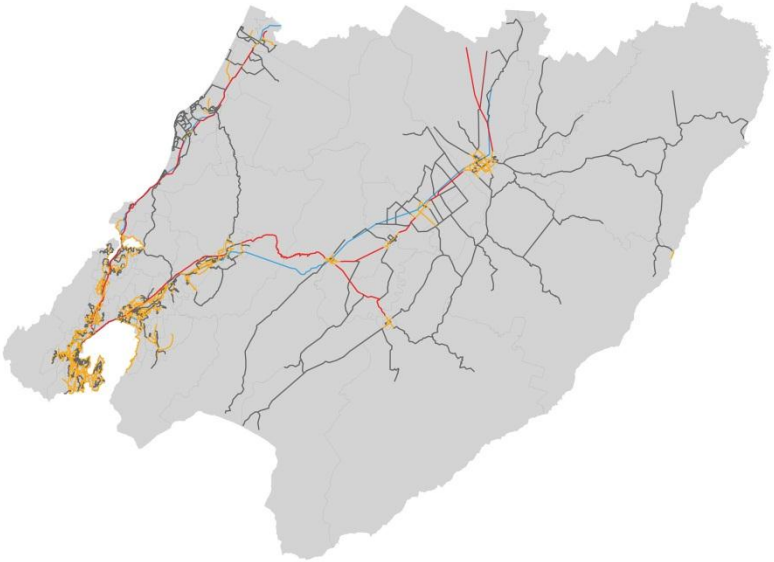
OPUS INTERNATIONAL CONSULTANTS AND ARUP

WELLINGTON TRANSPORT MODELS

Contract No C3079



TN13: Base Model Car Ownership

Date: December 2012

ARUP OPUS

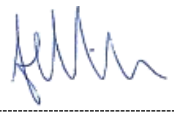
Wellington Transport Models

TN13: Base Model Car Ownership

prepared for

Greater Wellington Regional Council

Prepared By



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Date: December 2012
Reference: g:\localauthorities\wrc\proj\5-c2050.00 - c3079 wtsm wptm\600 deliverables\630 final tech notes\tn13 base model car ownership final.docx
Status: Final
Revision: 1

Document History and Status

Issue	Rev	Issued To	Qty	Date	Reviewed	Approved
Draft	V1	Nick Sargent and John Bolland	electronic	13/07/2012	Fraser Fleming	David Dunlop
Final	V1	Nick Sargent - GW	1 Hard & 1 CD	06/12/2012	Fraser Fleming	David Dunlop

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John Bolland: _____
(Peer Reviewer)

Nick Sargent: _____
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Contents

1 Introduction

Opus International Consultants Limited (Opus) and Arup Australia (Arup) were commissioned by Greater Wellington Regional Council (GWRC) to rebase the existing 2006 Wellington Transport Strategy Model (WTSM) to a new base year of 2011. Opus updated the WTSM while Arup developed a Wellington Public Transport Model (WPTM) based on figures from WTSM and detailed public transport surveys. The whole process of model updates and development is complex and involves several steps which have each been individually reported in a series of technical notes.

This technical note documents the process of updating the WTSM car ownership model to a base of 2011. The work was then commissioned separately by GWRC to David Young Consulting (DYC) who subsequently went on to produce a memo documenting the findings (contained in Appendix A). The following sections go on to discuss the:

- Role of car ownership in WTSM and why it needed to be rebased to 2011 (Chapter 2);
- Methodologies considered for the rebasing work (Chapter 3);
- Results of the rebasing work (Chapter 4); and
- Conclusions in Chapter 5.

There are three important aspects of the update to consider before reading the rest of the note:

1. As the 2011 Census was not undertaken the 2011 “actual” data has been estimated from analysis of historic Census data. Hence the “actual” is labelled “target” car ownership.

2. The reporting is focused on calculating car ownership *rates* i.e. the sections do not go on to document the resulting number of households with 0 cars, 1 car or 2 cars. **“Target rate”** of cars per household across the region are calculated and the rest of the model is adjusted to match the overall regional target.

