:	16.93%		RMS:	10.35%

Home–primary education

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car passenger	212,517	1,506,054	68.9%	68.2%	68.5%	0.33%
Train	1,303	36,884	0.4%	0.5%	0.4%	-0.11%
Bus	8,756	135,116	2.9%	4.2%	2.8%	-1.38%
School bus	18,842	191,329	6.2%	7.1%	6.1%	-1.07%
Bike	2,924	9,237	1.1%	0.9%	0.9%	0.03%
Walk	64,944	145,439	20.1%	18.9%	20.9%	2.08%
Taxi	871	7,360	0.3%	0.1%	0.3%	0.13%
Total	310,156	2,031,420	100.0%	100.0%	100.0%	0.00%
					RMS:	1.04%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car passenger	7.9	7.1	-10.34%	7.8	7.1	-9.55%
Train	18.2	28.3	55.57%	24.4	28.3	15.78%
Bus	9.7	15.4	59.31%	14.1	15.4	9.57%
School bus	12.7	10.2	-20.21%	12.3	10.2	-17.33%
Bike	2.4	3.2	32.97%	3.9	3.2	-19.28%
Walk	4.3	2.2	-47.91%	2.3	2.2	-1.33%
Taxi	7.3	8.4	15.99%	12.7	8.4	-33.38%
Total	7.3	6.5	-10.07%	7.2	6.5	-9.21%
		RMS:	26.64%		RMS:	9.63%

Home–secondary education

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver	3,397	62,674	2.2%	2.3%	1.4%	-0.96%
Car passenger	88,590	1,001,976	35.5%	33.7%	36.3%	2.57%
Train, K&R	9,580	347,331	4.3%	3.5%	3.9%	0.40%
Train, other	14,176	359,556	6.1%	9.2%	5.8%	-3.35%
Bus	36,471	649,876	15.0%	14.8%	14.9%	0.18%
School bus	48,557	779,530	20.7%	20.3%	19.9%	-0.45%
Bike	3,780	16,488	1.4%	1.7%	1.5%	-0.15%
Walk	39,106	110,825	14.5%	14.4%	16.0%	1.57%
Taxi	462	8,170	0.2%	0.0%	0.2%	0.19%
Total	244,118	3,336,425	100.0%	100.0%	100.0%	0.00%
					RMS:	1.55%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	% Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver	23.1	18.5	-19.95%	17.4	18.5	6.30%
Car passenger	13.1	11.3	-13.60%	12.2	11.3	-7.42%
Train, K&R	37.4	36.3	-3.19%	37.2	36.3	-2.51%
Train, other	22.3	25.4	13.55%	21.5	25.4	18.24%
Bus	15.9	17.8	11.86%	17.1	17.8	4.28%
School bus	18.4	16.1	-12.65%	18.7	16.1	-14.22%
Bike	4.2	4.4	4.67%	4.5	4.4	-3.44%
Walk	2.9	2.8	-3.38%	2.9	2.8	-1.46%
Taxi	*0.0*	*17.7*	*0.00%*	*35.3*	*17.7*	*-49.96%*
Total	14.9	13.7	-8.32%	14.6	14.9	1.90%
		RMS:	12.02%		RMS:	9.29%

