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STM3 2011 base frequency, mode-destination and car ownership models

James Fox, Bhanu Patruni

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Preface

RAND Europe was commissioned by the Bureau of Transport Statistics (BTS) of Transport for NSW to modify the Sydney Strategic Transport Model (STM) to reflect a 2011 base year. The work was undertaken in the second half of 2014, but this report was not made publicly available until 2015.

The STM was designed by Hague Consulting Group (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 (2001–2002), RAND Europe, incorporating Hague Consulting Group, developed mode and destination and frequency models for the remaining home-based purposes, as well as for non-home-based business travel. Then, during 2003 and 2004, RAND Europe undertook a detailed validation of the performance of the Stage 1 and 2 models. Finally, Halcrow undertook Stage 3 of model development (2007), re-estimating the home–work mode-destination models, and at the same time developing 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 with sufficient accuracy the current behaviour of residents of Sydney. Furthermore, changes to the zone structure of the model occurred with the number of zones approximately trebling in number and the area of coverage increased to include Newcastle and Wollongong. Therefore, the BTS commissioned RAND Europe to re-estimate the STM models using more recent information on the travel behaviour of Sydney residents, and implement those updated models. The updated version of the model system is referred to as STM3.

The work to modify STM3 to work with and reflect a 2011 base year was undertaken in the second half of 2014. The work involved updating the frequency, mode-destination and car ownership models with more recent data so that they reflected a 2011 base year. The work to make these updates is documented in this report.

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

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For more information about RAND Europe or this document, please contact James Fox:

RAND Europe
Westbrook Centre
Milton Road
Cambridge CB4 1YG
United Kingdom
Tel. +44 (1223) 353 329
jfox@rand.org

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1. Introduction

The Sydney Strategic Transport Model version 3 (STM3) frequency, mode-destination (MD) and car ownership models have been updated so that they reflect a 2011 base year instead of the 2006 base year used in the previous versions of the model. The 2011 update was not a full-scale re-estimation examining alternative model specifications; rather, the intention was to minimise the changes relative to the 2006-base version of STM3.

Updating the base year from 2006 to 2011 has resulted in a number of changes to the frequency and MD model inputs:

- Updated choice data (Household Travel Survey data)
- Updated level-of-service (LOS) data
- Updated attraction data[1]
- Updated car cost data
- Updated taxi cost data.

The updated choice, LOS and attraction data were supplied by BTS. As well as reflecting changes in demand between 2006 and 2011, the highway assignment is impacted by changes to the Emme assignment algorithm that results in fewer paths being used on average for a particular origin-destination pair. For the public transport (PT) assignment, the 2011 skims incorporate an improved treatment of waiting time.

The updates that have been made to the car and taxi cost data are documented in Appendices A and B respectively.

This report describes the changes to the models as a result of this update. It is structured as follows. Chapter 2 presents a summary of the key changes to the frequency, MD and car ownership models. Then Chapter 3 presents a complete comparison of the 2006 and 2011-base model parameters. Chapter 4 presents the mode-destination model validation, namely analysis of the implied values of time (VOTs) and the model elasticities. Finally Chapter 5 summarises the changes to the frequency, MD and car ownership models.

[1] BTS did not supply updated enrolment data for education, so for the three education purposes the 2011-base models were estimated using 2006 attraction data.

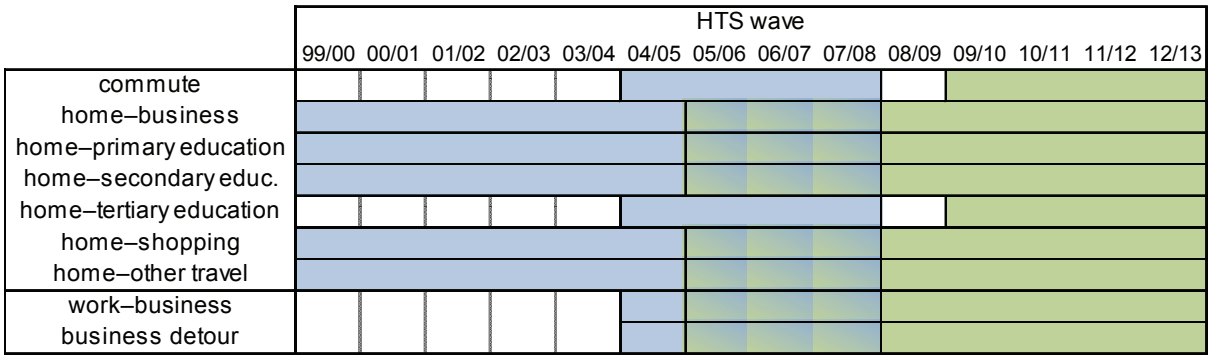
2. Summary of changes

2.1. Updates to choice data

For the 2006-base versions of the frequency and MD models the waves of Household Travel Survey (HTS) data used in estimation varied according to the model purpose. For the frequency models, different samples were used due to changes in the tour rate over the nine waves of data available for estimation. For the MD models, different samples were used because for some purposes it was necessary to use more waves of data so that the samples of toll road users and park-and-ride users were sufficiently large to develop the models.

Similar logic was used for the new 2011-base versions of the models. For commute and home–tertiary education travel, where the tour rates show greater variability between waves, only data from 2009 to 2012 has been used to ensure that the tour rates are representative of the new 2011-base year. For the other purposes, which show less variability in tour rates, eight waves of data have been used to maximise the sample sizes. Table 1 summarises the waves of data used for the 2006-base models (blue) and the 2011-base models (green).

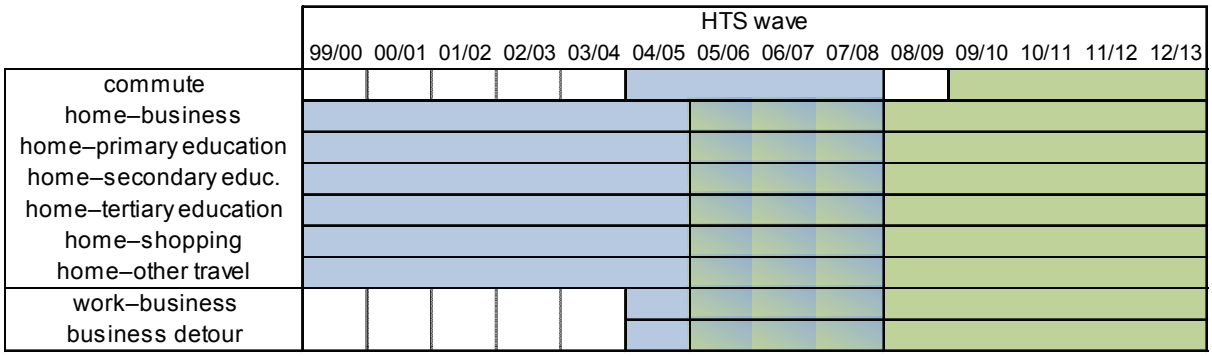
Table 1: HTS waves used in 2006 and 2011-base versions of the frequency models



2006-base models shown in blue, 2011-base version models shown in green.

The waves of data used for the frequency and MD models are the same for all purposes except for home–tertiary education, where more waves were used in the MD models (to ensure sufficient samples of park-and-ride and kiss-and-ride users) than in the frequency models. Table 2 summarises the waves used for each purpose.

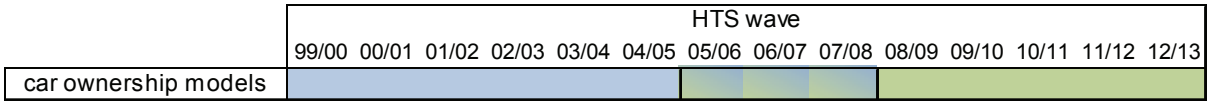
Table 2: HTS waves used in 2006 and 2011-base versions of the MD models



2006-base models shown in blue, 2011-base version models shown in green.

For purposes other than commute, separate mode constants have been estimated for the earlier waves of data (2005/2006–2008/2009) and later waves of data (2009/2010–2012/2013). In application, only the mode constants estimated from the later waves of data will be used as these best reflect the 2011 base year. For the frequency models, the selection of which waves of data to use in estimation was informed by examining the variability in the tour rates by wave (with the aim of minimising variability). Thus, alternative specific constants in the frequency model, which define the base trip rates, were estimated across all the waves of data in the estimation sample for each purpose.

Table 3: HTS waves used in 2006 and 2011-base versions of the car ownership models



2006-base models shown in blue, 2011-base version models shown in green.

2.2. Overall model fit

As Table 1 to Table 3 show, the 2006-base and 2011-base versions of the models have been estimated from different waves of HTS data and therefore the log-likelihoods cannot be directly compared. Therefore the log-likelihood (LL) per observation (obs) has been calculated to provide a measure of overall model fit that can be compared between the two sets of models.

Table 4 presents the LL/obs for the 2006 and 2011-base frequency models, and then from this measure calculates a fit ratio that quantifies the relative change in the fit per observation (calculated as the 2011-base LL divided by the 2006-base LL). A fit ratio less than one (green) indicates that the LL/obs has improved in the 2011-base model compared with the 2006-base model.[2] For some of the purposes, the frequency model specification was revised in the 2011-base version of the model because parameters that were identified in the 2006-base version of the model were no longer significant. For these purposes the 2011-base LL/obs measure in Table 4 has been calculated using the 2006-base specification rather than

[2] Note that the closer the LL/obs measure is to zero, the better the model fits the observed choices.

using the final model specification with the insignificant terms dropped. A column has been added in Table 4 to clarify whether there have been changes to the model specification between the 2006-base and 2011-base versions of the model; for some purposes all of the parameters estimated in the 2006-base model remained significant and therefore no changes to the model specification were necessary.

Table 4: Changes in frequency model fit

	2006 base			2011 base (2006 base model specification)			Change to specification?	Fit ratio
	LL	obs	LL/obs	LL	obs	LL/obs		
commute	-6,747.6	10,140	-0.665	-7,002.2	10,645	-0.658	yes	0.989
home–business	-8,392.4	31,456	-0.267	-7,688.6	28,849	-0.267	yes	0.999
home–primary education	-1,557.6	4,135	-0.377	-1,514.4	4,021	-0.377	yes	1.000
home–secondary education	-1,574.8	3,073	-0.512	-1,348.0	2,787	-0.484	yes	0.944
home–tertiary education	-1,034.4	13,183	-0.078	-1,121.4	13,839	-0.081	no	1.033
home–shopping	-17,154.0	40,209	-0.427	-15,407.1	36,561	-0.421	no	0.988
home–other travel	-51,273.2	50,421	-1.017	-36,962.1	36,561	-1.011	no	0.994
work–business	-1,569.0	5,082	-0.309	-2,653.9	10,455	-0.254	no	0.822
bus. det., PD wk, out	-477.0	3,989	-0.120	-1,197.5	12,739	-0.094	yes	0.786
bus. det., PD wk, ret	-534.9	3,989	-0.134	-1,510.1	12,739	-0.119	yes	0.884
bus. det., PD bs, out	-828.9	1,501	-0.552	-1,859.7	3,609	-0.515	yes	0.933
bus. det., PD bs, ret	-875.8	1,501	-0.583	-1,646.7	3,003	-0.548	yes	0.940
Total	-87,734.0	152,617	-0.575	-71,043.8	133,263	-0.533	n/a	0.927

For all purposes except home–tertiary education the new 2011-base model gives a better fit to the data using the LL/obs measure.

One potential problem with the use of the LL/obs measure for the MD models is that if mean tour lengths increase, the LL/obs measure would be expected to worsen because shorter tours are easier to predict.[3] To investigate this, Table 5 presents the mean tour and detour lengths in the 2006 and 2011 estimation samples.

[3] To illustrate, imagine a destination choice only model with 100 destination alternatives. If tour lengths are short, we could imagine that an individual would only pick from one of the ten zones nearest to their origin. If each of these ten zones is equally likely to be chosen then the contribution to the LL would be ln(1/10)=-2.3. However, if tours were long and we assume that each of the 100 zones is equally likely to be chosen then the contribution to the LL would be ln(1/100)=-4.6. Therefore an increase in mean tour length will lead to a reduction in LL *ceteris paribus*.

Table 5: Mean tour and detour lengths by purpose (km)

Purpose	2006-base	2011-base	Change
commute	30.0	30.2	0.7%
home–business	40.2	40.4	0.5%
home–primary education	7.3	7.4	1.4%
home–secondary education	15.0	14.5	-3.4%
home–tertiary education	28.5	30.9	7.8%
home–shopping	9.9	10.4	4.8%
home–other travel	13.6	13.3	-2.3%
work–business	16.3	16.4	0.6%
business detour	13.3	13.3	0.0%

With the exception of the home–tertiary education, the changes in tour lengths are no greater than ±5.0% and therefore it is reasonable to compare the LL/obs values between models.

Table 6: Mode-destination model fit

	2006 base			2011 base (2006 base model specification)			Fit ratio
	LL	obs	LL/obs	LL	obs	LL/obs	
commute	-39,116.8	6,015	-6.50	-38,465.7	6,033	-6.38	0.980
home–business	-26,370.2	3,748	-7.04	-23,056.7	3,296	-7.00	0.994
home–primary education	-10,592.4	3,195	-3.32	-9,711.0	2,907	-3.34	1.008
home–secondary education	-8,740.4	2,057	-4.25	-8,448.9	1,963	-4.30	1.013
home–tertiary education	-4,536.5	959	-4.73	-4,217.8	853	-4.94	1.045
home–shopping	-33,402.9	8,752	-3.82	-30,123.8	7,909	-3.81	0.998
home–other travel	-149,057.1	29,616	-5.03	-134,837.2	26,757	-5.04	1.001
work–business	-3,506.4	596	-5.88	-5,341.2	914	-5.84	0.993
business detour	-7,672.6	1,243	-6.17	-12,809.3	2,115	-6.06	0.981
Total	-271,816.3	54,342	-5.00	-248,861.1	49,718	-5.01	1.001

The changes in fit for the MD models are more mixed than those for the frequency models, with improvements for commute, home–shopping and the three business purposes, but reductions in fit for the three education purposes and for home–other travel. As home–other travel represents a large fraction of total travel, the overall fit measure shows a very slight worsening in the new models. However, it is emphasised that there are no large changes in LL/obs in any of the models.

Table 7: Car ownership model fit

	2006 base			2011 base (2006 base specification)			Fit ratio
	LL	obs	LL/obs	LL	obs	LL/obs	
company cars	-11,700.8	16,730	-0.699	-10,252.2	15,590	-0.658	0.940
total cars	-15,971.1	22,677	-0.704	-14,914.4	20,901	-0.714	1.013

The pattern of changes is mixed – the company car ownership model has an improved LL/obs, whereas the fit has worsened slightly for the total car ownership model.

2.3. Accessibility parameters in the frequency models

A key feature of the frequency models for home-based tours in STM3 is the incorporation of MD accessibility parameters. These parameters take account of the fact that individuals with higher accessibility make more tours than those with lower accessibility. Accessibility varies according to both the home zone of the individual and their socio-economic segment. For example, individuals living close to the centre of Sydney have higher accessibility than those living in residential suburbs, and for individuals resident in a given zone those with access to a car have higher accessibility than those without access to a car.

Accessibility parameters have been tested in both the zero/one-plus models, which represent an individual's decision to participate in an activity on a given day, and the stop/go models, which model the amount of activity participation given that at least one tour is made.

Accessibility parameters have not been included in the frequency model specifications for non-home-based (NHB) trips. In model application, the NHB models are applied as a function of the predicted number of home-based (HB) tours, and therefore changes in the number of HB tours as a result of changes in accessibility will in turn result in changes in the numbers of NHB tours.

Table 8 summarises the changes to the accessibility parameters in the HB frequency models. Improvements in the strength (i.e. magnitude) and significance of the parameters are highlighted in green, while reductions are highlighted in red. The final two columns indicate whether the changes in the parameter magnitudes are statistically significant.