3. It is not the purpose of this report to document the full workings of the car ownership model but merely to highlight some of the key aspects of work undertaken by DYC and how they have been incorporated into the model update. The reader should direct themselves to TN15.1 from the original 2003 model development technical documentation (referred to in the report as WTSM-01) for anything regarding technical aspects of the following sections beyond the brief content provided.

2 Background

2.1 Role of the Car Ownership Model

The WTSM car ownership model is an integral component of the WTSM trip generation and mode choice models and consequently it is integral to both the base and forecast WTSM models. It was developed as part of the 2001 WTSM update and documented in the Beca / SKM WTSM Technical Note 15.1 (WTSM-01 TN15.1). The intended role was to forecast the proportions of 0, 1 and 2+ car owning households in each zone, for input into the family structure and trip end models.

This is important as the proportions of households which own 0, 1, or 2(+) cars directly impacts on both:

- The trip generation model (the more cars per household, the more trips per day); and
- The mode choice model (the less cars per household the more likely residents are to use public transport).

2.2 Approach to the 2006 Update of the Car Ownership Model

WTSM-01 TN15.1 used time series data sourced from a Booz Allen Hamilton (BAH) report on car ownership trends and Statistics NZ information to build up a number of predictor variables that could be used to help forecast car ownership rates. The BAH research has been used as basis for forecasting car ownership rates for a number of 3 and 4 stage transportation models in NZ and at the time was considered best practice.

The WTSM-01 Beca / SKM investigation concluded with the model form reported in Figure 2-1 below. The investigation projected slightly lower car ownership rates than the BAH report and this was attributed in WTSM-01 TN15.1 to using a different gross domestic product (GDP) elasticity. The differences are illustrated in Figure 2-2 and precise parameters used are listed in Appendix B, Table B1.

The mathematical structure is as follows (it is the same at each level in the model):

$$P_m = S_{mh}/[1 + \text{Exp}(LP_{mh})]$$

where:

P_m is the car ownership probability for model m; m=1 refers to the probability of owning 1 or more cars; m=2 refers to the probability owning 2 or more cars for the group of households owning at least 1 car;
S_{mh} is the saturation level for each model which can be a function of the household type h,
and LP is called the linear predictor.

and:

$$LP_{mh} = \alpha_{mh}.f(I) + \delta_{mh}$$

where:

α is the coefficient of some function of household income I (either income, log income or square root of income – established through statistical analysis),
δ is a constant,
the values varying by model m and household category h.

The convention is to symbolise the probability of owning one or more cars as $P_{1+/0}$ and the probability of owning 2 or more cars, given at least one car is owned as $P_{2+/1+}$.

Figure 2-1: Extract from WTSM-01 TN15.1 on the Form of the Car Ownership Model

Final car ownership model parameters used in the 2011 model are included in Appendix B for completeness (they have not been altered from the 2006 model). For more detail on what these parameters are the reader should refer to WTSM-01 TN15.1.