Home–tertiary education

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver no toll	42,415	1,514,328	39.4%	37.7%	40.1%	2.35%
Car Passenger	9,829	246,434	9.0%	8.4%	9.3%	0.90%
Train, P&R	2,581	149,824	2.2%	2.8%	2.4%	-0.38%
Train, K&R	5,699	365,534	4.8%	6.4%	5.4%	-1.05%
Train, other	17,313	852,733	14.2%	17.7%	16.4%	-1.38%
Bus	15,938	357,822	15.9%	15.8%	15.1%	-0.71%
Bike	1,587	14,045	1.7%	1.2%	1.5%	0.27%
Walk	10,368	32,210	12.7%	9.8%	9.8%	0.02%
Taxi	134	5,029	0.1%	0.1%	0.1%	-0.02%
Total	105,863	3,537,958	100.0%	100.0%	100.0%	0.00%
					RMS:	1.06%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver no toll	37.4	35.7	-4.51%	34.1	35.7	4.55%
Car passenger	21.6	25.1	15.82%	22.3	25.1	12.20%
Train, P&R	65.6	58.1	-11.52%	66.9	58.1	-13.15%
Train, K&R	52.4	64.1	22.39%	60.3	64.1	6.39%
Train, other	36.3	49.3	35.78%	39.1	49.3	26.03%
Bus	21.3	22.5	5.28%	17.6	22.5	27.69%
Bike	8.7	8.9	1.17%	7.9	8.9	12.28%
Walk	3.0	3.1	3.99%	2.9	3.1	7.30%
Taxi	*1.9*	*37.5*	*1874.76%*	*1.9*	37.5	*1874.76%*
Total	31.3	33.4	6.7%	28.7	33.4	16.55%
		RMS:	17.25%		RMS:	15.96%

Home–shopping

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver toll	2,730	132,275	0.3%	0.3%	0.3%	0.01%
Car driver no toll	523,565	4,719,381	59.0%	60.5%	57.8%	-2.76%
Car Passenger	133,186	1,622,138	15.5%	14.4%	14.7%	0.26%
Train, P&R	1,520	81,569	0.2%	0.2%	0.2%	-0.02%
Train, K&R	1,218	64,779	0.1%	0.1%	0.1%	0.07%
Train, other	9,968	311,648	1.1%	1.4%	1.1%	-0.30%
Bus	37,095	444,876	4.0%	4.2%	4.1%	-0.07%
Bike	5,251	22,182	0.6%	0.6%	0.6%	0.01%
Walk	190,637	397,512	19.0%	17.9%	21.0%	3.09%
Taxi	1,314	8,630	0.1%	0.4%	0.1%	-0.30%
Total	906,484	7,804,990	100.0%	100.0%	100.0%	0.00%
					RMS:	1.32%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver toll	11.6	9.2	-20.42%	74.2	48.5	-34.66%
Car driver no toll				10.6	9.0	-15.21%
Car passenger	14.2	12.2	-14.32%	13.2	12.2	-7.66%
Train, P&R	50.6	53.7	6.11%	64.0	53.7	-16.11%
Train, K&R	24.5	53.2	117.14%	80.7	53.2	-34.14%
Train, other	37.3	31.3	-16.28%	31.6	31.3	-1.04%
Bus	10.6	12.0	13.00%	10.9	12.0	9.68%
Bike	5.3	4.2	-20.06%	4.4	4.2	-4.54%
Walk	2.1	2.1	-1.70%	2.0	2.1	2.66%
Taxi	6.1	6.6	7.35%	9.2	6.6	-28.69%
Total	10.6	8.6	-18.82%	10.0	8.6	-13.70%
		RMS:	17.47%		RMS:	12.55%

Home–other travel

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver toll	22,244	1,248,959	0.6%	0.6%	0.7%	0.08%
Car driver no toll	1,439,528	16,917,293	45.5%	46.9%	46.1%	-0.84%
Car Passenger	881,408	13,072,754	30.5%	29.2%	28.2%	-0.98%
Train, P&R	8,003	601,403	0.3%	0.3%	0.3%	0.00%
Train, K&R	11,004	816,820	0.4%	0.3%	0.4%	0.07%
Train, other	45,649	2,239,269	1.2%	1.3%	1.5%	0.17%
Bus	72,593	1,568,223	2.1%	1.8%	2.3%	0.49%
Bike	29,706	182,808	1.1%	1.0%	1.0%	-0.06%
Walk	599,089	1,374,107	17.9%	18.1%	19.2%	1.08%
Taxi	15,700	184,073	0.4%	0.5%	0.5%	-0.02%
Total	3,124,925	38,205,708	100.0%	100.0%	100.0%	0.00%
					RMS:	0.56%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver toll	15.3	12.4	-18.66%	69.5	56.1	-19.19%
Car driver no toll				14.2	11.8	-17.37%
Car passenger	16.8	14.8	-11.49%	16.6	14.8	-10.75%
Train, P&R	67.8	75.2	10.89%	78.6	75.2	-4.35%
Train, K&R	63.2	74.2	17.52%	69.5	74.2	6.85%
Train, other	37.5	49.1	30.92%	41.9	49.1	17.08%
Bus	13.1	21.6	65.33%	19.2	21.6	12.35%
Bike	6.4	6.2	-3.60%	5.6	6.2	9.31%
Walk	2.5	2.3	-6.95%	2.4	2.3	-4.14%
Taxi	9.9	11.7	18.68%	10.5	11.7	11.20%
Total	13.8	12.2	-11.33%	13.8	12.2	-11.67%
		RMS:	17.50%		RMS:	13.65%