Table 8: Changes to the accessibility parameters in the HB frequency models

	2006 base				2011 base				Significant change?	
	0/1+ model		stop/go model		0/1+ model		stop/go model		0/1+	stop/go
commute	-0.119	(-4.9)	no term		-0.095	(-3.9)	no term		no	n/a
home–business	-0.114	(-4.0)	no term		-0.100	(-3.4)	no term		no	n/a
home–primary education	-0.139	(-1.9)	no term		-0.168	(-2.7)	no term		no	n/a
home–secondary education	no term		-0.139	(-0.6)	no term		-0.382	(-1.2)	n/a	no
home–tertiary education	-0.062	(-1.1)	no term		-0.064	(-1.2)	no term		no	n/a
home–shopping	-0.105	(-6.4)	-0.207	(-4.7)	-0.122	(-7.2)	-0.138	(-3.1)	no	no
home–other travel	-0.239	(-14.4)	-0.170	(-7.2)	-0.214	(-12.6)	-0.175	(-7.2)	no	no

Some of the accessibility parameters have increased in strength, while others have reduced. However, the significance of most of the accessibility parameters is relatively low and it can be seen from Table 8 that none of the parameter changes are statistically significant.

2.4. Public transport out-of-vehicle time ratios in the MD models

The following out-of-vehicle components are available from the PT LOS data:

- Access and egress time
- First wait time
- Other wait time
- Boardings.

Where possible, separate parameters have been estimated for each of these four components. However, in some models it has been necessary to combine first and other wait times, and/or add boardings to in-vehicle time (IVT) using a fixed penalty, in order to obtain defensible parameter values. Table 9 summarises the treatment of boardings for each model purpose.

Table 9: Treatment of boardings in the mode-destination models

Purpose	2006-base	2011-base
commute	5 mins of IVT	5 mins of IVT
home–business	5 mins of IVT	5 mins of IVT
home–primary education	5 mins of IVT	5 mins of IVT
home–secondary education	5 mins of IVT	5 mins of IVT
home–tertiary education	5 mins of IVT	5 mins of IVT
home–shopping	separate estimate	5 mins of IVT
home–other travel	separate estimate	separate estimate
work-based business	5 mins of IVT	5 mins of IVT
business detour	5 mins of IVT	5 mins of IVT

It can be seen from Table 9 that home–shopping is the only purpose where the treatment of boardings has changed between the 2006-base and 2011-base versions of the models.

Table 10 presents the ratios of the out-of-vehicle LOS parameters relative to the rail IVT parameter. For the new 2011-base models, green is used to highlight components where the relative valuation is more plausible than that in the 2006-base model and correspondingly red shows components where the relative valuation is less plausible.

Table 10: Out-of-vehicle LOS parameters expressed relative to rail IVT parameters

	2006 base				2011 base			
	acc/eg time	first wait time	other wait time	boardings	acc/eg time	first wait time	other wait time	boardings
commute	2.33	3.67	1.73	n/a	2.65	2.36	1.86	n/a
home–business	4.15	4.48		n/a	4.26	4.73		n/a
home–primary education	0.17	0.25		n/a	0.21	0.49		n/a
home–secondary education	0.34	1.50		n/a	0.55	1.52		n/a
home–tertiary education	0.20	2.58		n/a	0.19	2.68		n/a
home–shopping	0.77	1.77	0.77	17.8	0.64	1.61		n/a
home–other travel	0.20	0.93		15.6	0.82	2.06		7.4

Overall the out-of-vehicle component estimates are more plausible in the 2011-base models relative to the ranges quoted in the UK Department of Transport's WebTAG guidance:[4]

- Value of walk time: 1.5 to 2.0 times in-vehicle time
- Value of wait time: 1.5 to 2.5 times in-vehicle time
- Interchange penalty: 5 to 10 minutes of in-vehicle time per interchange.

For commute, the first wait time parameter is more plausible (lower); for primary education the wait time estimate is more plausible (higher, though it remains low), and for home–other travel access and egress time, wait time and boardings are all more plausible than in the 2006-base model.

For home–shopping, it was necessary to merge first and wait time in the 2011-base model, and add boardings to IVT as the separate boardings parameter estimate was implausibly high relative to rail IVT. The access and egress time estimate is less plausible (lower) in the 2011-base model.

Table 11 presents the ratios of the out-of-vehicle components relative to bus IVT.

Table 11: Out-of-vehicle components expressed relative to bus IVT

	2006 base				2011 base			
	acc/eg time	first wait time	other wait time	boardings	acc/eg time	first wait time	other wait time	boardings
commute	2.45	3.67	1.39	n/a	2.33	2.05	1.62	n/a
home–business	2.27	2.45		n/a	2.10	2.33		n/a
home–primary education	0.28	0.41		n/a	0.23	0.56		n/a
home–secondary education	0.34	1.46		n/a	0.51	1.41		n/a
home–tertiary education	0.13	1.65		n/a	0.12	1.67		n/a
home–shopping	1.10	2.29	0.99	23.0	0.81	0.81		n/a
home–other travel	0.38	1.73		29.0	0.62	1.56		5.6

The pattern of changes for the ratios relative to bus IVT is consistent with that for the ratios calculated relative to rail IVT.

2.5. Changes to the toll choice model

When the 2006-base models were developed during 2009–2010, toll choice sub-models were included for the commute, home–business, home–shopping, home–other travel and business detour models. In the sub-models the choice between tolled and untolled alternatives is predicted on the basis of the differences in time and cost, a constant termed the 'toll bonus', and a distance effect to account for the fact that longer distance travellers are more likely to use toll roads *ceteris paribus*.

While travellers may have a residual preference or dislike of tolled alternatives so that the toll bonus and distance terms are required, if these two terms are strong relative to cost and car time this indicates that the toll skims are not able accurately to represent the choice between tolled and untolled alternatives. In the 2006-base models the constants and distance effects were relatively strong, thus in Table 10 the

[4] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/275628/webtag-tag-unit-m3-2-public-transport-assignment-modelling.pdf

changes in the magnitude and significance of these terms is examined. Parameters that have reduced in magnitude and significance are highlighted in green; correspondingly parameters that have increased in magnitude and significance are highlighted in red.

Table 12: Changes in the toll bonus and distance effect terms

	2006 base				2011 base			
	Toll bonus		Distance term		Toll bonus		Distance term	
commute	-0.764	(4.6)	0.0133	(5.4)	-0.379	(1.9)	0.0109	(3.5)
home–business	-0.854	(5.8)	0.0091	(6.1)	-0.422	(2.1)	0.0106	(5.7)
home–shopping	-2.644	(8.3)	0.0520	(14.5)	-0.947	(2.0)	0.0149	(1.4)
home–other	-1.874	(14.5)	0.0282	(18.0)	-1.519	(10.2)	0.0206	(10.3)
business detour	-0.461	(1.7)	0.0154	(2.4)	0.004	(0.0)	0.0254	(4.5)

The changes to all the toll bonus terms, and to three of the distance terms, indicate an improvement in the models in that the magnitude of the terms is reduced so that the explanatory power of the terms is reduced relative to the cost and time parameters. This suggests that the new 2011-base skims are better able to predict the choice between tolled and untolled alternatives.

3. Model parameters

The following tables compare the parameters in the 2006-base and 2011-base versions of the models. The comparison tables also present the t-ratio for the difference in the parameter values between the 2006-base and 2011-base models. This is calculated using formula (3.1):

$$t(\beta_{2011} - \beta_{2006}) = \frac{abs\left(\beta_{2011} - \beta_{2006}\right)}{\sqrt{\left(\sigma\left[\beta_{2011}\right]\right)^2 + \left(\sigma\left[\beta_{2006}\right]\right)^2}} \qquad (3.1)$$

where: β_{2006} and β_{2011} are the 2006-base and 2011-base parameters

$\sigma\left[\beta_{2006}\right]$ and $\sigma\left[\beta_{2011}\right]$ are the standard errors for the 2006-base and 2011-base parameters

Cases where the change in parameter magnitude is statistically significant at a 95 per cent confidence interval are highlighted in red, whereas cases where the change is not significant at a 95 per cent confidence level are highlighted in green.

3.1. Frequency models

Table 13: Commute frequency model parameters

Parameter	Description	2006 base Model 20 Value	2006 base Model 20 t-ratio	2011 base Model 23 Value	2011 base Model 23 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
Constant	constant to ensure fraction making at least one tour replicated	-0.448	-2.9	-0.488	-3.1	0.18
FTed	full-time students less likely to make tours than full-time w orkers	2.205	19.8	2.136	20.2	0.45
PTed	part-time students less likely to make tours than full-time w orkers	1.724	11.4	1.566	10.0	0.72
PTw k	part-time w orkers less likely to make tours than full-time w orkers	0.760	10.8	0.700	10.6	0.62
casw k	causal w orkers less likely to make tours than full-time w orkers	0.891	9.5	0.874	9.7	0.13
volw k	voluntary w orkers less likely to make tours than full-time w orkers	1.728	11.0	1.247	7.9	2.17
ageo39	persons aged over 39 less likely to make tours than those aged up to 39	0.153	3.1	0.151	3.1	0.02
ageo59	persons aged over 59 less likely to make tours than those aged up to 59	0.305	3.5	0.277	3.7	0.25
carcompet	individuals in households w ith car competition make few er tours	-0.185	-3.2	-0.086	-1.6	1.25
compcar	individuals in households w ith company cars make more tours	0.741	14.4	0.596	11.8	2.01
males	males less likely to make tours than females	0.631	12.7	0.555	11.7	1.11
manufac	individuals w ith manufacturing occupations make more tours	-0.676	-8.2	-0.608	-7.4	0.58
incpu20.8k	individuals w ith incomes under $20,800 p.a. make few er tours	0.522	7.3	0.609	8.4	0.85
incge67.6k	individuals w ith incomes of $67,600 p.a. and above make more tours	-0.149	-2.5	-0.113	-1.9	0.43
access	individuals w ith higher accessibility make more tours	-0.119	-4.9	-0.095	-3.9	0.71
Stop/go model:						
Constant2	constant to observed multiple tour making rate is replicated	3.309	31.2	3.497	32.7	1.25
compcar2	individuals in households w ith company cars make more multiple tours	-0.459	-2.9	-0.563	-3.2	0.44
manufac2	individuals w ith manufacturing occupations make few er multiple tours	0.490	1.7	0.340	1.2	0.37
inpu20.8k2	individuals w ith incomes under $20,800 p.a. make more multiple tours	-0.477	-2.6			
inge67.6k2	individuals w ith incomes of $67,600 p.a. and above make few er multiple tours	0.563	2.7	0.506	2.4	0.19

The low-income term in the stop/go model was not significant in the 2011-base model (t=0.6) and was therefore dropped from the final model specification.

It can be seen that most of the commute model parameters have only changed slightly, with statistically significant changes observed for only two out of 19 cases.

Table 14: Home–business frequency model parameters

Parameter	Description	2006 base Model 17 Value	2006 base Model 17 t-ratio	2011 base Model 19 Value	2011 base Model 19 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	7.936	18.5	20.068	0.1	0.06
zerocrs0	individuals in zero car households make fewer tours	0.312	2.2	0.355	2.3	0.20
carcomp0	individuals in households with car competition make fewer tours	0.144	2.5	0.224	3.5	0.92
cmpcar0	individuals in households with company cars make more tours	-0.942	-19.1	-0.962	-18.9	0.28
manual0	individuals with manual occupations make many more tours than non-workers	-5.913	-14.3	-18.016	-0.1	0.06
nonmanual0	individuals with non-manual occupations make many more tours than non-workers	-4.507	-10.9	-16.679	-0.1	0.06
manu0	individuals with manufacturing occupations make fewer tours	1.217	15.0	1.240	13.4	0.19
FTst_pens0	full-time students and pensioners make fewer tours	0.990	6.3	1.107	6.6	0.51
male0	males more likely to make tours than females	-0.906	-17.7	-0.919	-17.2	0.17
age<24_0	individuals aged up to 24 make fewer tours	0.472	6.2	0.450	5.4	0.20
lsm0	individuals with higher accessibility make more tours	-0.114	-4.0	-0.100	-3.4	0.33
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	2.552	24.7	2.488	23.9	0.43
cmpcarpl	individuals in households with company cars make more multiple tours	-0.481	-4.1	-0.523	-4.4	0.26
age<24pl	individuals aged up to 24 make fewer multiple tours	0.631	2.7	0.868	3.2	0.67
incu31.2	individuals with incomes under $31,200 p.a. make more multiple tours	-0.541	-4.4	-0.516	-4.0	0.14

Most of the changes in the parameter values are small and it can be seen from the t-ratio of the parameter difference column that none of the parameter changes are statistically significant.

The large negative parameters for manual and non-manual workers reflect the fact that workers have significantly higher business tour rates than non-workers. This is illustrated by Table 15.

Table 15: Home–business tour frequency rates (2011-base sample)

Workers	0.171
Non-workers	0.008
All adults	0.107

The insignificant 'noneASC' parameter in the 2011-base model then follows from the fact that nearly all non-workers make zero tours.

Table 16: Home–primary education frequency model parameters

Parameter	Description	2006 base Model 13 Value	2006 base Model 13 t-ratio	2011 base Model 15 Value	2011 base Model 15 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	-1.285	-2.9	-0.673	-1.3	0.89
spec0	children attending special schools make fewer tours	1.997	4.9	1.447	3.0	0.88
hinc<25k0	individuals from households with incomes under $25,000 p.a. make fewer tours	0.179	1.3	0.211	1.5	0.16
lsm0	individuals with higher accessibility make more tours	-0.139	-1.9	-0.168	-2.7	0.29
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	5.264	22.9	5.347	22.0	0.25

While the magnitude of some of the 'noneASC' constant has changed noticeably, the low significance of the term in the 2011-base model means that the change in parameter value is not statistically significant, and overall none of the parameters have changed significantly.

Table 17: Home–secondary education frequency model parameters

Parameter	Description	2006 base Model 16 Value	2006 base Model 16 t-ratio	2011 base Model 18 Value	2011 base Model 18 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	-1.702	-28.6	-1.802	-27.4	1.13
age>15_0	persons aged over 15 make fewer tours	0.612	6.3	0.568	5.5	0.31
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	5.962	2.7	8.915	2.7	0.75
lsmpl	individuals with higher accessibility make more multiple tours	-0.138	-0.6	-0.382	-1.2	0.62

None of the parameters in the secondary education frequency model have changed significantly.

Table 18: Home–tertiary education frequency model parameters

Parameter	Description	2006 base Model 22 Value	2006 base Model 22 t-ratio	2011 base Model 27 Value	2011 base Model 27 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	4.491	13.9	4.989	16.3	1.12
FlTmSt_0	full-time students make more tours than other adult categories	-3.635	-18.6	-4.262	-22.6	2.31
FlTmWk_0	full-time w orkers make more tours than other adult categories	0.506	2.0			
Uni_0	university students make few er tours than other education types	-0.382	-2.2	-0.165	-1.0	0.91
Plnc>15.6k	individuals w ith personal incomes over $15,600 p.a. make few er tours	0.816	5.2	0.764	4.9	0.23
age1518_0	individuals aged 15-18 make more tours than older individuals	-0.709	-3.3	-0.231	-1.2	1.67
lsm0	individuals w ith higher accessibility make more tours	-0.062	-1.1	-0.064	-1.2	0.02
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	9.342	3.4	3.454	12.7	2.14
lsmpl	individuals w ith higher accessibility make more multiple tours	-0.898	-2.2			

The full-time worker term in the zero/one-plus model was insignificant in the 2011-base data (t=0.0) and was therefore dropped from the model specification. While the age term 'age1518_0' is not significant at a 95 per cent confidence level, it was retained because it has the correct sign and because no changes are being made to the segmentations in this work[5] and therefore segments exist in the implementation to apply the term.

[5] Changes to the segmentation entail significant amounts of work because as well as changes to the code used to implement the mode-destination models they necessitate changes to the population synthesiser.