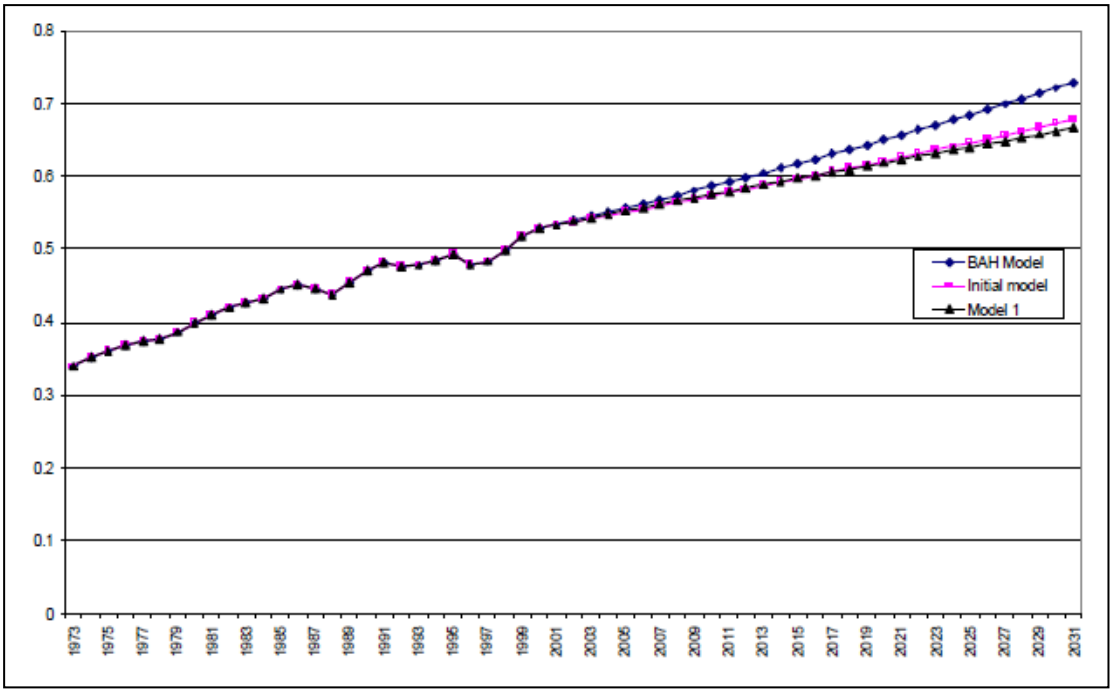

Figure 2-2: Extract from WTSM-01 TN15.1 on the Car Ownership forecasts

Figure 2-2 shows both the initial and preferred modelling approach (from WTSM-01 TN15.1) compared with the BAH process. For the purposes of the WTSM 2011 update the 'initial' model can be ignored as it was the Model 1 (or the "preferred model") that was taken forward into the forecasts.

2.3 Issues with the 2011 Update of the Car Ownership Model

Four stage transport model updates in New Zealand are traditionally undertaken after a national census. For the car ownership model this means car ownership inputs to the demographic data need to be rebased at the same time. For the 2006 model update, census data was available, however due to the September 2010 and February 2011 Christchurch earthquakes no census data was available for this 2011 model update. This required a re-estimation of base 2011 demographic inputs (which has been documented in TN29).

A methodology therefore needed to be developed which provided the most robust estimate for the 2011 car ownership data. A brief was prepared for DYC to investigate the following sources:

- The 1996, 2001 and 2006 census car ownership rates;
- The 1996, 2001, 2006 and 2011 car registrations; and
- The National Household Travel Survey data from Ministry of Transport.

The following section summarises the evaluation of those data sources and goes on to document the final selected methodology.

3 Methodology

DYC was asked to investigate the best source of data for rebasing car ownership rates to 2011. Those options are summarised below:

- **NZTA Vehicle Registration Data.** This was suggested by Opus as a potential source of data as it may have been possible for it to be combined with Statistics NZ estimates of households and population to produce WTSM car ownership rates. This approach was ultimately discarded due to the concerns that the data was difficult and time-consuming to collect (especially at a regional level).

- **National Household Travel Survey (NHTS).** The Ministry of Transport were able to supply trends in car ownership rates going back as far as 2003. However, the low sample sizes meant that it was more statistically appropriate to analyse this data as 2-year moving averages rather than for each individual year. Despite using the moving averages approach it was found to be markedly different from historical census data and consequently DYC concluded that it was inadvisable to use the NHTS data in the car ownership rebasing process.

- **Census Trend Data for 1996, 2001, and 2006.** After these investigations, DYC concluded (with agreement from Opus) that the best approach was to extrapolate time series census data for car ownership rates to 2011. Three sub options were considered:
  - A: Extrapolation of straight line between 1996 and 2006;
  - B: Extrapolation of straight line between 2001 and 2006; and
  - C: Exponential functions for 0 and 1 cars, with 2+ cars making the difference to 100%.