Work-based business tours

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Tours	KM	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver	86,206	1,612,764	63.2%	63.7%	62.3%	-1.41%
Car passenger	9,743	288,975	6.6%	6.4%	7.0%	0.62%
Train	1,802	73,834	1.3%	1.4%	1.3%	-0.10%
Bus	725	6,200	0.5%	0.6%	0.5%	-0.08%
Walk	32,071	58,916	23.0%	22.7%	23.2%	0.43%
Taxi	7,911	90,805	5.4%	5.2%	5.7%	0.55%
Total	138,457	2,131,495	100.0%	100.0%	100.0%	0.00%
					RMS:	0.69%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver	18.6	18.7	0.61%	20.2	18.7	-7.19%
Car passenger	31.6	29.7	-6.26%	36.5	29.7	-18.76%
Train	26.0	41.0	57.50%	31.2	41.0	31.11%
Bus	13.9	8.6	-38.62%	18.0	8.6	-52.53%
Walk	1.8	1.8	1.26%	1.7	1.8	6.43%
Taxi	11.3	11.5	2.01%	11.1	11.5	3.20%
Total	15.3	15.4	0.53%	16.6	15.4	-7.48%
		RMS:	7.67%		RMS:	5.47%

NHB business detours

Mode share comparisons

	TravDem (2006 Base)		Mode Shares			
Mode	Detours (out plus return)	KM (out plus return)	HTS Estim. Sample	Weighted HTS	TravDem Predicted	Diff.
Car driver no toll	25,372	762,328	5.6%	5.6%	8.2%	2.56%
Car driver toll	217,530	3,068,782	74.6%	75.4%	70.1%	-5.26%
Car passenger	25,599	327,960	7.9%	7.1%	8.3%	1.17%
Train	2,471	23,851	0.6%	1.2%	0.8%	-0.40%
Bus	280	738	0.1%	0.1%	0.1%	-0.03%
Walk	35,605	35,606	10.3%	9.9%	11.5%	1.60%
Taxi	3,422	22,031	1.0%	0.7%	1.1%	0.36%
Total	310,279	4,241,295	100.0%	100.0%	100.0%	0.00%
					RMS:	0.70%

Tour length comparisons

	RMS1 Comparison			RMS2 Comparison		
Mode	Weighted HTS	TravDem Predicted	Diff.	HTS Estim. Sample	TravDem Predicted	Diff.
Car driver no toll Car driver toll	16.2	15.8	-2.92%	37.5 13.4	30.0 14.1	-19.94% 5.00%
Car passenger	16.8	12.8	-23.89%	14.5	12.8	-11.53%
Train	10.1	9.7	-4.90%	9.9	9.7	-2.17%
Bus	4.6	2.6	-42.13%	1.9	2.6	38.15%
Walk	0.9	1.0	5.95%	0.7	1.0	38.86%
Taxi	5.6	6.4	14.55%	5.5	6.4	16.76%
Total	14.6	13.7	-6.45%	13.4	13.7	1.73%
		RMS:	7.41%		RMS:	8.16%