Table 19: Home–shopping frequency model parameters

Parameter	Description	2006 base Model 18 Value	2006 base Model 18 r-ratio	2011 base Model 21 Value	2011 base Model 21 r-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	1.906	28.7	1.769	26.3	1.45
FTstu_0	full-time students make fewer tours	0.607	7.9	0.639	7.9	0.28
PTstu_0	part-time students make fewer tours	0.289	2.8	0.317	2.9	0.19
FTwkr_0	full-time workers make substantially fewer tours	1.011	21.4	1.006	20.8	0.07
unempl_0	unemployed persons make more tours	-0.340	-3.9	-0.343	-3.9	0.03
lookhm_0	people looking after the home make more tours	-0.418	-9.8	-0.417	-8.9	0.02
lic_0	licence holders make more tours	-0.363	-7.4	-0.258	-5.0	1.48
0_1cars_0	individuals in households with zero or one tour make more tours	-0.179	-5.3	-0.145	-4.1	0.69
compcr_0	individuals in households with car competition make fewer tours	0.165	4.3	0.147	3.6	0.32
age<10_0	children aged under 10 make fewer tours	1.167	7.3	1.571	7.8	1.58
age<15_0	children aged under 15 make fewer tours	1.552	12.9	1.683	12.6	0.73
age>29_0	individuals aged over 29 make more tours	-0.375	-7.8	-0.481	-9.1	1.49
PerInc>26k	individuals with incomes > $26,000 p.a. make fewer tours	0.155	3.6	0.193	4.4	0.62
male_0	males make fewer tours	0.096	3.0	0.037	1.1	1.29
lsm0	individuals with higher accessibility make more tours	-0.105	-6.4	-0.122	-7.2	0.72
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	2.661	22.3	2.304	36.2	2.64
lsmpl	individuals with higher accessibility make more multiple tours	-0.207	-4.7	-0.138	-3.1	1.10

None of the parameters in the zero/one-plus sub-model have undergone significant changes between the 2006-base and 2011-base versions of the shopping frequency model. In the stop/go sub-model, the reduction in the 'stopASC' parameter is statistically significant; this parameter has adjusted in response to the change in magnitude of the accessibility parameter.

Table 20: Home–other travel frequency model parameters

Parameter	Description	2006 base Model 19 Value	2006 base Model 19 t-ratio	2011 base Model 21 Value	2011 base Model 21 t-ratio	t-ratio for parameter diff.	σ_{2006}	σ_{2011}
Zero/one-plus model:								
noneASC	constant to ensure fraction making at least one tour is replicated	0.693	14.9	0.716	14.4	0.34	0.046	0.050
FlTmSt_0	full-time students make fewer tours	0.329	7.2	0.429	9.2	1.54	0.046	0.046
FlTmWk_0	full-time workers make substantially fewer tours	1.040	29.5	1.113	30.3	1.44	0.035	0.037
PtTmWk_0	part-time workers make fewer tours	0.163	3.5	0.217	4.6	0.80	0.047	0.047
unempl_0	unemployed persons make more tours	-0.588	-7.2	-0.529	-6.4	0.50	0.082	0.083
lookhm_0	people looking after the home make more tours	-0.409	-9.8	-0.375	-8.0	0.53	0.042	0.047
retired_0	retired persons make more tours	-0.255	-5.9	-0.200	-4.5	0.88	0.043	0.045
lic_0	licence holders make more tours	-0.385	-11.1	-0.420	-11.7	0.71	0.035	0.036
free1lic_0	individuals in households with one licence holder and free car use make more tours	-0.164	-4.5	-0.149	-3.8	0.29	0.037	0.039
2pcars_0	individuals in households with two or more cars make more tours	-0.074	-3.1	-0.087	-3.4	0.38	0.024	0.026
hinc>104k0	individuals with incomes of $104,000 p.a. and above make more tours	-0.085	-3.5	-0.109	-4.4	0.68	0.025	0.025
0kids_0	individuals in households with no children make fewer tours	0.436	15.4	0.393	13.2	1.04	0.028	0.030
1kid_0	individuals in households with one child make fewer tours	0.146	4.6	0.143	4.2	0.08	0.032	0.034
lsm0	individuals with higher accessibility make more tours	-0.240	-12.9	-0.214	-12.6	1.06	0.019	0.017
Stop/go model:								
stopASC	constant to observed multiple tour making rate is replicated	1.498	22.8	1.569	22.6	0.75	0.066	0.069
FlTmStPl	full-time students make fewer multiple tours	0.388	5.5	0.426	6.0	0.38	0.070	0.071
FlTmWkPl	full-time workers make fewer multiple tours	0.652	17.0	0.620	15.5	0.56	0.038	0.040
licpl	licence holders make more multiple tours	-0.772	-19.8	-0.761	-18.5	0.19	0.039	0.041
hinc>104kp	individuals with incomes $104,000 p.a. and above make more multiple tours	-0.081	-2.6	-0.109	-3.4	0.61	0.032	0.032
0kidspl	individuals from households without children make fewer multiple tours	0.528	16.2	0.476	13.8	1.09	0.033	0.034
3plkidspl	individuals from households with three or more children make more multiple tours	-0.304	-7.4	-0.280	-6.4	0.39	0.041	0.044
lsmpl	individuals with higher accessibility make more multiple tours	-0.179	-6.7	-0.175	-7.2	0.11	0.027	0.024

None of the parameters in the other travel frequency model have undergone significant changes between the 2006-base and 2011-base versions of the model.

Table 21: Work-based business frequency model parameters

Parameter	Description	2006 base Model 8 Value	2006 base Model 8 t-ratio	2011 base Model 12 Value	2011 base Model 12 t-ratio	t-ratio for parameter diff.
Zero/one-plus model:						
noneASC	constant to ensure fraction making at least one tour replicated	4.023	20.7	4.326	28.2	1.22
compcar_0	individuals from households with company cars make more tours	-0.632	-5.5	-0.570	-6.3	0.42
FTwk_0	full-time workers make more tours	-0.431	-3.4	-0.379	-2.7	0.28
PI>41.6k_0	individuals with incomes ≥ $41,600 p.a. make more tours	-0.373	-2.5	-0.465	-4.4	0.51
HB_CarD_0	individuals who drive to work are more likely to make tours	-0.556	-3.8	-0.677	-5.7	0.64
male_0	males make more tours	-0.472	-4.0	-0.390	-4.3	0.56
CBD_0	tours are more likely to be made from workplaces in the CBD than zones that are not in one of the centres	-0.550	-3.2	-0.638	-4.7	0.40
OthCent_0	tours are more likely to be made from centres other than the CBD than zones not in one of the centres	-0.246	-1.6			
Stop/go model:						
stopASC	constant to observed multiple tour making rate is replicated	1.721	6.5	1.820	8.1	0.29
HB_CarD_pl	individuals who drive to work are more likely to make multiple tours	-0.399	-1.4	-0.466	-1.9	0.18

The 'OthCent_0' parameter was dropped from the 2011 model because it was insignificant (t=1.0). None of the changes to the remaining parameters are statistically significant.

Table 22: Business detour frequency model parameters, PD work

Parameter	Description	2006 base Models 7 & 7 Value	2006 base Models 7 & 7 t-ratio	2011 base Models 9 & 9 Value	2011 base Models 9 & 9 t-ratio	t-ratio for parameter diff.
Outward detours:						
noneASC_OW	constant to ensure observed outward detour rate is replicated	5.052	17.1	5.092	25.7	0.11
compcar_OW	individuals from households with company cars make more outward detours	-0.915	-4.5	-1.139	-7.9	0.90
PI>67.6kOW	individuals with personal incomes of $67,600 and above make more outward detours	-0.448	-2.3	-0.494	-3.3	0.19
HB_CarD_OW	individuals who drive to work PD make more outward detours	-0.655	-2.5	-0.643	-3.3	0.04
male_OW	males make more outward detours	-0.762	-3.4	-0.516	-3.3	0.90
Return detours:						
noneASC_RW	constant to ensure observed return detour rate is replicated	4.982	17.4	4.682	27.7	0.90
compcar_RW	individuals from households with company cars make more return detours	-0.655	-3.4	-0.781	-6.2	0.55
PI>67.6kRW	individuals with personal incomes of $67,600 and above make more return detours	-0.578	-3.1	-0.613	-4.8	0.15
HB_CarD_RW	individuals who drive to work make more return detours	-0.986	-3.8	-0.771	-4.7	0.69
male_RW	males make more return detours	-0.548	-2.7	-0.374	-2.9	0.73

None of the parameter changes are statistically significant.

Table 23: Business detour frequency model parameters, PD business

Parameter	Description	2006 base Models 9 & 5		2011 base Models 11 & 7		t-ratio for parameter diff.
Outward detours:						
noneASC_OB	constant to ensure observed outward detour rate is replicated	1.832	8.7	1.900	11.7	0.26
PI<31.2kOB	individuals with personal incomes under $31,200 p.a. make fewer outward detours	0.473	2.5	0.347	3.2	0.59
HB_CarD_OB	individuals who drive to their business PD make more outward detours	-0.627	-3.4	-0.561	-4.0	0.28
male_OB	males make more outward detours	-0.322	-2.1	-0.310	-2.6	0.06
Return detours:						
noneASC_RB	constant to ensure observed return detour rate is replicated	1.675	8.7	1.872	12.9	0.82
compcar_RB	individuals from households with company cars make more return detours	-0.275	-2.3	-0.437	-4.9	1.09
HB_CarD_RB	individuals who drive to their business PD make more return detours	-0.548	-3.0	-0.408	-3.0	0.62
male_RB	males make more return detours	-0.139	-1.0	-0.223	-2.1	0.47

Again none of the parameter changes are statistically significant.

3.2. Mode-destination models

The following tables present the 2006-base and 2011-base MD model parameters and their associated t-ratios, and the significance of the difference between the 2006-base and 2011-base parameter values. All t-ratios are calculated relative to a value of zero except for the structural parameters, which are calculated relative to a value of one.

The following codes are used to abbreviate the names of the modes represented in the model parameters.

Table 24: Mode codes

Code	Mode
CD	car driver
CD TL	car driver toll
CD NT	car driver no toll
CP	car passenger
TR	train
TR P&R	train, park-and-ride access
TR K&R	train, kiss-and-ride access
TR OT	train, other access
BS	bus
SB	school bus
BK	bike
WK	walk
TX	taxi

In the 2011-base models, for purposes other than commute, separate mode constants have been estimated for the first four waves of data (2005/2006–2008/2009) and for the last four waves of data (2009/2011–2012/2013). In model application, only the mode constants estimated from the last four waves of data are used as they better reflect the 2011 base year.

In the 2006-base models, this approach was not followed and so the mode constants cover all the waves of data included in the estimation sample for the purpose in question, as detailed in Table 2.

Table 25: Commute mode-destination model parameters

Parameter	Description	Modes	2006 base Model 188 Value	2006 base Model 188 t-ratio	2011 base Model 192 Value	2011 base Model 192 t-ratio	t-ratio for parameter diff.	T-ratio of difference calc σ_{2006}	T-ratio of difference calc σ_{2011}	T-ratio of difference calc t-ratio
Cost and level of service terms:										
LogCost	logarithm of cost in cents	CD, CP, TR, BS, TX	-0.338	-4.4	-0.550	-4.5	1.45	0.078	0.123	1.45
Cost13	cost (cents), personal income < $20,800 p.a.	CD, CP, TR, BS, TX	-0.003	-7.1	-0.002	-5.8	0.43	0.000	0.000	0.43
Cost4	cost (cents), personal income $20,000-$31,199 p.a.	CD, CP, TR, BS, TX	-0.002	-7.0	-0.002	-5.8	0.07	0.000	0.000	0.07
Cost5	cost (cents), personal income $31,200-$41,599 p.a.	CD, CP, TR, BS, TX	-0.002	-6.9	-0.002	-5.8	0.03	0.000	0.000	0.03
Cost67	cost (cents), personal income $41,600-$67,599 p.a.	CD, CP, TR, BS, TX	-0.001	-6.8	-0.001	-6.0	0.69	0.000	0.000	0.69
Cost810	cost (cents), personal income $67,600+ p.a.	CD, CP, TR, BS, TX	-0.001	-6.5	-0.001	-6.0	0.36	0.000	0.000	0.36
Cost	cost (cents), personal income missing	CD, CP, TR, BS, TX	-0.004	-3.9	-0.003	-3.2	0.81	0.001	0.001	0.81
CarTime	car in-vehicle time (mins)	CD, CP, TX	-0.061	-8.3	-0.051	-6.2	0.91	0.007	0.008	0.91
RlTime	rail and ferry in-vehicle time (mins)	TR	-0.033	-7.2	-0.034	-5.8	0.14	0.005	0.006	0.14
BusTime	bus in-vehicle time (mins)	TR, BS	-0.041	-7.0	-0.039	-5.8	0.23	0.006	0.007	0.23
FWaitTm	first wait time (mins)	TR, BS	-0.121	-6.2	-0.080	-4.6	1.56	0.019	0.017	1.56
OWaitTm	other wait time (mins)	TR, BS	-0.057	-6.0	-0.063	-5.2	0.39	0.010	0.012	0.39
AcEgTm	access & egress time (mins)	TR, BS	-0.077	-7.6	-0.090	-6.0	0.74	0.010	0.015	0.74
CrAcEgTm	car access & egress time to P&R and K&R (mins)	TR P&R, TR K&R	-0.181	-7.1	-0.218	-5.6	0.79	0.026	0.039	0.79
CarPDist	car passenger distance (km)	CP	-0.046	-5.5	-0.064	-5.2	1.22	0.008	0.012	1.22
BikeDist	bike distance (km)	BK	-0.315	-5.8	-0.263	-5.4	0.71	0.054	0.049	0.71
WalkDist	walk distance (km)	WK	-1.152	-7.8	-1.282	-6.0	0.50	0.149	0.213	0.50
Toll choice terms:										
TollBonus	constant on car driver toll alternative	CD TL	-0.764	-4.6	-0.379	-1.9	1.46	0.166	0.204	1.46
CarTDist	distance term on CD TL alternative (km)	CD TL	0.013	5.4	0.011	3.5	0.62	0.002	0.003	0.62
Train access mode terms:										
OrigGW	Gosford-Wyong origin constant for train P&R	TR P&R	2.228	3.4	1.635	2.2	0.60	0.662	0.732	0.60
OrigSWS	Outer South Western Sydney constant for train P&R	TR P&R	2.054	3.5	1.061	1.6	1.14	0.584	0.645	1.14
TrnOthG75	constant for train tours > 75 km for non-car access	TR BS, TR WK	-1.845	-3.8	-1.652	-3.4	0.28	0.482	0.480	0.28
Car availability terms:										
CarComp	car competition term (licence holders > cars)	CD	-4.412	-7.2	-4.395	-5.8	0.02	0.611	0.754	0.02
CmpCrDr	company car term	CD	1.813	5.2	1.646	4.3	0.32	0.346	0.383	0.32
PassOpts	passenger opportunity term	CP	4.541	5.3	4.093	4.5	0.36	0.852	0.906	0.36
PRCarComp	car competition term (licence holders > cars)	TR P&R	-1.558	-3.0	-2.217	-3.5	0.80	0.523	0.634	0.80
PRFr2pCar	free car use, 2-plus cars term	TR P&R	1.230	2.8	0.454	1.0	1.23	0.447	0.445	1.23
PRLicence	licence holder term	TR P&R	2.032	3.9	3.032	4.1	1.11	0.523	0.732	1.11
KRPassOpts	passenger opportunity term	TR K&R	3.972	2.7	1.929	2.2	1.21	1.449	0.872	1.21
Other socio-economic terms:										
MaleCrDr	male term on car driver	CD	0.659	3.1	0.739	3.2	0.25	0.213	0.233	0.25
MaleBike	male term on bike	BK	6.245	4.0	5.451	4.1	0.38	1.567	1.343	0.38
FTWrkDist	full-time worker distance term (km)	all	0.016	5.5	0.014	4.4	0.51	0.003	0.003	0.51
Mode constants:										
CarP	car passenger (relative to car driver no toll)	CP	-12.626	-7.2	-12.480	-5.8	0.05	1.751	2.146	0.05
Train	train (relative to car driver no toll)	TR	-2.701	-4.9	-1.931	-3.4	0.97	0.555	0.572	0.97
TrainPR	train P&R (relative to train bus access)	TR P&R	-5.496	-6.3	-6.510	-5.4	0.68	0.874	1.199	0.68
TrainKR	train K&R (relative to train bus access)	TR K&R	-8.337	-4.9	-6.847	-5.0	0.68	1.710	1.368	0.68
TrainWk	train walk (relative to train bus access)	TR WK	1.397	4.1	1.860	4.4	0.85	0.341	0.427	0.85
Bus	bus (relative to car driver no toll)	BS	-2.211	-4.9	-2.513	-4.5	0.42	0.455	0.555	0.42
Bike	bike (relative to car driver no toll)	BK	-18.624	-6.6	-18.842	-5.7	0.05	2.818	3.301	0.05
Walk	walk (relative to car driver no toll)	WK	-2.082	-3.0	-2.699	-3.1	0.55	0.696	0.868	0.55
Taxi	taxi (relative to car driver no toll)	TX	-11.841	-6.6	-13.390	-5.2	0.49	1.801	2.583	0.49
Destination constants:										
CBDRail	CBD, rail	TR	1.188	5.5	1.122	4.5	0.20	0.216	0.248	0.20
CBDBus	CBD, bus	BS	1.148	4.5	2.010	5.0	1.82	0.256	0.399	1.82
Pmatta	Parramatta centre	all	1.055	4.8	1.122	4.5	0.20	0.220	0.248	0.20
Cwood	Chatswood centre	all	1.351	4.5	1.902	4.8	1.11	0.298	0.399	1.11
SLC	St Leonards Crows Nest centre	all	1.246	4.9	1.600	4.8	0.84	0.252	0.335	0.84
NSyd	North Sydney centre	all	1.816	6.3	2.753	5.8	1.69	0.289	0.472	1.69
ISyd	Inner Sydney area	all	0.824	6.0	0.952	5.3	0.57	0.138	0.179	0.57
ESub	Eastern Sydney area	all	1.002	5.1	1.037	4.1	0.11	0.198	0.251	0.11
NBeach	Northern Beaches area	all	0.687	3.3	0.751	3.1	0.20	0.205	0.245	0.20
Walk distance from workplace and workplace location terms:										
LWdistCBD	walk log-distance of CBD from workplace (km)	WK	-0.790	-5.1	-1.122	-4.9	1.21	0.156	0.228	1.21
WWng	walk, workplace in Wollongong	WK	-3.834	-3.3	-2.667	-2.4	0.73	1.161	1.108	0.73
WNcast	walk, workplace in Newcastle	WK	-1.338	-1.9	-3.872	-3.5	1.93	0.689	1.117	1.93
Intrazonal constants:										
CrDNoTllZ	car driver no toll	CD NT	-0.692	-2.1	-0.920	-2.3	0.44	0.328	0.392	0.44
CarPIZ	car passenger	CP	0.046	0.1	-0.483	-0.7	0.58	0.611	0.677	0.58
BikeIZ	bike	BK	0.477	0.3	-1.330	-0.6	0.69	1.487	2.174	0.69
WalkIZ	walk	WK	1.337	3.8	1.780	3.8	0.76	0.349	0.468	0.76
Attraction term:										
TotEmp	total employment in destination zone	all	1.000	n/a	1.000	n/a	n/a	n/a	n/a	n/a
Structural parameters:										
Theta_MD	relative sensitivity of main modes and destinations	n/a	0.678	8.9	0.712	7.7	0.64	0.036	0.037	0.64
Theta_PT	relative sensitivity of destinations and PT modes	n/a	1.000	n/a	1.000	n/a	n/a	n/a	n/a	n/a
Theta_AcMd	relative sensitivity of PT modes and train access modes	n/a	1.000	n/a	1.000	n/a	n/a	n/a	n/a	n/a
sta_ch	relative sensitivity of train access modes and stations	n/a	1.000	n/a	1.000	n/a	n/a	n/a	n/a	n/a
Theta_toll	relative sensitivity of stations and toll choice	n/a	0.526	7.5	0.490	6.6	0.36	0.063	0.077	0.36