  DYC's investigation concluded that sub option C be used to determine the target car ownership levels in updating the WTSM car ownership models to 2011.

With regards to forecasting, the demographic forecasts were rebased in a process described in TN29. Car ownership categories are then updated using the approach below:

- A future regional average income growth is assumed (shown in Appendix B as 1.7952%);
- The incomes of surveyed households are uniformly factored by the assumed growth;
- The car ownership model is run to generate the forecasts of car ownership for each household type and for each band (for each household type and each model: 1/ 2+. See WTSM-01 TN15.1 for further details);
- The car ownership level for a particular zone is taken for the relevant band;
- Car ownership is summed across the zones in the region and compared with the forecasts of the time series model (Table B2 in Appendix B); and
- A further adjustment to the linear estimator is introduced which ensures that, when the car ownership model is re-run, the car ownership totals match the time series model regional target rate.

4 Results

After completion of the calculation the figures in Table 4-1 below compare:

- The 2011 estimated target of proportions of households, by car ownership levels;
- The initial 2011 model (before any adjustment); and
- The final 2011 model (after adjustment).

Table 4-1: Regional Car Ownership Rebased 2011

	Estimated Target		WTSM Initial		WTSM Final	
	Households	%	Households	%	Households	%
0 cars	17,965	10.28%	19,943	11.41%	17,989	10.30%
1 car	73,730	42.20%	74,571	42.68%	73,583	42.11%
2+ cars	83,036	47.52%	80,216	45.91%	83,158	47.59%
Total	174,730	100%	174,730	100%	174,730	100%

The update resulted in a final car ownership rate for 2011 of 0.592 cars / person in the Wellington region which compared with 0.569 for 2006 (and 0.599 forecast for 2011 in 2006). The implications of the 2011 rebasing exercise can be seen clearly in Figure 4-1. Overall it shows that forecast car ownership targets have decreased by between 1% and 1.2% between 2011 and 2041 compared with WTSM 06.