None of the changes to the commute MD model parameters are statistically significant.

Table 26: Home–business mode-destination model parameters

Parameter	Description	Modes	2006 base Model 47 Value	2006 base Model 47 T-ratio	2011 base Model 51 Value	2011 base Model 51 T-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
GCost14	gamma cost term, personal income < $31,200 p.a.	CD, TR, BS, TX	-0.0042	-6.4	-0.0053	-6.1	1.06
GCost56	gamma cost term, personal income < $31,200-$51,999 p.a.	CD, TR, BS, TX	-0.0030	-6.2	-0.0039	-5.9	1.11
GCost710	gamma cost term, personal income $52,000+ p.a.	CD, TR, BS, TX	-0.0023	-6.0	-0.0028	-5.6	0.79
GCostX	gamma cost term, personal income missing	CD, TR, BS, TX	-0.0052	-4.9	-0.0064	-5.1	0.70
CarTime	car in-vehicle time (mins)	CD, CP, TX	-0.038	-7.7	-0.034	-7.1	0.55
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.014	-3.5	-0.017	-3.9	0.59
BusTime	bus in-vehicle time (mins)	TR, BS	-0.025	-4.1	-0.035	-4.6	1.00
WaitTm	first and other w ait time (mins)	TR, BS	-0.061	-4.7	-0.081	-4.8	0.92
AcEgTm	access & egress time (mins)	TR, BS	-0.057	-4.1	-0.073	-4.2	0.72
CarAccTime	car access & egress time to K&R (mins)	TR P&R, TR K&R	-0.108	-4.4	-0.142	-4.4	0.85
CarPDist	car passenger distance (km)	CP	-0.014	-3.1	-0.012	-2.6	0.24
BikeDist	bike distance (km)	BK	-0.341	-4.2	-0.315	-3.8	0.23
WalkDist	w alk distance (km)	WK	-0.611	-5.7	-1.280	-5.4	2.58
Toll choice terms:							
TollBonus	constant on car driver toll, 2009-2012 w aves	CD TL	-0.854	-5.8	-0.422	-2.1	1.71
TBonus0508	constant on car driver toll, 2005-2008 w aves	CD TL			-0.263	-1.4	
CarTDist	distance term on CD TL alternative (km)	CD TL	0.009	6.1	0.011	5.7	0.64
Train access mode terms:							
OrigGW	Gosford-Wyong origin constant for train P&R	TR P&R	2.278	2.2	1.720	1.6	0.37
TrnOthG100	constant for train tours > 100 km for non-car access	TR OT	-1.723	-2.0	-0.516	-0.7	1.06
Car availability terms:							
CarComp	car competition term (licence holders > cars)	CD	-3.404	-4.4	-3.996	-4.4	0.50
CmpCrDr	company car term	CD	2.442	4.0	2.714	3.8	0.29
PassOpts	passenger opportunity term	CP	2.338	2.9	2.516	2.5	0.14
PRCarComp	car competition term (licence holders > cars)	TR P&R	-0.927	-1.5	-1.453	-1.9	0.54
Other socio-economic terms:							
CarPu25	under-25 term on car passenger	CP	2.683	3.5	2.759	3.0	0.06
TrnManProf	managerial & professional occupation types term on train	TR	2.372	4.4	2.265	4.0	0.14
Mode constants:							
CarP	car passenger, 2009-2012 w aves	CP	-16.004	-5.6	-19.550	-5.5	0.78
Train	train, 2009-2012 w aves	TR	-7.010	-4.4	-5.497	-3.5	0.67
TrainPR	train P&R, 2009-2012 w aves	TR P&R	-4.066	-5.2	-4.775	-4.9	0.57
TrainKR	train K&R, 2009-2012 w aves	TR K&R	-5.768	-5.9	-6.684	-5.3	0.57
Bus	bus, 2009-2012 w aves	BS	-6.283	-4.2	-5.532	-3.6	0.35
Bike	bike, 2009-2012 w aves	BK	-17.095	-5.1	-22.269	-4.9	0.92
Walk	w alk, 2009-2012 w aves	WK	-11.265	-4.8	-9.890	-4.3	0.42
Taxi	taxi, 2009-2012 w aves	TX	-15.022	-4.7	-16.855	-4.4	0.37
CarP_0508	car passenger, 2005-2008 w aves	CP			-19.157	-5.5	n/a
Train_0508	train, 2005-2008 w aves	TR			-5.246	-3.5	n/a
TrPR_0508	train P&R, 2005-2008 w aves	TR P&R			-4.587	-4.8	n/a
TrKR_0508	train K&R, 2005-2008 w aves	TR K&R			-6.389	-5.3	n/a
Bus_0508	bus, 2005-2008 w aves	BS			-4.927	-3.4	n/a
Bike_0508	bike, 2005-2008 w aves	BK			-19.174	-5.1	n/a
Walk_0508	w alk, 2005-2008 w aves	WK			-10.653	-4.3	n/a
Taxi_0508	taxi, 2005-2008 w aves	TX			-15.846	-4.5	n/a
Destination constants:							
CBDRail	CBD destination constant on rail	RL	0.983	3.1	0.740	2.2	0.53
Intrazonal constants:							
CrDNoTllIZ	car driver no toll	CD NT	0.942	3.9	0.732	2.8	0.59
CarPIZ	car passenger	CP	2.945	4.1	3.081	3.3	0.11
BikeIZ	bike	BK	2.527	2.1	4.478	3.2	1.05
WalkIZ	w alk	WK	2.206	3.6	1.005	1.6	1.36
Attraction term:							
TotEmp	total employment in destination zone	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_P	relative sensitivity of main modes and PT modes	n/a	0.516	7.3	0.508	7.8	0.09
Theta_P_A	relative sensitivity of PT modes and train access modes	n/a	1.000	n/a	1.000	n/a	n/a
Theta_A_D	relative sensitivity of train access modes and destinations	n/a	1.000	n/a	1.000	n/a	n/a
Theta_D_S	relative sensitivity of destinations and stations	n/a	1.000	n/a	1.000	n/a	n/a
Theta_S_T	relative sensitivity of stations and toll choice	n/a	0.613	4.4	0.556	5.2	0.47

Only one parameter – the walk distance term – has changed significantly between the 2006-base and 2011-base models.

Table 27: Home–primary education mode-destination model parameters

Parameter	Description	Modes	2006 base Model 16 Value	2006 base Model 16 t-ratio	2011 base Model 19 Value	2011 base Model 19 t-ratio	t-ratio for parameter diff.
Level of service terms:							
CarTime	car in-vehicle time (mins)	CP, TX	-0.148	-55.3	-0.133	-54.5	4.14
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.061	-4.2	-0.065	-4.1	0.17
BusTime	bus in-vehicle time (mins)	TR, BS	-0.038	-8.6	-0.057	-7.9	2.29
ScBusTime	school bus in-vehicle time (mins)	SB	-0.076	-3.9	-0.066	-4.0	0.39
WaitTm	first and other w ait time (mins)	TR, BS	-0.016	-2.4	-0.032	-3.1	1.35
AcEgTm	access & egress time (mins)	TR, BS	-0.010	-4.0	-0.013	-3.8	0.68
SBusDist	school bus distance (km)	SB	-0.051	-1.8	-0.050	-2.0	0.02
BikeDist	bike distance (km)	BK	-0.464	-5.1	-0.659	-4.8	1.19
WalkDist	w alk distance (km)	WK	-0.818	-21.3	-0.859	-20.0	0.70
Car availability terms:							
PassOpts	passenger opportunity term	CP	5.515	6.3	8.033	6.9	1.74
CarP_CCar	company car(s) in household term	CP	0.457	2.7	0.484	3.1	0.11
Other socio-economic terms:							
CarP<8	under-8 term on car passenger	CP	1.184	4.9	0.789	4.0	1.27
Bike_Male	male term	BK	2.798	2.8	1.003	1.3	1.43
Mode constants:							
Train	train, 2009-2012 w aves	TR	-2.763	-2.6	2.353	2.0	3.18
Bus	bus, 2009-2012 w aves	BS	-1.715	-2.7	2.681	3.6	4.49
ScBus	school bus, 2009-2012 w aves	SB	-0.372	-0.7	3.071	4.1	3.68
Bike	bike, 2009-2012 w aves	BK	-5.148	-4.2	1.041	1.0	3.86
Walk	w alk, 2009-2012 w aves	WK	4.784	6.8	7.701	8.0	2.44
Taxi	taxi, 2009-2012 w aves	TX	-6.591	-5.2	-2.005	-1.8	2.73
Train_0508	train, 2005-2008 w aves				1.483	0.9	
Bus_0508	bus, 2005-2008 w aves				3.548	4.7	
ScBus_0508	school bus, 2005-2008 w aves				2.707	3.8	
Bike_0508	bike, 2005-2008 w aves				0.634	0.6	
Walk_0508	w alk, 2005-2008 w aves				7.638	7.9	
Taxi_0508	taxi, 2005-2008 w aves				0.000	n/a	
Destination constants:							
SCB_NC	New castle destination constant for school bus	SB	1.194	1.8	-0.603	-0.6	1.50
Intrazonal constants:							
CarPIZ	car passenger	CP	0.468	6.2	0.484	6.1	0.15
BikeIZ	bike	BK	1.621	2.6	1.194	1.8	0.47
WalkIZ	w alk	WK	0.822	5.8	0.800	5.3	0.11
Attraction term:							
TotEnrol	primary enrolments	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_P	relative sensitivity of main modes and PT modes	n/a	0.491	2.7	0.694	1.1	0.59
Theta_P_D	relative sensitivity of PT modes and destinations	n/a	0.880	0.4	0.762	0.8	0.27

Statistically significant changes to the car time and bus in-vehicle time parameters are observed in the primary education MD model. For bus, the change – an increase in magnitude – is welcome as in the 2006-base version of model the bus in-vehicle time valuation was low relative to car time and rail in-vehicle time. The reduction in the magnitude of the car time parameter is also welcome, in that it reduces the difference between the car time and PT in-vehicle time sensitivities.

Table 28: Home–secondary education mode-destination model parameters

Parameter	Description	Modes	2006 base Model 35 Value	2006 base Model 35 T-ratio	2011 base Model 39 Value	2011 base Model 39 T-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
LogCost	log of costs in cents	CD, TR, BS, TX	-0.289	-3.5	-0.563	-6.5	2.31
CarTime	car in-vehicle time (mins)	CD, CP, TX	-0.047	-7.5	-0.047	-9.4	0.10
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.031	-11.5	-0.031	-12.3	0.04
BusTime	bus in-vehicle time (mins)	TR, BS	-0.032	-14.1	-0.034	-14.9	0.53
SBusTime	school bus in-vehicle time (mins)	SB	-0.053	-5.6	-0.060	-7.5	0.64
WaitTm	first and other w ait time (mins)	TR, BS	-0.011	-3.5	-0.017	-4.8	1.35
AcEgTm	access & egress time (mins)	TR, BS	-0.007	-7.3	-0.009	-5.4	1.23
CarAccTime	car access & egress time to P&R and K&R (mins)	TR K&R	-0.100	-8.4	-0.089	-8.0	0.71
CrP_dist	car passenger distance (km)	CP	-0.091	-8.7	-0.081	-8.7	0.71
SBus_dist	school bus distance (km)	SB	-0.039	-3.1	-0.018	-1.6	1.21
BikeDist	bike distance (km)	BK	-0.478	-6.2	-0.455	-5.7	0.21
WalkDist	w alk distance (km)	WK	-0.766	-17.5	-0.793	-16.3	0.41
Train access mode distance fit terms:							
OCWS	Central Western Sydney origins	TR OT	1.529	4.0	0.102	0.3	2.58
OIWS	Inner Western Sydney origins	TR OT	1.414	3.2	0.862	1.9	0.88
OCantB	Canterbury Bankstow n origins	TR OT	1.274	3.3	0.220	0.6	1.97
TrnOthGt30	constant for train tours > 100 km for non-car acces	TR OT	-1.537	-5.8	-1.136	-4.7	1.12
Car availability terms:							
PassOpts	passenger opportunity term	CP	3.246	5.3	3.573	5.1	0.35
Mode constants:							
CrD	car driver, 2009-2012 w aves	CP	5.057	6.1	7.225	8.9	1.87
Train	train, 2009-2012 w aves	TR	2.747	3.7	5.787	8.2	2.98
TrainKR	train K&R, 2009-2012 w aves	TR K&R	-0.166	-0.5	-1.048	-3.4	1.92
Bus	bus, 2009-2012 w aves	BS	3.571	5.0	5.846	8.5	2.29
ScBs	school bus, 2009-2012 w aves	SB	1.037	1.7	1.615	2.4	0.63
Bike	bike, 2009-2012 w aves	BK	0.834	1.1	-0.088	-0.1	0.77
Walk	w alk, 2009-2012 w aves	WK	4.885	7.9	4.932	7.1	0.05
Taxi	taxi, 2009-2012 w aves	TX	-2.320	-2.2	0.989	1.1	2.38
CrD_0508	car driver, 2005-20 w aves				6.494	8.1	
Train_0508	train, 2005-2008 w aves				5.397	7.7	
TrKR_0508	train K&R, 2005-2008 w aves				-1.770	-4.8	
Bus_0508	bus, 2005-2008 w aves				5.626	8.3	
ScBs_0508	school bus, 2005-2008 w aves				1.519	2.2	
Bike_0508	bike, 2005-2008 w aves				1.701	2.1	
Walk_0508	w alk, 2005-2008 w aves				5.244	7.5	
Taxi_0508	taxi, 2005-2008 w aves				0.000	n/a	
Destination constants:							
ScB_OutRng	Sydney outer ring destinations	SB	0.597	3.4	0.179	1.1	1.72
ScB_New	New castle destinations	SB	1.528	5.4	1.372	5.2	0.41
ScB_Wng	Wollongong destinations	SB	2.027	7.0	1.051	3.7	2.41
Intrazonal constants:							
CarPIZ	car passenger	CP	-0.468	-2.3	-0.266	-1.3	0.69
BikeIZ	bike	BK	-0.774	-1.1	-1.708	-1.4	0.68
WalkIZ	w alk	WK	-0.311	-1.6	-0.184	-0.9	0.46
Attraction term:							
TotEnrol	secondary enrolments in destination zone	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_P	relative sensitivity of main modes and PT modes	n/a	1.000	n/a	1.000	n/a	n/a
Theta_P_A	relative sensitivity of PT modes and train access m	n/a	1.000	n/a	1.000	n/a	n/a
Theta_A_D	relative sensitivity of train access modes and destir	n/a	0.745	4.8	0.827	3.0	1.04
Theta_D_S	relative sensitivity of destinations and stations	n/a	1.000	n/a	1.000	n/a	n/a

There has been a significant increase in the magnitude of the log cost parameter. The implication of this change for the implied values of time in the model is discussed in Section 4.1. There have also been significant reductions in the magnitude of the terms for the use of non-car access to train in the Central Western Sydney and Canterbury Bankstown regions, and significant changes to some of the mode and destination constants.