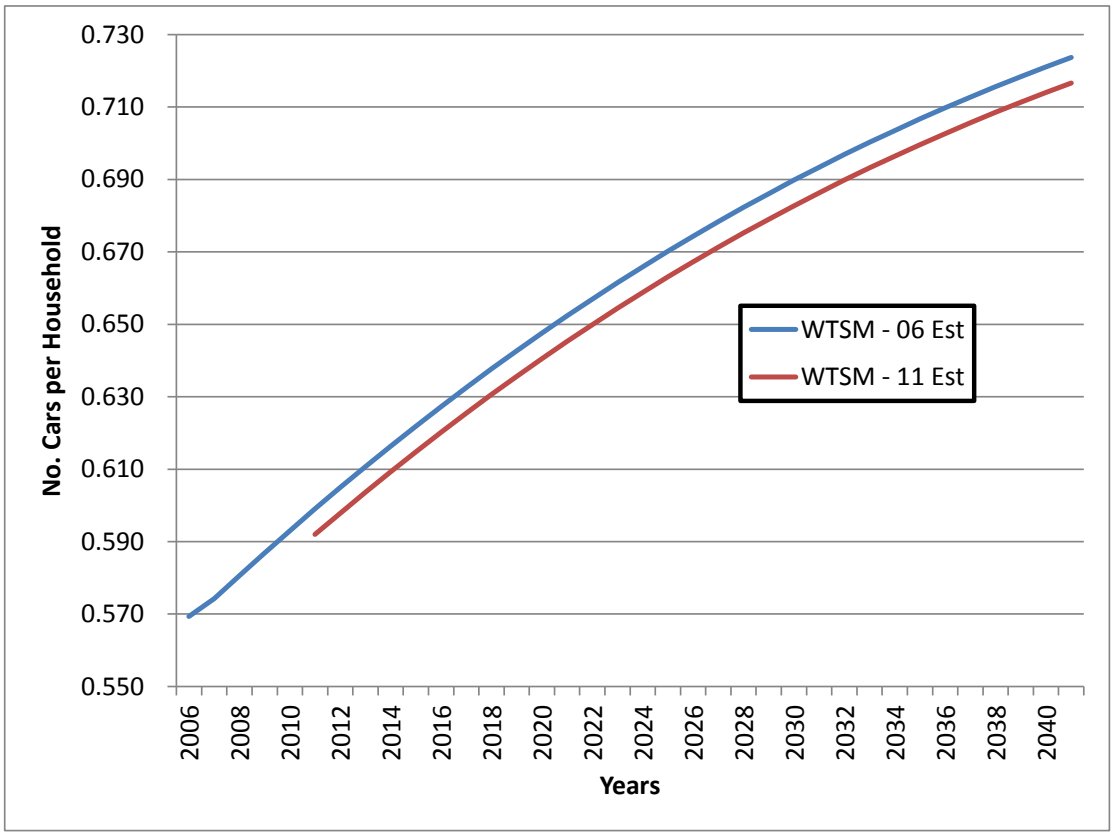

Figure 4-1: Rebasing Implications for Forecast Car Ownership Targets

5 Conclusion

David Young Consulting was sub-contracted to GWRC to investigate trends in car ownership in the Wellington region and therefore to formulate a proposed level of car ownership to be used in the updated 2011 base WTSM.

Ultimately DYC concluded (with agreement from Opus) that the best approach was to extrapolate time series census data for car ownership rates to 2011. Three sub options were considered:

- A: extrapolation of straight line between 1996 and 2006;
- B: extrapolation of straight line between 2001 and 2006; and
- C: exponential functions for 0 and 1 cars, with 2+ cars making the difference to 100%.

The investigation concluded that 'Estimate C' be used as the target car ownership levels in updating the WTSM car ownership models to 2011.

The update resulted in a final car ownership rate for 2011 of 0.592 cars/person in the Wellington region which compared with 0.569 for 2006 (and 0.599 forecast for 2011 in 2006). The implications of the 2011 rebasing exercise shows that forecast car ownership targets have decreased by between 1% and 1.2% between 2011 and 2041 compared with WTSM 06 forecasts.

APPENDIX A - David Young's Note on the Car Ownership Model Update

▪ Update of WTSM to 2011 Base Year -
▪ Car Ownership Model

1 Introduction

This note sets out the update of the WTSM car ownership model to a 2011 base year.

The update is undertaken by comparing actual car ownership in the Wellington region with the 2011 model forecast of the proportions of households by car ownership level (0 cars, 1 car, 2+ cars). The forecast is from the original model base year, 2001. An additive adjustment factor is applied which shifts the forecast up or down in order to fit the actual data.

As the 2011 Census was not undertaken the 2011 "actual" data has been estimated from analysis of historic Census data. Hence the "actual" is labelled the target car ownership.

2 2011 Target Car Ownership

Car ownership data for the Wellington region from the 1996, 2001, and 2006 Census have been collated and their trends analysed in order to determine the 2011 estimated car ownership levels.

Figure 2 shows the trends in car ownership for each level (0 cars, 1 car, 2+ cars), with the exponential trend line and equation given for 0 and 1 cars. From this it is apparent that the proportion of zero car households is declining over time, as is the proportion of 1 car households though at a lower rate, whereas 2+ car households are becoming a greater proportion of total households.