Table 29: Home–tertiary education mode-destination model parameters

Parameter	Description	Modes	2006 base Model 45 Value	2006 base Model 45 t-ratio	2011 base Model 49 Value	2011 base Model 49 t-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
LogCost	log of costs in cents	CD, CP, TR, BS, TX	-0.347	-5.9	-0.392	-4.2	0.41
CarTime	car in-vehicle time and car access time (mins)	CD, CP, TR P&R, TR K&R, TX	-0.032	-16.5	-0.029	-12.4	1.00
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.015	-7.2	-0.011	-6.6	1.34
BusTime	bus in-vehicle time (mins)	TR, BS	-0.019	-8.3	-0.018	-8.5	0.47
WaitTm	first and other wait time (mins)	TR, BS	-0.027	-5.8	-0.029	-6.3	0.35
AcEgTm	access & egress time (mins)	TR, BS	-0.005	-1.8	-0.002	-1.2	0.75
CarPDist	car passenger distance (km)	CP	-0.013	-2.1	-0.011	-1.5	0.20
BikeDist	bike distance (km)	BK	-0.208	-5.0	-0.197	-4.0	0.17
WalkDist	walk distance (km)	WK	-0.583	-11.6	-0.678	-11.4	1.22
Train access mode distance fit terms:							
OrigGW	Gosford-Wyong origins	TR K&R	1.475	2.6	0.122	0.2	1.55
TrnOthG50	constant for train tours > 100 km for non-car access	TR OT	-0.820	-3.4	-0.879	-4.0	0.18
Car availability terms:							
CarComp	car competition term	CD	-1.042	-5.7	-1.325	-6.6	1.04
CmpCrDr	company car(s) in household term	CD	0.436	1.7	-0.085	-0.3	1.40
PassOpts	passenger opportunity term	CP	2.104	4.4	2.055	3.4	0.06
Mode constants:							
CarP	car passenger, 2009-2012 waves	CP	-4.779	-9.7	-5.269	-8.0	0.60
Train	train, 2009-2012 waves	TR	-0.986	-3.9	-0.949	-3.4	0.10
TrainPR	train P&R, 2009-2012 waves	TR P&R	-3.149	-12.5	-3.345	-10.8	0.49
TrainKR	train K&R, 2009-2012 waves	TR K&R	-2.015	-9.5	-2.170	-8.8	0.48
Bus	bus, 2009-2012 waves	BS	-1.083	-4.7	-1.040	-4.0	0.12
Bike	bike, 2009-2012 waves	BK	-4.583	-8.6	-5.583	-6.7	1.01
Walk	walk, 2009-2012 waves	WK	-0.886	-2.2	-0.715	-1.2	0.24
Taxi	taxi, 2009-2012 waves	TX	-6.783	-6.7	-16.593	-0.1	0.05
CarP_0508	car passenger, 2005-2008 waves	CP			-5.108	-7.9	
Train_0508	train, 2005-2008 waves	TR			-1.256	-4.3	
TrPR_0508	train P&R, 2005-2008 waves	TR P&R			-3.316	-9.6	
TrKR_0508	train K&R, 2005-2008 waves	TR K&R			-2.097	-7.8	
Bus_0508	bus, 2005-2008 waves	BS			-1.355	-4.9	
Bike_0508	bike, 2005-2008 waves	BK			-5.391	-6.7	
Walk_0508	walk, 2005-2008 waves	WK			-1.052	-1.7	
Taxi_0508	taxi, 2005-2008 waves	TX			-6.109	-6.0	
Destination constants:							
PT_UNSW	PT to University of New South Wales destination zone	TR, BS	0.940	6.0	0.591	3.8	1.58
Intrazonal constants:							
CrDNoTllZ	car driver	CD	-2.451	-2.4	-1.601	-2.2	0.67
CarPIZ	car passenger	CP	-0.883	-0.9	-20.358	0.0	0.00
WalkIZ	walk	WK	0.555	1.9	-1.227	-2.8	3.39
Attraction term:							
TotEmp	tertiary employment in destination zone	all	1.000	n/a	1.000	n/a	n/a

The only parameter that has changed significantly is the walk intrazonal constant.

Table 30: Home–shopping mode-destination model parameters

Parameter	Description	Modes	2006 base Model 59 Value	2006 base Model 59 t-ratio	2011 base Model 70 Value	2011 base Model 70 t-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
GCost	gamma cost term	CD, CP, TR, BS, TX	-0.0164	-29.7	-0.0229	-35.4	7.64
CarTime	car in-vehicle time and car access time (mins)	CD, CP, TR P&R, TR, K&R, TX	-0.083	-42.4	-0.050	-23.8	11.79
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.025	-7.2	-0.019	-7.1	1.30
BusTime	bus in-vehicle time (mins)	TR, BS	-0.019	-7.6	-0.025	-9.5	1.58
FWaitTm	first wait time (mins)	TR, BS	-0.044	-5.2			
OWaitTm	other wait time (mins)	TR, BS	-0.019	-1.5			
WaitTm	total wait time (mins)	TR, BS			-0.027	-6.7	
AcEgTm	access & egress time (mins)	TR, BS	-0.021	-5.8	-0.014	-4.2	1.41
Boardings	PT boardings	TR, BS	-0.443	-5.4			
CarPDist	car passenger distance (km)	CP	0.023	8.4	0.018	7.5	1.36
BikeDist	bike distance (km)	BK	-0.452	-8.0	-0.492	-7.7	0.46
WalkDist	walk distance (km)	WK	-1.072	-41.5	-1.043	-38.7	0.78
Toll choice terms:							
TollBonus	constant on car driver toll, 2009-2012 waves	CD TL	-2.644	-8.3	-1.283	-2.2	2.06
TBus_0508	constant on car driver toll, 2005-2008 waves	CD TL			-0.789	-1.6	
CarTDist	distance term on CD TL alternative (km)	CD TL	0.052	14.5	0.012	1.2	3.59
Train access mode terms:							
CarADist	car access distance (km)	TR P&R, TR K&R	0.030	5.7	0.014	1.7	1.61
Car availability terms:							
CarComp	car competition term (licence holders > cars)	CD	-1.104	-9.6	-1.092	-9.6	0.08
CmpCrDr	company car term	CD	0.660	4.9	0.518	3.8	0.74
PassOpts	passenger opportunity term	CP	2.952	13.5	2.790	12.7	0.52
Other socio-economic terms:							
CarD<20	under-20 term on car driver	CD	-0.742	-2.2	-0.292	-0.8	0.91
CarP_Male	male term on car passenger	CP	-1.468	-10.3	-1.419	-10.3	0.25
CarP<10	under-10 term on car passenger	CP	2.938	6.6	3.154	6.1	0.32
Ret_CarP	retired term on car passenger	CP	0.791	6.2	0.679	5.6	0.64
Bus_Male	male term on bus	BS	-1.110	-5.3	-1.114	-5.2	0.01
Bus_Pens	pensioner term on bus	BS	1.045	5.2	0.583	2.8	1.61
Bike_Male	male term on bike	BK	1.371	2.8	2.107	3.6	0.96
Bike_10_19	aged 10-19 term on bike	BK	1.473	2.7	1.243	2.1	0.29
Mode constants:							
CarP	car passenger, 2009-2013 waves	CP	-6.525	-19.4	-6.414	-19.0	0.23
Train	train, 2009-2013 waves	TR	-3.969	-8.4	-2.408	-5.4	2.41
TrainPR	train P&R, 2009-2013 waves	TR P&R	-4.802	-8.3	-6.399	-5.3	1.19
Bus	bus, 2009-2013 waves	BS	-3.255	-8.9	-2.193	-5.7	2.00
Bike	bike, 2009-2013 waves	BK	-11.797	-16.4	-14.461	-16.5	2.35
Walk	walk, 2009-2013 waves	WK	-3.149	-13.5	-5.742	-21.2	7.25
Taxi	taxi, 2009-2013 waves	TX	-7.665	-10.7	-5.738	-6.1	1.63
CarP_0508	car passenger, 2005-2008 waves	CP			-6.542	-19.2	n/a
Train_0508	train, 2005-2008 waves	TR			-3.256	-6.6	n/a
TrPR_0508	train P&R, 2005-2008 waves	TR P&R			-5.214	-5.0	n/a
Bus_0508	bus, 2005-2008 waves	BS			-2.184	-6.0	n/a
Bike_0508	bike, 2005-2008 waves	BK			-14.020	-17.0	n/a
Walk_0508	walk, 2005-2008 waves	WK			-5.822	-21.5	n/a
Taxi_0508	taxi, 2005-2008 waves	TX			-4.911	-6.9	n/a
TrainKR	train K&R, 2005-2013 waves	TR K&R	-5.235	-8.4	-6.616	-6.4	1.14
Destination constants:							
Dest_CBD	CBD destination constant	all	-1.028	-5.7	-0.909	-4.6	0.44
CBDRail	CBD rail destination constant	RL	1.532	5.1	1.287	4.0	0.55
CBDBus	CBD bus destination constant	BS	0.827	3.3	0.910	3.1	0.22
Car_MidRng	Sydney middle ring destination constant	CD, CP	0.211	3.4	0.368	5.5	1.72
Car_OutRng	Sydney outer ring destination constant	CD, CP	0.428	6.1	0.615	8.5	1.86
Dest_PopDn	destination population density (persons/ha)	all	0.002	6.9	0.002	6.7	0.45
Regional	regional shopping centres (floor space > 35,000m²)	all	0.442	12.1	0.628	16.3	3.50
HiQualShps	other shopping centres (floor space < 35,000m²)	all	0.249	8.0	0.475	15.1	5.11
Intrazonal constants:							
CrDNoTllZ	car driver no toll	CD TL	-2.309	-20.2	-4.881	-28.6	12.54
CarPtZ	car passenger	CP	-2.372	-15.0	-4.800	-22.8	9.22
BikeIZ	bike	BK	0.801	1.9	0.425	0.8	0.56
WalkIZ	walk	WK	0.313	4.1	0.471	5.6	1.39
Attraction term:							
TotEmp	retail employment in destination zone	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_P	relative sensitivity of main modes and PT modes	n/a	1.000	n/a	1.000	n/a	n/a
Theta_P_A	relative sensitivity of PT modes and train access mo	n/a	1.000	n/a	1.000	n/a	n/a
Theta_A_D	relative sensitivity of train access modes and destir	n/a	0.612	13.1	0.665	10.0	1.18
Theta_D_S	relative sensitivity of destinations and stations	n/a	1.000	n/a	1.000	n/a	n/a
Theta_S_T	relative sensitivity of stations and toll choice	n/a	1.000	n/a	1.000	n/a	n/a

For shopping, significant changes are observed for the cost and car time terms; the implications of these changes for the implied VOTs are discussed in Section 4.1. Significant changes are also observed to the

toll choice terms – as discussed in Section 2.5, these have reduced in magnitude and significance – and also for some of the mode, destination and intrazonal constants.

Table 31: Home–other travel mode-destination model parameters

Parameter	Description	Modes	2006 base Model 50 Value	2006 base Model 50 t-ratio	2011 base Model 59 Value	2011 base Model 59 t-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
GCost	gamma cost term	CD, CP, TR, BS, TX	-0.0155	-65.2	-0.0149	-66.0	1.70
CarTime	car in-vehicle time and car access time (mins)	, TR, P&R, TR K&R, TX	-0.053	-66.4	-0.040	-48.6	11.65
RlFrTime	rail and ferry in-vehicle time (mins)	TR	-0.013	-11.0	-0.017	-13.4	1.94
BusTime	bus in-vehicle time (mins)	TR, BS	-0.007	-6.5	-0.022	-15.1	8.15
WaitTm	first and other w ait time (mins)	TR, BS	-0.013	-4.2	-0.035	-7.8	4.14
AcEgTm	access & egress time (mins)	TR, BS	-0.003	-4.0	-0.014	-6.0	4.62
Boardings	PT boardings	TR, BS	-0.210	-7.0	-0.124	-3.4	1.81
CarPDist	car passenger distance (km)	CP	0.012	13.9	0.008	8.7	3.53
BikeDist	bike distance (km)	BK	-0.228	-17.9	-0.230	-17.0	0.11
WalkDist	w alk distance (km)	WK	-0.771	-67.8	-0.745	-65.7	1.59
TaxiDist	taxi distance (km)	TX	0.014	1.3	0.039	4.1	1.67
Toll choice terms:							
TollBonus	constant on car driver toll, 2009-2012 w aves	CD TL	-1.874	-14.5	-1.350	-8.0	2.46
TBus_0508	constant on car driver toll, 2005-2008 w aves				-1.563	-8.8	
CarTDist	distance term on CD TL alternative (km)	CD TL	0.028	18.0	0.021	10.4	2.86
Train access mode terms:							
OrigGW	Gosford-Wyong origins	TR P&R, TR K&R	0.794	1.9	0.791	2.0	0.00
OrigCNS	Central Northern Sydney origins	TR P&R, TR K&R	1.403	4.8	1.097	4.0	0.76
CarADist	car access distance (km)	TR P&R, TR K&R	0.013	6.9	0.012	5.6	0.35
Car availability terms:							
CarComp	car competition term (licence holders > cars)	CD	-1.343	-10.5	-1.005	-10.4	2.12
CmpCrDr	company car term	CD	0.455	3.9	0.370	3.9	0.56
PassOpts	passenger opportunity term	CP	4.836	14.8	3.488	15.7	3.42
Other socio-economic terms:							
CarP_Male	male term on car passenger	CP	-1.332	-10.4	-0.860	-9.3	2.99
CarP<10	under-10 term on car passenger	CP	3.927	15.2	2.752	16.4	3.82
CarPFTPTW	full- and part-time w orker term on car passenger	CP	-1.266	-9.4	-1.066	-10.3	1.18
Bike_Male	male term on bike	BK	3.439	7.9	2.929	7.7	0.89
Bike_10_19	aged 10-19 term on bike	BK	2.883	8.2	1.578	5.4	2.86
Walk_Male	male term on w alk	WK	-0.752	-6.7	-0.557	-6.4	1.37
Sub-purpose mode terms:							
CarD_DrPu	drop-off pick-up term on car driver	CD	3.708	14.3	2.903	15.7	2.53
CarP_Enter	entertainment term on car passenger	CP	2.046	12.1	1.452	12.3	2.88
PT_Enter	entertainment term on PT	TR, BS	2.697	11.1	1.924	10.6	2.55
Walk_Recr	recreation term on w alk	WK	5.352	16.4	3.995	18.8	3.48
Mode constants:							
CarP	car passenger, 2009-2013 w aves	CP	-8.534	-17.4	-6.555	-19.7	3.33
Train	train, 2009-2013 w aves	TR	-8.353	-15.0	-4.046	-10.0	6.25
TrainPR	train P&R, 2009-2013 w aves	TR P&R	-3.744	-14.6	-5.004	-16.6	3.18
TrainKR	train K&R, 2009-2013 w aves	TR K&R	-3.403	-14.7	-4.416	-17.6	2.97
Bus	bus, 2009-2013 w aves	BS	-8.619	-15.8	-4.451	-11.5	6.22
Bike	bike, 2009-2013 w aves	BK	-18.536	-19.1	-16.415	-22.7	1.76
Walk	w alk, 2009-2013 w aves	WK	-6.162	-19.3	-6.235	-27.4	0.19
Taxi	taxi, 2009-2013 w aves	TX	-11.446	-12.8	-8.154	-11.9	2.92
CarP_0508	car passenger, 2005-2008 w aves	CP			-6.502	-19.8	
Train_0508	train, 2005-2008 w aves	TR			-4.373	-10.7	
TrPR_0508	train P&R, 2005-2008 w aves	TR P&R			-4.238	-16.1	
TrKR_0508	train K&R, 2005-2008 w aves	TR K&R			-4.044	-16.4	
Bus_0508	bus, 2005-2008 w aves	BS			-4.405	-11.3	
Bike_0508	bike, 2005-2008 w aves	BK			-15.800	-23.1	
Walk_0508	w alk, 2005-2008 w aves	WK			-6.137	-27.9	
Taxi_0508	taxi, 2005-2008 w aves	TX			-7.922	-12.1	
Destination constants:							
Car_OutRng	Sydney outer ring destination constant	CD, CP	0.159	5.0	0.194	6.1	0.78
Intrazonal constants:							
CrDNoTllZ	car driver no toll	CD TL	-3.093	-48.5	-4.101	-51.9	9.93
CarPtZ	car passenger	CP	-2.766	-41.6	-3.893	-47.5	10.67
BikeIZ	bike	BK	1.831	11.5	1.372	7.3	1.85
WalkIZ	w alk	WK	0.518	12.7	0.686	16.6	2.91
Attraction terms:							
L_S_M	log-size-multiplier	all	1.000	n/a	1.000	n/a	n/a
Retail	retail employment	all	2.706	n/a	3.017	n/a	n/a
Pop	population	all	0.366	n/a	0.411	n/a	n/a
Structural parameters:							
Theta_M_P	relative sensitivity of main modes and PT modes	n/a	0.457	13.3	0.504	19.6	1.09
Theta_P_A	relative sensitivity of PT modes and train access m	n/a	1.000	n/a	1.000	n/a	n/a
Theta_A_D	relative sensitivity of train access modes and desti	n/a	0.832	3.0	1.000	n/a	n/a
Theta_D_S	relative sensitivity of destinations and stations	n/a	1.000	n/a	1.000	n/a	n/a
Theta_S_T	relative sensitivity of stations and toll choice	n/a	1.000	n/a	1.000	n/a	n/a

More parameters have changed significantly in the home–other travel model compared with the other home-based purposes. The car time parameter has reduced in magnitude, whereas the bus in-vehicle time, wait time and access and egress time parameters all increased in significance. As discussed in Section 2.4, in the new model the PT out-of-vehicle time ratios are more plausible than those in the 2006-base model. Furthermore, the reduction in the magnitude of the car time parameter combined with the increase in the magnitude of the PT IVT parameters means that the discrepancy between the car time and PT IVT valuations has reduced in the 2011-base model.

Table 32: Work-based business mode-destination model parameters

Parameter	Description	Modes	2006 base Model 11 Value	2006 base Model 11 T-ratio	2011 base Model 15 Value	2011 base Model 15 T-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
LogCost	log of cost in cents	CD, TR, BS, TX	-0.714	-12.5	-0.794	-15.3	1.05
CarTime	car in-vehicle time (mins)	CD, CP, TX	-0.033	-13.0	-0.028	-14.9	1.68
GenPTTime	generalised PT time (mins)	TR, BS	-0.011	-3.1	-0.019	-5.2	1.74
WalkDist	walk distance (km)	WK	-0.606	-10.0	-0.757	-12.5	1.77
TaxiDist	taxi distance (km)	TX	-0.027	-1.7	-0.037	-2.5	0.43
Home-based tour mode constants:							
CarDCarD	home-based and NHB modes car driver	CD	1.990	5.4	1.902	6.6	0.19
Socio-economic terms:							
WalkMale	male term on walk	WK	-1.246	-4.5	-0.614	-3.0	1.83
Mode constants							
CarP	car passenger (relative to car driver)	CP	-5.600	-11.0	-6.213	-12.7	0.87
Train	train (relative to car driver)	TR	-1.772	-2.1	0.609	0.7	1.94
Bus	bus (relative to car driver)	BS	-3.873	-4.6	-0.600	-0.8	2.85
Walk	walk (relative to car driver)	WK	-0.555	-1.1	-0.873	-1.9	0.46
Taxi	taxi (relative to car driver)	TX	0.452	1.1	0.651	1.6	0.35
CarP_0508	car passenger (relative to car driver)				-6.228	-13.7	
Train_0508	train (relative to car driver)				0.621	0.8	
Bus_0508	bus (relative to car driver)				-1.288	-1.7	
Walk_0508	walk (relative to car driver)				-1.030	-2.4	
Taxi_0508	taxi (relative to car driver)				0.591	1.7	
Intrazonal constants:							
CrDIZ	car driver	CD	-0.385	-1.7	-0.651	-3.4	0.88
WalkIZ	walk	WK	0.883	3.7	0.556	2.8	1.05
Attraction term:							
TotEmp	total employment	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_PT	relative sensitivity of main modes and PT modes	n/a	1.000	n/a	1.000	n/a	n/a
Theta_PT_D	relative sensitivity of PT modes and destinations	n/a	0.896	1.5	0.955	0.8	0.65

The only parameter that has undergone a statistically significant change is the bus mode constant.

Table 33: Business detour mode-destination model parameters

Parameter	Description	Modes	2006 base Model 17 Value	2006 base Model 17 t-ratio	2011 base Model 23 Value	2011 base Model 23 t-ratio	t-ratio for parameter diff.
Cost and level of service terms:							
LogCost	log of cost in cents	CD, TR, BS, TX	-0.958	-14.6	-1.174	-18.6	2.36
CarTime	car in-vehicle time (mins)	CD, CP, TX	-0.083	-15.7	-0.082	-18.9	0.06
GenPTTime	generalised PT time (mins)	TR, BS	-0.054	-4.0	-0.043	-5.4	0.72
CarPDist	car passenger distance (km)	CP	-0.050	-3.7	-0.038	-3.9	0.69
WalkDist	walk distance (km)	WK	-2.307	-11.0	-4.553	-13.6	5.69
TaxiDist	taxi distance (km)	TX	-0.148	-1.7	-0.128	-1.7	0.18
Toll choice terms:							
TollBonus	constant on car driver toll, 2009-2012 waves	CD TL	-0.461	-1.7	0.004	0.0	1.12
TlBon_0508	constant on car driver toll, 2005-2008 waves	CD TL			-0.611	-2.0	
CarTDist	car toll distance (km)	CD TL	0.015	2.4	0.025	3.9	1.09
Home-based tour mode constants:							
CarDCarD	home-based and NHB modes car driver	CD	7.208	5.7	8.767	7.1	0.88
CarPCarP	home-based and NHB modes car passenger	CP	4.720	4.1	5.756	5.7	0.68
WalkWalk	home-based and NHB modes walk	WK	3.820	2.3	1.878	1.5	0.94
Car availability terms:							
CarDCCar	company car(s) in household term	CD	1.477	3.3	1.924	4.2	0.69
Other socio-economic terms:							
CarPA1625	aged 16-25 term on car passenger	CP	3.362	4.5			
WalkMale	male term on walk	WK	-1.615	-3.1			
Mode constants							
CarP	car passenger, 2009-2012 waves	CP	-4.005	-4.5	-5.408	-6.2	1.12
Train	train, 2009-2012 waves	TR	4.664	2.8	4.292	2.7	0.16
Bus	bus, 2009-2012 waves	BS	-1.681	-0.8	1.425	1.0	1.26
Walk	walk, 2009-2012 waves	WK	4.477	4.3	4.985	4.9	0.35
Taxi	taxi, 2009-2012 waves	TX	1.485	1.3	0.005	0.0	0.82
CarP_0508	car passenger, 2005-2008 waves	CP			-5.609	-6.5	
Train_0508	train, 2005-2008 waves	TR			3.410	2.2	
Bus_0508	bus, 2005-2008 waves	BS			-0.769	-0.4	
Walk_0508	walk, 2005-2008 waves	WK			6.417	6.1	
Taxi_0508	taxi, 2005-2008 waves	TX			0.495	0.4	
Attraction term:							
TotEmp	total employment	all	1.000	n/a	1.000	n/a	n/a
Structural parameters:							
Theta_M_PT	relative sensitivity of main modes and PT modes	n/a	0.787	2.1	0.680	4.6	0.27
Theta_PT_D	relative sensitivity of PT modes and destinations	n/a	1.000	n/a	1.000	n/a	
Theta_D_T	relative sensitivity of destinations and toll choice	n/a	0.637	14.2	0.575	22.3	1.21

There has been a substantial change to the log-cost and walk distance parameters in the new model.

3.3. Car ownership models

The following tables present the 2006-base and 2011-base car ownership model parameters and their associated t-ratios, and the significance of the difference between the 2006-base and 2011-base parameter values. All t-ratios are calculated relative to a value of zero except for the structural parameters, which are calculated relative to a value of one.

The changes to the company car ownership model parameters are detailed in Table 34.

Table 34: Changes to company car ownership model parameters

Parameter	Description	Alternative(s)	2006 base Model 25 Value	2006 base Model 25 t-ratio	2011 base Model 34 Value	2011 base Model 34 t-ratio	t-ratio for parameter diff.
Income terms:							
HHInc1	log of household income	1 car	0.295	8.1			
HHInc2	log of household income	2+ cars	0.343	4.8			
Head of the household terms:							
FMHdHHCmp	female head	1 car, 2+ cars	-0.410	-9.6	-0.343	-7.6	1.08
D1age35	years over 35 *if* aged 35-plus	1 car	0.009	3.9	0.012	5.1	0.95
D2age35	years over 35 *if* aged 35-plus	2+ cars	0.033	7.9	0.029	6.8	0.60
Age<29c1	years under 29 *if* aged under 29	1 car	-0.064	-4.3	-0.100	-5.4	1.49
Age<29c2	years under 29 *if* aged under 29	2+ cars	-0.060	-1.9	-0.118	-2.9	1.14
HdHHtrade	occupation is tradesperson	1 car, 2+ cars			0.593	6.2	
Household composition terms:							
nworkers1	number of workers	1 car	0.098	3.0	0.190	5.8	1.99
nworkers2	number of workers	2+ cars	0.245	3.5	0.276	3.7	0.30
nFTwks0_1	no full-time workers in household	1 car	-1.001	-9.2	-0.925	-8.9	0.51
nFTwks0_2	no full-time workers in household	2+ cars	-0.772	-3.4	-1.109	-4.5	1.00
nresident1	number of residents in household	1 car	0.171	9.8	0.202	10.5	1.19
nresident2	number of residents in household	2+ cars	0.304	8.7	0.367	10.1	1.24
couples1	married couple lives in household	1 car	0.294	5.7	0.262	4.7	0.42
couples2	married couple lives in household	2+ cars	0.332	3.2	0.377	3.4	0.30
WkAus1	worker 1 or worker 2 born in Australia	1 car	0.170	6.3	0.246	7.7	1.81
WkAus2	worker 1 or worker 2 born in Australia	2+ cars	0.197	4.1	0.281	4.7	1.09
Car availability terms:							
UnlicAdsc1	number of adults with no licence	1 car	-0.296	-8.1	-0.341	-8.4	0.82
UnlicAdsc2	number of adults with no licence	2+ cars	-0.458	-6.4	-0.498	-6.4	0.37
D2-LIC<CAR	less than two workers with licences	2+ cars	-0.772	-6.4	-0.651	-4.9	0.68
Zonal terms:							
Pcost	parking cost in the zone	1 car, 2+ cars	-0.017	-2.7	-0.011	-1.7	0.67
Alternative-specific constants:							
1CpCar	1 company car constant	1 car	-3.096	-19.5	-2.500	-28.3	3.28
2pCpCar	2+ company car constant	2+ cars	-5.527	-15.4	-4.652	-19.9	2.04
wav06_07_1	late wave constant (2006/07-2007/08)	1 car	-0.246	-5.4			
wav06_07_2	late wave constant (2006/07-2007/08)	2+ cars	-0.288	-3.3			
1CCar0508	early wave constant (2005/08-2008/09)				-2.371	-27.4	
2pCCar0508	early wave constant (2005/08-2008/09)				-4.522	-19.4	

Notes:

1) The 'WkAus1' and 'WkAus2' terms are applied twice if both worker 1 and worker 2 were born in Australia.
2) The occupation codes changed from the 2006/2007 wave onwards. For records in the 2005/2006 wave, the definition of the tradesperson term is 'tradespersons and related workers', for records in the 2006/2007 wave onwards, the definition is 'technicians and trades workers'.
3) In the 2006-base model, the '1CpCar' and '2pCpCar' constants are estimated across all waves of data, whereas in the 2011-base model these models are only estimated from the late waves of data (2009/2010–2012/2013).

A number of changes were made to the company car ownership model specification in the 2011-base model. First, the household income terms were dropped as they were no longer significant. It can be seen from Table 34 that to compensate for this the magnitude of the 'nworkers1' parameter for the number of

workers has increased. In addition, a new term has been added to both the 1 company car and 2 company car alternatives that is applied if the head of the household's occupation is tradesperson.

These terms, together with the early and late wave constants in the 2011-base model, show a pattern of declining car ownership over time[6] and suggest that the importance of income in explaining company car ownership has also reduced over time. It may be that as a result of tax changes, company car ownership is increasingly the preserve of tradespersons such as plumbers and electricians who need a vehicle to undertake their work.

It is noted that the only statistically significant changes to the parameters are observed for numbers of workers terms and the constants (changes in the constants follow from the changes in the other parameters), with the changes to the numbers of workers terms following from dropping the income terms.

The changes to the total car ownership parameters are detailed in Table 35.

[6] In later waves ownership rates seem to have stopped declining and have stabilised.