Figure 2 Census Car Ownership

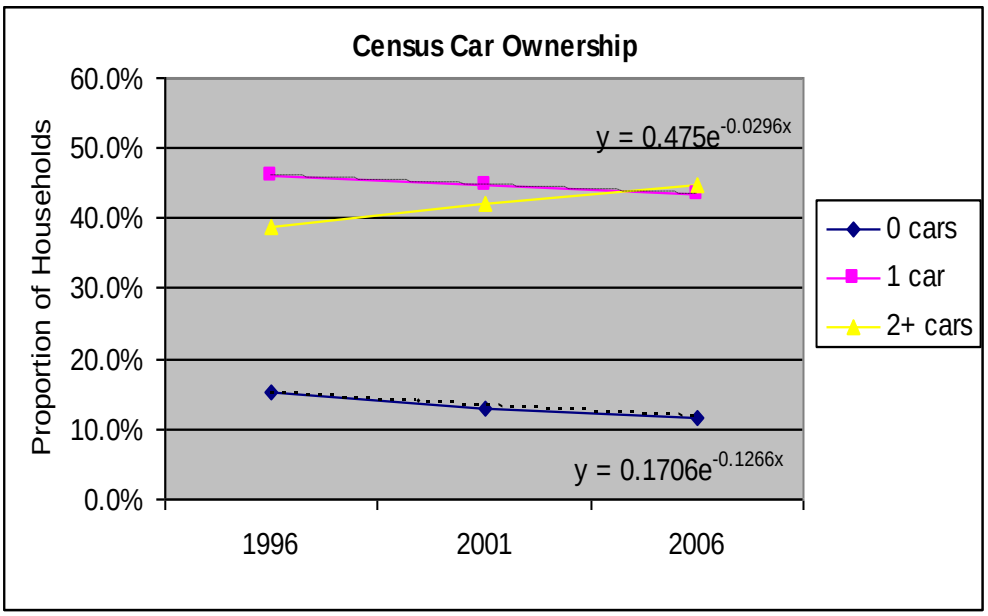

Table 2 gives the Census data and three estimates of 2011 regional car ownership. The 2011 estimates are based on the Census data as follows:

- A: extrapolation of straight line between 1996 and 2006,
- B: extrapolation of straight line between 2001 and 2006, and
- C: exponential functions for 0 and 1 cars (see **Figure 2**), with 2+ cars making the difference to 100%.

Table 2 Census and Estimated 2011 Car Ownership

	Census			2011 Estimated		
	1996	2001	2006	A	B	C
0 cars	15.1%	13.1%	11.7%	10.0%	10.4%	10.3%
1 car	46.1%	44.7%	43.5%	42.2%	42.3%	42.2%
2+ cars	38.7%	42.2%	44.8%	47.8%	47.3%	47.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

The curved trend in the Census data for 0 cars suggests that Estimate A would give a slightly lower than expected proportion in 2011; while Estimate B would tend to give a slightly high estimate for 0 cars. Estimate C gives car ownership levels between these two.

Similarly, for 2+ cars, A would a slightly higher estimate than suggested by the graph, and C a slightly lower estimate, with C in between.

Hence, from this analysis of historic Census data trends it is suggested that Estimate C be used as the target car ownership levels in updating the WTSM car ownership models to 2011.

In an attempt to confirm the above proposal, data has been sourced from the National Household Travel Survey database. Households by car ownership levels for the years 2003 to 2010 was available, but the low sample sizes meant that it was more statistically appropriate to analyse this data as 2-year moving averages rather than for each year. The sample sizes in each 2-year period were around 200.

In providing this data Lynley Povey of the MoT commented that it was recognised that the zero car households are lower than in the Census possibly due to under-representation of inner city apartment dwellers and residents of gated communities arising from access difficulties.

This is evident in the data as presented in Table 3. It is also evident that there is no consistent trend in the data at any of the three car ownership levels, which will be related to the relatively low sample sizes.

Table 3 National Household Travel Survey, Car Ownership in Wellington

	2003_2005	2004_2006	2005_2007	2006_2008	2007_2009	2008_2010
0 cars	6.5%	6.4%	6.6%	7.1%	6.9%	6.2%
1 car	43.3%	43.8%	44.3%	47.9%	50.8%	41.4%
2+ cars	50.2%	49.8%	49.1%	45.0%	42.2%	52.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Given this, it is not possible to use the NHTS data to confirm or otherwise the 2011 car ownership targets estimated from the Census data. As such, the target levels proposed above, Estimate C, will be used.