Table 35: Changes to total car ownership model parameters

Parameter	Description	Alternative(s)	2006 base Model 36 Value	2006 base Model 36 t-ratio	2011 base Model 44 Value	2011 base Model 44 t-ratio	t-ratio for parameter diff.
Income terms:							
HHInc1	log of net household income	1 car	0.150	8.7	0.120	5.3	1.05
HHInc23	log of net household income	2 cars, 3+ cars	0.203	14.9	0.176	10.8	1.26
Head of the household terms:							
FmHdHH2	female head	2 cars	-0.176	-4.2	-0.309	-7.1	2.21
FmHdHH3	female head	3+ cars	-0.302	-4.3	-0.301	-4.5	0.01
D1age35	years over 35 *if* aged 35-plus	1 car	0.031	10.9	0.031	9.7	0.02
D2age35	years over 35 *if* aged 35-plus	2 cars	0.072	15.3	0.065	12.7	1.02
D3age35	years over 35 *if* aged 35-plus	3+ cars	0.084	16.0	0.084	15.3	0.01
Household composition terms:							
FtTmWrk1	number of full-time w orkers	1 car	0.392	5.3	0.433	5.2	0.37
FtTmWrk2	number of full-time w orkers	2 cars	0.641	8.1	0.789	9.0	1.26
FtTmWrk3	number of full-time w orkers	3+ cars	0.878	10.0	1.154	12.1	2.13
PrTmWrk1	number of full-time w orkers	1 car	0.457	3.9	0.573	4.3	0.66
PrTmWrk2	number of full-time w orkers	2 cars	0.734	6.0	0.913	6.6	0.97
PrTmWrk3	number of full-time w orkers	3+ cars	0.915	6.9	1.139	7.8	1.14
couple1	household comprising only a couple	1 car	0.142	3.2	0.100	2.1	0.64
NChildCof	number of children in HH	1 car, 2 cars, 3+cars	0.313	4.9	0.432	5.0	1.11
NAus_1	number of Australian-born in HH	1 car	0.095	2.3	0.178	3.5	1.25
NAus_2	number of Australian-born in HH	2 cars	0.274	6.4	0.400	7.5	1.84
NAus_3	number of Australian-born in HH	3+ cars	0.351	7.7	0.493	8.9	1.98
Company car ow nership terms							
CmpCar1_2	one company car in HH	2 cars	1.193	20.3	1.098	15.7	1.04
CmpCar1_3	one company car in HH	3+ cars	1.654	20.7	1.680	19.5	0.22
CmpCar2_3	tw o-plus company cars in HH	3+ cars	1.446	16.0	1.414	15.3	0.24
Car availability terms:							
NumLics1	number of licences	1 car	1.400	13.7	1.148	10.7	1.70
NumLics2	number of licences	2 cars	2.509	18.2	2.127	15.4	1.95
NumLics3	number of licences	3+ cars	3.280	23.8	3.072	22.5	1.07
D2Lic_Car	less than tw o adults w ith licences	2 cars	-0.928	-7.4	-1.132	-9.5	1.18
D3Lic_Car	less than three adults w ith licences	3+ cars	-0.907	-7.6	-0.534	-4.5	2.21
Accessibility terms:							
m_d_access	commuter accessibility	all alternatives	0.640	12.1	0.708	11.7	0.85
Zonal terms:							
CBDDist	log of distance to the CBD	1 car, 2 cars, 3+cars	0.522	23.1	0.590	25.8	2.12
Mode constants:							
1CarOw ned	1 car constant	1 car	-3.508	-19.5	-3.074	-16.2	1.66
2CarOw ned	2 car constant	2 cars	-8.527	-27.8	-7.861	-25.9	1.54
3+CarOw ned	3+ car constant	3+ cars	-14.325	-36.4	-14.903	-37.3	1.03
1car_0508	early w ave constant (2005/08-2008/09)	1 car			-3.216	-17.1	
2car_0508	early w ave constant (2005/08-2008/09)	2 cars			-8.132	-26.9	
3+car_0508	early w ave constant (2005/08-2008/09)	3+ cars			-15.226	-38.2	

Notes:

1) Net household income is defined as gross household income less the annual cost of car ownership times the number of cars owned. The annual cost of car ownership including fuel and other running costs was modelled as $12k in the 2006-base model, but as $11k in the 2011-base model. The $12k figure in the 2006-base model was determined on the basis of the value that gave the best fit to the data, whereas the

2011-base value was based on a representative value of a range of different vehicle types quoted in published statistics.[7]

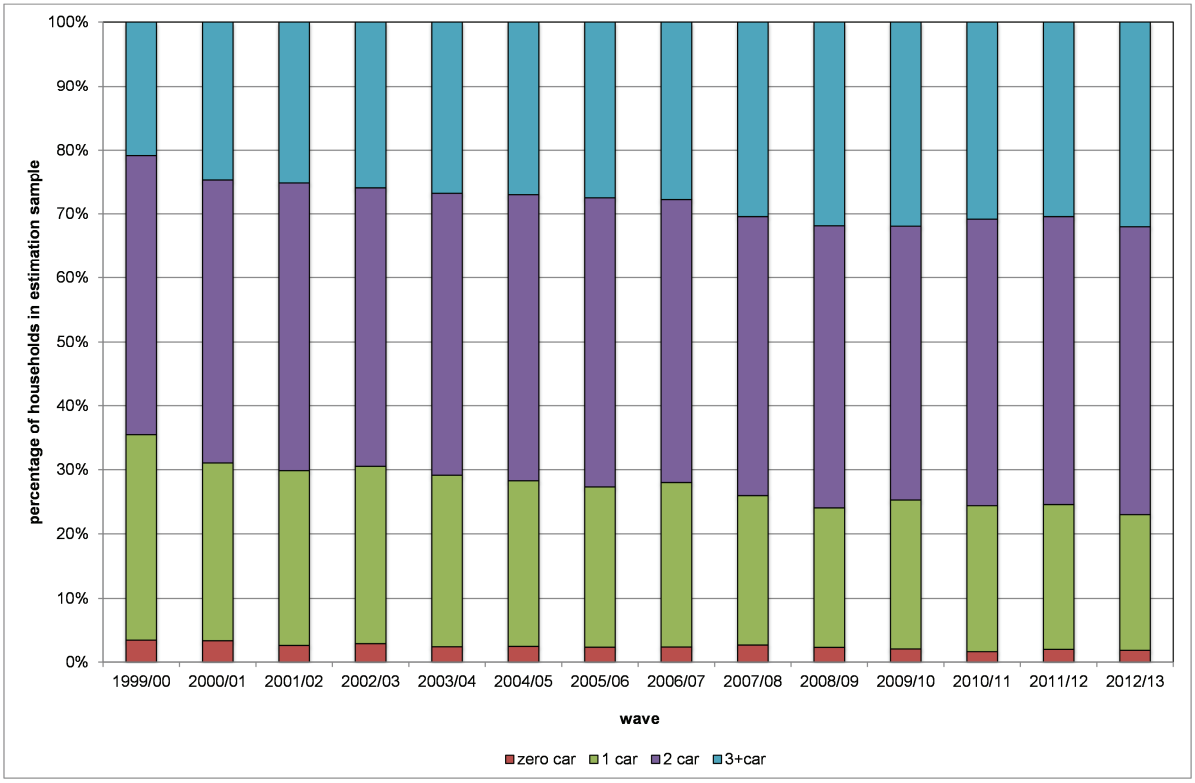
2) In the 2006-base model, the '1CpCar' and '2pCpCar' constants are estimated across all waves of data, whereas in the 2011-base model these models are estimated from the late waves of data (2009/2010–2012/2013) only.

Most parameters have not changed significantly between the 2006-base and 2011-base models. However, significant changes are observed for the following parameters:

- 'FmHdHH2' – female head of household term on 2 cars
- 'FtTmWrk3' – number of full-time workers term on 3+ cars
- 'NAus_3' – number of Australian-born people term on 3+ cars
- 'D3Lic_Car' – less than three adults with licences term on 3+ cars
- 'CBD_dist' – log of distance from CBD term on all car owning alternatives.

It is noteworthy that three of these terms that have changed significantly are applied to the 3+ car alternative. To investigate these changes further the proportions of the sample observed to choose each car ownership alternative in each wave of HTS data was plotted. The resulting plot is shown in Figure 1.

Figure 1: Car ownership rates by wave of HTS data



The proportion of households owning 3+ cars increased up to around 2008, after which it has remained more or less constant, explaining the significant changes to the model parameters on the 3+ cars alternative.

[7] Royal Automobile Club of Victoria (2013).

4. Validation of the MD models

4.1. Implied values of time

In a linear cost model, the implied values of time (VOTs) can be calculated directly from the ratio of the time and cost parameters. However, most of the models estimated have non-linear cost forms and, in these models, the VOTs vary with the tour cost according to the following formula:

$$VOT = \frac{\partial V / \partial Time}{\partial V / \partial Cost} = \frac{\beta_{Time}}{\beta_{Cost} + \frac{\beta_{LogCost}}{Cost}} \quad (4.1)$$

For models with non-linear cost formulations, graphs can be presented illustrating the variation in VOT with cost. In this section, to create summary results, the VOTs have been calculated using the mean cost for the chosen alternatives, for both the 2006-base and 2011-base models, and then these VOTs have been compared with guidance values. These comparisons are presented for the car, train and bus modes. For the commute and home–business models, where cost sensitivity is segmented by personal income band, VOTs are presented for the middle income band ($31,200–$41,599 for commute and $31,200–$51,999 p.a. for home–business). It is noted that when validating the 2006-base models, business guidance VOTs were not extracted for comparison to the values implied by the model parameters.

In the tables below, the 2006-base VOTs are in 2006 values and prices, whereas the 2011-base VOTs are in 2011 values and prices. To allow comparison between the two sets of VOTs, for each set the ratio of the VOT to the guidance value has been calculated. Cases where this ratio shows a noticeable improvement in the 2011-base model relative to the 2006-base model have been highlighted in green; correspondingly, cases where the ratio shows a noticeable deterioration have been highlighted in red.

Table 36 compares the car VOTs in the 2006-base and 2011-base models.

Table 36: Value of time for car ($/hr)

Purpose	2006-base (2006 prices)			2011-base (2011 prices)		
	VOT	guidance	ratio	VOT	guidance	ratio
commute	20.88	11.5	1.82	15.21	14.03	1.08
home–business	36.52			26.57	44.92	0.59
home–secondary education	22.06	11.5	1.92	25.23	14.03	1.80
home–tertiary education	44.40	11.5	3.86	46.63	14.03	3.32
home–shopping	11.79	11.5	1.03	5.86	14.03	0.42
home–other travel	8.61	11.5	0.75	7.21	14.03	0.51
work–business	25.82			19.50	44.92	0.43
business detour	55.40			28.19	44.92	0.63

For commute, the car VOTs in the new model are lower and are more consistent with the guidance values, whereas for home–shopping and home–other travel the VOTs in the new models have reduced and are now low relative to the guidance values. This decline in VOT has been driven by an increase in cost sensitivity.

For home–secondary and home–tertiary the VOTs have changed less and both remain substantially higher than guidance. This results from the fact that the cost variable is not strong in these models; as the cost parameter is on the denominator in Equation (4.1) a small cost parameter results in a high implied VOT.

As noted above, guidance VOTs for business were not extracted for the 2006-base models. The car VOTs are consistently lower than the guidance values; this may reflect differences between employer and employee valuations. Specifically, the guidance values are employer valuations, whereas the values implied from the model parameters will be impacted by how employees value their time and their valuations may be lower than that of their employers.

Table 37 compares the VOTs for train in the 2006-base and 2011-base models.

Table 37: Value of time for train ($/hr)

Purpose	2006-base (2006 prices)			2011-base (2011 prices)		
	VOT	guidance	ratio	VOT	guidance	ratio
commute	11.24	11.2	1.00	10.11	11.53	0.88
home–business	9.72	11.2	0.87	11.09	11.53	0.96
home–secondary education	16.30	11.2	1.46	16.61	11.53	1.44
home–tertiary education	11.78	11.2	1.05	15.45	11.53	1.34
home–shopping	7.36	11.2	0.66	4.56	11.53	0.40
home–other travel	5.70	11.2	0.51	6.54	11.53	0.57
work–business	6.12	11.2	0.55	15.34	11.53	1.33
business detour	19.60	11.2	1.75	21.57	11.53	1.87

For commute, the 2011 VOT is now low relative to the guidance value; however, for home–business the correspondence to the guidance value is slightly improved. For home–tertiary, the train VOT has increased in the 2011-base model so that it is now about one-third higher than the guidance value.

The VOT in the new work–business model is on the high side whereas in the 2006-base model it was on the low side. By contrast, the VOTs in the business detour model are on the high side in both models.

Table 38 presents values of time for bus. For 2011 guidance values have not been supplied so that the 2006 value has been inflated to 2011 prices for the purpose of this comparison.

Table 38: Value of time for bus ($/hr)

Purpose	2006-base (2006 prices)			2011-base (2011 prices)		
	VOT	guidance	ratio	VOT	guidance	ratio
commute	11.81	9.35	1.26	10.94	10.74	1.02
home–business	13.87	9.35	1.48	12.82	10.74	1.19
home–secondary education	16.08	9.35	1.72	17.86	10.74	1.66
home–tertiary education	12.34	9.35	1.32	13.76	10.74	1.28
home–shopping	4.24	9.35	0.45	4.27	10.74	0.40
home–other travel	2.46	9.35	0.27	5.67	10.74	0.53
work–business	7.77	9.35	0.83	12.87	10.74	1.20
business detour	9.12	9.35	0.97	17.23	10.74	1.60

The pattern of changes in the bus VOTs is more positive than that for train, with commute, home–business and home–other travel all showing improvements, with smaller changes for the other purposes.[8]

4.2. Elasticities

The changes to the direct fuel cost, car time, PT fare and PT in-vehicle time elasticities are summarised in the following tables. It is noted that for home–primary education, car driver is not modelled and furthermore PT fares are not modelled and therefore no PT fare elasticities are calculated.

[8] For work–business the change is larger but the level of error remains about the same, with the VOT about 20 per cent below guidance in the 2006-base model and about 20 per cent above guidance in the 2011 base model.

Table 39: Changes to car driver fuel cost kilometrage elasticities

Purpose	2006-base	2011-base	Ratio (2011-base / 2006-base)
commute	-0.318	-0.346	1.09
home–business	-0.096	-0.129	1.34
home–secondary education	-0.183	-0.178	0.97
home–tertiary education	-0.067	-0.085	1.27
home–shopping	-0.183	-0.230	1.26
home–other travel	-0.158	-0.216	1.37
work–business	-0.114	-0.136	1.19
business detour	-0.021	-0.024	1.14
Total	-0.210	-0.246	1.17

In general, the fuel cost kilometrage elasticities have increased, and because commute and home–other travel account for over two-thirds of total kilometrage the overall elasticity has increased by almost one-fifth. In the UK fuel cost elasticities of around -0.3 are judged to be acceptable and if the UK value is taken to be reasonable for travel in New South Wales then the increase from -0.21 to -0.25 indicates a more plausible sensitivity to fuel cost changes in the new model.

Table 40: Changes to car driver car time tour elasticities

Purpose	2006-base	2011-base	Ratio (2011-base / 2006-base)
commute	-0.154	-0.112	0.73
home–business	-0.032	-0.036	1.13
home–secondary education	-0.246	-0.171	0.70
home–tertiary education	-0.319	-0.432	1.35
home–shopping	-0.074	-0.050	0.68
home–other travel	-0.045	-0.051	1.13
work–business	-0.108	-0.100	0.93
business detour	-0.046	-0.032	0.70
Total	-0.083	-0.071	0.86

The overall car time tour elasticity has reduced by 15 per cent in the 2011-base model, principally as a result of a significant reduction in the elasticity for commute.

Table 41: Changes to PT fare tour elasticities

Purpose	Train			Bus		
	2006-base	2011-base	ratio	2006-base	2011-base	ratio
commute	-0.449	-0.421	0.94	-0.282	-0.365	1.29
home–business	-0.192	-0.238	1.24	-0.197	-0.233	1.18
home–secondary education	-0.178	-0.263	1.48	-0.230	-0.351	1.53
home–tertiary education	-0.163	-0.129	0.79	-0.204	-0.190	0.93
home–shopping	-0.637	-1.083	1.70	-0.425	-0.936	2.20
home–other travel	-0.482	-0.706	1.46	-0.314	-0.619	1.97
work–business	-0.535	-0.723	1.35	-0.230	-0.731	3.18
business detour	-0.380	-0.44	1.16	-0.129	-0.442	3.43
Total	-0.410	-0.452	1.10	-0.294	-0.488	1.66

For most purposes, the PT fare elasticities are higher in the new models, with larger increases observed for bus than for train for all but one of the purposes.

Table 42: Changes to PT in-vehicle time tour elasticities

Purpose	Train			Bus		
	2006-base	2011-base	ratio	2006-base	2011-base	ratio
commute	-0.518	-0.568	1.10	-0.563	-0.603	1.07
home–business	-0.370	-0.421	1.14	-0.341	-0.403	1.18
home–primary education	-1.202	-1.385	1.15	-0.591	-0.698	1.18
home–secondary education	-0.793	-1.015	1.28	-0.693	-0.821	1.18
home–tertiary education	-0.626	-0.442	0.71	-0.435	-0.507	1.17
home–shopping	-0.786	-0.926	1.18	-0.262	-0.489	1.87
home–other travel	-0.645	-0.848	1.31	0.014	-0.299	n/a
work–business	-0.743	-1.105	1.49	-0.233	-0.597	2.56
business detour	-0.894	-1.028	1.15	-0.259	-0.403	1.56
Total	-0.569	-0.645	1.13	-0.385	-0.531	1.38

The positive bus in-vehicle time elasticity in the 2006-base model was a result of the large difference between the bus and train IVT parameters in that model. Specifically, because the sensitivity to train IVT was much higher, when a 10 per cent increase was made to all PT IVTs in the elasticity test, some mode shift from train to bus was observed. In the 2011-base model the train and bus IVT parameters are closer in magnitude and as a result the bus elasticity value is more plausible.