3 2011 Target Car Ownership

Table 4 gives the proportion of households by car ownership levels for 2011 estimated target, the initial 2011 model (before any adjustment) and the final 2011 model (after adjustment). This equates to 0.592 cars/person in the Wellington region, compared with 0.569 in 2006.

Table 4 Car Ownership

	Estimated Target		WTSM Initial		WTSM Final	
	Households	%	Households	%	Households	%
0 cars	17,965	10.28%	19,943	11.41%	17,989	10.30%
1 car	73,730	42.20%	74,571	42.68%	73,583	42.11%
2+ cars	83,036	47.52%	80,216	45.91%	83,158	47.59%
Total	174,730	100%	174,730	100%	174,730	100%

Any adjustments to the car ownership model in forecasting beyond 2011 need to be considered in the forecasting phase of the 2011 update. For this the temporal model will need to be adjusted to fit with the 2011 target of 0.592 cars/person and the forecasts beyond 2011 adjusted accordingly. This can only occur when the future land use inputs are available.

David Young

21 September 2011

APPENDIX B – Car Ownership Model Parameters

The following section tabulates some of the key modelling assumptions so it can be clearly seen which numbers were used. If this information needs to be understood in greater detail by the reader then they should seek access to and read WTSM 01 TN15.1.

Table B1: Car Ownership Parameters

Current	0/1 Model				1/2+ Model			
H'Hold Cat	Alpha	Delta	Saturation	Lambda	Alpha	Delta	Saturation	Lambda
1	-0.99022	1.590697	1	0.000				
2	-0.82946	1.590697	1	0.000				
3	-1.35895	1.590697	1	0.000	-0.012886	0.072287	0.95	0.000
4	-1.30666	1.590697	1	0.000	-0.002714	1.026083	0.95	0.000
5	-1.43795	1.590697	1	0.000	-0.039014	1.053779	0.95	0.000

Table B2: Car Ownership Time Series Model

Year	P_{1+}					$P_{2+/1}$					Income Growth	1.017952		Cars/person	
	Hhold Category 1	Hhold Category 2	Hhold Category 3	Hhold Category 4	Hhold Category 5	Hhold Category 1	Hhold Category 2	Hhold Category 3	Hhold Category 4	Hhold Category 5		Income index	Adjustment Factor	current	target
2001	0	0	0	0	0	0	0	0	0	0	0.00%	1.0000			
2002												1.0180			
2003												1.0362			
2004												1.0548			
2005												1.0738			
2006	0.012695	0.012695	0.012695	0.012695	0.012695	0.012695	0.012695	0.012695	0.012695	0.012695	2.40%	1.0930	1.00	0.5715	
2007												1.1127			
2008												1.1326			
2009												1.1530			
2010												1.1737			
2011	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	-0.122852	19.47%	1.1947	-3.70	0.591967	0.5920
2012												1.2162			0.5979
2013												1.2380			0.6036
2014												1.2603			0.6093
2015												1.2829			0.6148
2016	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	-0.258398	30.59%	1.3059	-4.20	0.6273	0.6202
2017												1.3293			0.6255
2018												1.3532			0.6306
2019												1.3775			0.6356
2020												1.4022			0.6405
2021	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	-0.562188	42.74%	1.4274	-10.28	0.6503	0.6453
2022												1.4530			0.6499
2023												1.4791			0.6544
2024												1.5057			0.6588
2025												1.5327			0.6631
2026	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	-0.674297	56.02%	1.5602	-12.33	0.6743	0.6672
2027												1.5882			0.6713
2028												1.6167			0.6752
2029												1.6458			0.6790
2030												1.6753			0.6827
2031	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	-1.029766	70.54%	1.7054	-18.83	0.6912	0.6863
2032												1.7360			0.6898
2033												1.7672			0.6932
2034												1.7989			0.6964
2035												1.8312			0.6996
2036												1.8641			0.7027
2037												1.8975			0.7057
2038												1.9316			0.7085
2039												1.9663			0.7113
2040												2.0016			0.7140
2041	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	-1.2974609	103.75%	2.0375	-23.725	0.7213	0.7166