For most purposes, the PT in-vehicle time elasticities are higher in the new models, with larger increases observed for bus than for train for all but one of the purposes.

5. Implementation of the car ownership models

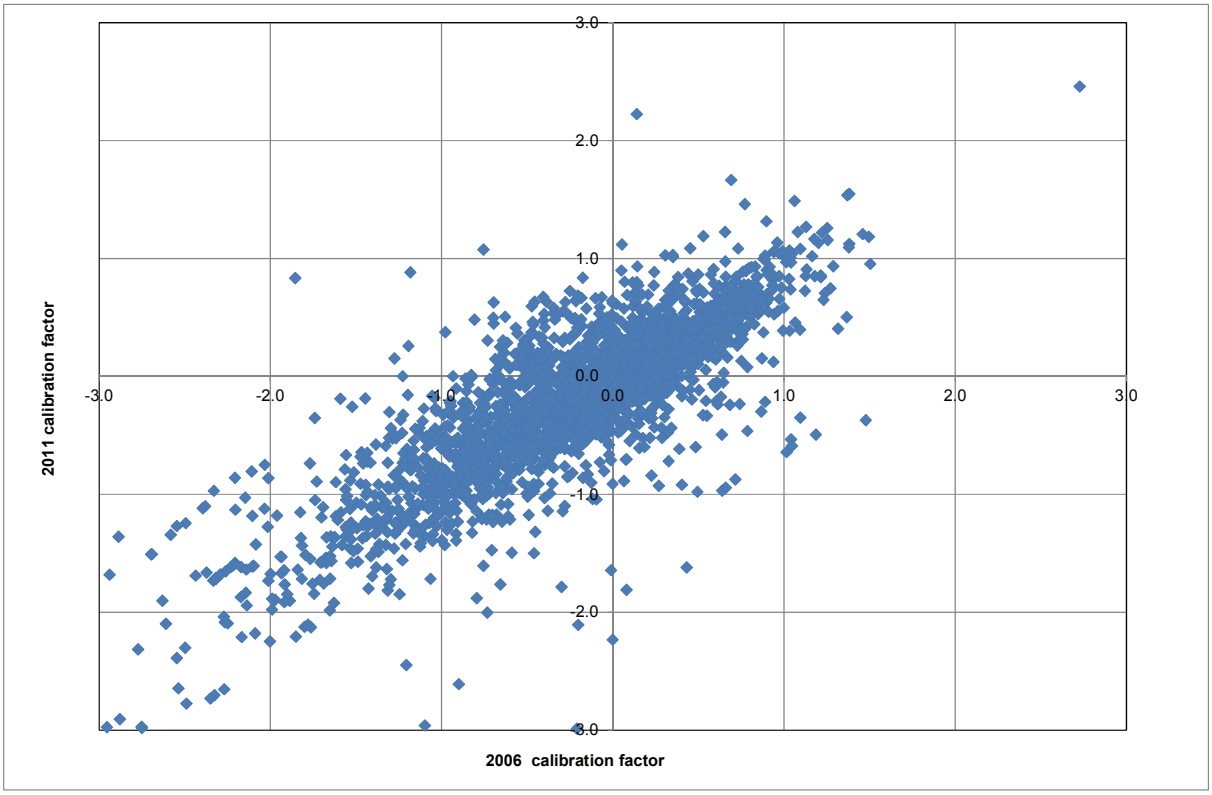
5.1. Car ownership pivot

The disaggregate car ownership models in STM3 are applied using a pivoting approach whereby the disaggregate models are used to predict changes in car ownership relative to the car ownership levels observed in Census data. The car ownership pivot was documented in detail in Fox et al. (2012).

As the models have been rebased to 2011 in this work, the Census data used in the pivot has been updated from 2006 to 2011. The Census data defines the number of households who own zero, one, two and three-plus cars by zone. These numbers are converted into proportions, which are applied to the number of households predicted by the Population Synthesiser in the 2011-base year. This defines the 'observed' 2011 car ownership levels that are used to define the base year calibration factors that are taken forward for forecast years in the pivot process.

The calibration factors that are obtained for each zone to match the 'observed' ownership levels have been scattered against those obtained in the 2006-base calibration. The resulting scatter plot is shown in Figure 2.

Figure 2: Car ownership calibration scatter



As would be expected there is a good level of consistency between the old and new calibration factors with most points clustered along the y=x diagonal (the points off the y=x line create the impression that there are significant changes; however, the central 'cloud' along the y=x line is dense so that for the average zone the point lies along the y=x diagonal). The correlation between the two series is 0.77.

5.2. Car availability adjustment

The car availability adjustment adjusts total car ownership, and thus the availability of cars at the person level, to take account of changes in commuter accessibility in the forecast year relative to the base year. The procedure works using a simple pivot-point model. The procedure was documented in detail in Chapter 3 of HCG and ITS (2002).

Table 43 compares the 2006-base and 2011-base parameter values.

Table 43: Car availability adjustment parameter comparison

Base *aext2*	Coefficient	2006-base	2011-base	abs(2011/ 2006)
3	c05_1	-0.44419	-0.45062	1.014
	c05_3	-0.41777	-0.42776	1.024
	c05_4	0.17056	0.17462	1.024
	co5_5	-0.08832	-0.06690	0.757
	c11_1	0.35961	0.36429	1.013
	c11_3	0.33481	0.34325	1.025
	c11_4	-0.09367	-0.09842	1.051
	c11_5	0.15957	0.13600	0.852
10	c16_6	-0.24102	-0.23881	0.991
	c16_8	0.23398	0.23033	0.984
2	c07_1	-0.48515	-0.51896	1.070
	c07_3	0.00262	0.00294	1.123
	c07_4	0.47913	0.51123	1.067
	c07_5	0.00072	0.00103	1.423
4	c06_1	-0.41646	-0.43807	1.052
	c06_3	0.56608	0.64443	1.138
	c06_4	0.00570	0.00615	1.079
	c06_5	-0.16322	-0.22144	1.357
	c12_1	-0.40221	-0.42309	1.052
	c12_3	0.43032	0.45267	1.052
	c12_4	0.00542	0.00584	1.078
	c12_5	-0.03745	-0.03986	1.064
	c13_1	-0.40656	-0.42651	1.049
	c13_3	0.02598	0.04121	1.586
	c13_4	0.00546	0.00588	1.078
	c13_5	0.36818	0.37207	1.011
8	c14_6	-0.19353	-0.21773	1.125
	c14_8	0.19549	0.21959	1.123
	c15_6	-0.57220	-0.63088	1.103
	c15_8	0.57400	0.63309	1.103

It can be seen that there is a good level of correspondence between the 2006-base and 2011-base parameter values. The correlation between the two series is very high at 0.999.

6. Summary

The STM3 frequency, mode-destination and car ownership models have been re-estimated to reflect a 2011 base year in place of the 2006 base year used previously. To make this change, the models have been updated to use more recent HTS data, and to use LOS, attraction, car cost and taxi data that reflect 2011 travel conditions.

Tour rates for commute and home–tertiary education showed greater variability with wave of HTS data than the tour rates for the other purposes. Therefore the tour frequency models for commute and home–tertiary education were estimated using the 2009/2010–2012/2013 waves only, whereas the frequency models for the remaining purposes were estimated using the 2005/2006–2012/2013 waves of data.

For the mode-destination models all purposes were estimated using 2005/2006–2012/2013 data to ensure sufficient samples sizes with the exception of commute, where the sample sizes in the more recent 2009/2010–2012/2013 waves were sufficient. The car ownership models were also estimated using 2005/2006–2012/2013 data to ensure sufficient sample sizes.

The 2006-base and 2011-base models were estimated using different samples of data and therefore the measures of fit output from the estimations could not be compared directly. A comparison measure was calculated by dividing the log-likelihood, which measures the fit of the model to the observed choices, by the number of observations.

For the frequency models, the LL/obs measure showed a slightly improved fit to the data for 11 of the 12 models. For the mode-destination models, the pattern was more mixed with a slight improvement for four models and a slight deterioration for five models.[9] The pattern was also mixed for the car ownership models, with the company car ownership model showing a slight improvement in fit and the total car ownership model a slight worsening.

A key feature of the home-based frequency models in STM3 is the incorporation of an accessibility linkage, which ensures that any future changes in accessibility have an impact on travel frequency. The changes to the accessibility terms were analysed but none of the changes were statistically significant.

To investigate the impact of the changes to the PT LOS skims on the model parameters, ratios of the PT out-of-vehicle components were calculated relative to PT in-vehicle time. In most cases, the changes to these ratios demonstrated the PT out-of-vehicle time components to be more plausible in the new 2011-base models.

[9] Seven home-based purposes and two non-home-based purposes are modelled in STM3. However, for the business detour purpose four separate frequency models are estimated, so there are a total of 12 frequency models.

A noteworthy change to the road assignments in the 2011 skims is that as a result of a change to the way paths are stored in EMME, the 2011 skims tend to have fewer paths and hence fewer cases with small toll values. The skims have also been updated to reflect changes to the toll roads, specifically the removal of tolls from the M4, and the opening of the M7.

The impact of these changes was assessed by examining the changes to the 'toll bonus' constant on the car driver toll alternative, and the toll distance term on the car driver term, which accounts for the fact that the likelihood of using a toll road increases as the distance travelled increases. For four of the five purposes where the toll road choice is explicitly modelled, the magnitude and significance of the toll bonus and/or toll distance terms is reduced in the 2011-base models. This indicates that overall the 2011 skims are better able to predict the choice between toll and no-toll alternatives on the basis of differences in travel time and travel cost.

Tables were presented showing the new 2011-base parameters alongside the 2006-base parameters, and calculating the t-ratio for the difference in parameter value. The clear majority of parameters have not changed significantly. One noteworthy change to the company car ownership model is that the household income terms were not significant when estimated from the 2011-base sample (covering 2005/2006–2012/2013 waves of data). It was suggested that this follows from declines in company car ownership as a consequence of taxation changes that mean that the importance of income in explaining company car ownership has reduced over time.

The new mode-destination model parameters were validated by comparing the implied VOTs to guidance values, and by calculating cost and in-vehicle time elasticities.

The VOTs were calculated by using the mean cost of the chosen alternatives and compared with guidance values. For the majority of cases the VOTs have not changed much between the 2006-base and 2011-base models. Where there have been changes, the level of correspondence to guidance is mixed: for car, two out of three changes show a worse match to guidance; for train, three changes show a worse match to guidance, and for bus all three changes show an improved match to guidance.

All but one of the fuel cost kilometrage elasticities are higher in the 2011-base models, and the overall increase in fuel cost kilometrage elasticity can be judged to be an improvement if the UK guidance value of -0.3 is assumed to be transferable to the Sydney context. The car time tour elasticities have generally reduced in the new models, and the PT fare and PT IVT tour elasticities have generally increased in the new models.

Overall, the quality of the frequency and car ownership models is judged to be similar in the 2006-base and 2011-base versions of the models. However, for the MD models the improvements to the PT out-of-vehicle time parameters and to the toll parameters indicate that the quality of the models has improved.

References

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Appendix A – Updates to car cost data

The car cost data used in the 2006-base models was documented in Section 3.1.1 of 'Sydney Strategic Model Re-estimation: Mode-Destination Mode' (DRR-5270-BTS). Updates have been made to the car costs for business and non-business travel, as documented below.

No changes have been made to the parking cost data, which was documented in DRR-5270-BTS. Therefore the 2011-base models use the 2006 parking costs documented in DRR-5270-BTS inflated to 2011 prices.

Business travel

Car costs for business travel are modelled using a fixed cost per kilometre travelled. The values vary by wave and are summarised in Table 44.

Table 44: Business kilometrage costs by wave (nominal values)

Wave	Fuel price (c/km)
2005/2006	62.7
2006/2007	65.7
2008/2008	65.7
2008/2009	70.7
2009/2010	70.7
2010/2011	70.7
2011/2012	70.7
2012/2013	70.7

Non-business travel

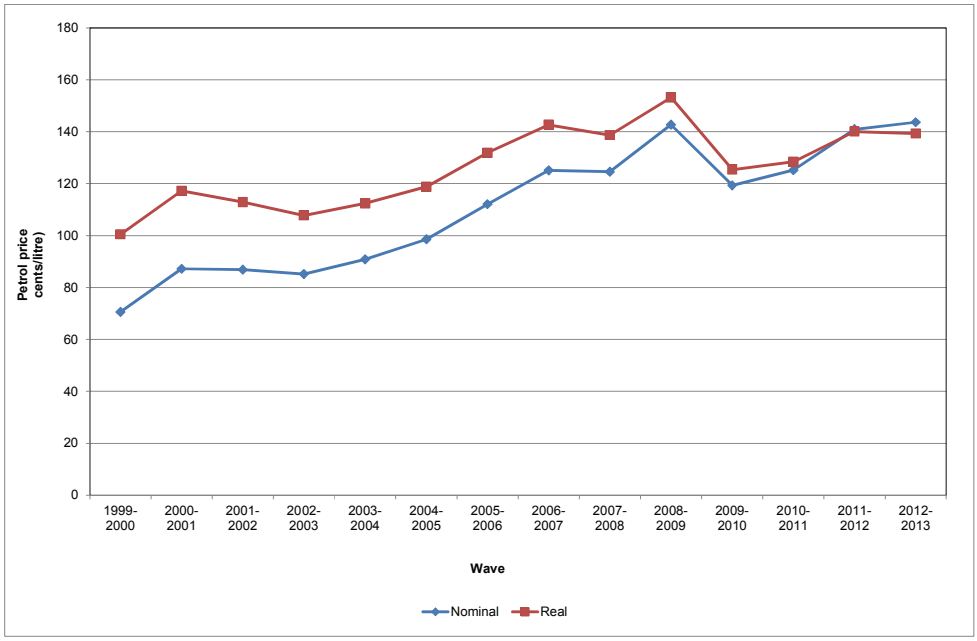
Mean fuel costs have been calculated for each wave of HTS data used in model estimation by averaging over quarterly values. The average values that were calculated are presented in Table 45.

Table 45: Mean fuel costs by HTS wave (nominal values)

Wave	Fuel price (c/litre)
2005/2006	112.1
2006/2007	125.1
2008/2008	124.6
2008/2009	142.7
2009/2010	119.3
2010/2011	125.2
2011/2012	140.9
2012/2013	143.6

Figure 3 plots the variation in the mean fuel costs over waves, both as nominal values and as real values (i.e. after taking account of inflation).

Figure 3: Variation in mean fuel costs by wave



Fuel consumption is calculated using a quadratic relationship to speed. This relationship is the same relationship as was used in the 2006-base models, and is documented in full in Section 3.1.1 of 'Sydney Strategic Model Re-estimation: Mode-Destination Model' (DRR-5270-BTS).

Non-fuel costs are calculated using a fixed cost per kilometre of 16.7 c/km (2011 prices).[10]

[10] Transport for New South Wales. 2013. Principles and Guidelines for Economic Appraisal of Transport Investment and Initiatives.

Appendix B – Updates to taxi cost data

The taxi fare data assembled for the 2006-base models has been supplemented by values for the more recent waves of HTS data. The data used in the 2011-base estimations is summarised in Table 46.

Table 46: Taxi fare schedules by wave (nominal costs)

Wave	Flagfall ($)	Distance cost ($/km)	Waiting cost ($/min)	Booking fee ($)
2005/2006	2.80	1.62	0.68	1.40
2006/2007	2.90	1.67	0.72	1.50
2007/2008	3.00	1.77	0.76	1.60
2008/2009	3.10	1.85	0.80	2.00
2009/2010	3.20	1.93	0.83	2.10
2010/2011	3.30	1.99	0.86	2.20
2011/2012	3.40	2.06	0.89	2.30
2012/2013	3.50	2.14	0.92	2.40