Australasian Transport Research Forum 2015 Proceedings
30 September - 2 October 2015, Sydney, Australia
Publication website: http://www.atrf.info/papers/index.aspx

Assessing the effects of long-term travel behaviour changes on travel forecasts

Li Shen[1], Grace Corpuz[1], Peter Hidas[1]

[1]Bureau of Statistics and Analytics, Transport for NSW

Email for correspondence: li.shen@transport.nsw.gov.au

Abstract

The Sydney Household Travel Survey (HTS) was first conducted in 1997 and is now among the longest running continuous travel surveys in the world. The data from the Sydney HTS is used in a number of behavioural models including the Sydney Strategic Travel Model (STM) which is the main travel forecasting tool for this city.

The STM updates its model parameters regularly to take into account changes in travel behaviour as new HTS data becomes available. However, said parameters are then fixed when producing long term forecasts. This procedure does not take into consideration long-run travel behaviour changes in terms of how these parameters may have changed and whether these changes should be applied to adjust long term forecasts accordingly.

This study aims to inform this issue by investigating travel behaviour changes using available repeated cross-sectional data (i.e., HTS). The key measures of travel (i.e., the number of trips and travel distance) from 2001 to 2011 at a disaggregate level are analysed. Statistical tests are undertaken to show the travel behaviour changes over the ten years. Groups are formed based on people's socio-demographic characteristics consistent with those used as STM model parameters.

This paper examines whether travel behaviour has indeed changed from 2001 to 2011, and determine whether the behavioural models in the STM need to be adjusted to forecast long term travel demand. The results show that a number of those key indicators are significantly different between 2001 and 2011. These findings suggest that demand forecasts from the STM may need to be adjusted to take these changes into account.

1. Background

Travel behaviour research mainly focuses on the questions of how, when and where people travel, and how people use transport (Pendyala and Bhat, 2012). It explains how people would respond to changes of transport system and policies. The effects of travel behaviour change are taken into consideration in travel demand forecasting models. In Sydney, the Strategic Travel Model (STM) does this by updating its model parameters regularly to take into account changes in travel behaviour as new HTS data becomes available. However, said parameters are then fixed when producing long term forecasts. This procedure does not take into consideration long-run travel behaviour changes in terms of how these parameters may change into the future (Fox et al., 2014) and whether these changes should be applied to adjust long term forecasts accordingly.

While there is very limited literature discussed the temporal effects on STM model transferability, this issue has been assessed in mode choice models decades ago (Koppelman and Wilmot, 1982; Badoe and Miller, 1995). According to Fox et al. (2014), there are two typical methods which can be used for the assessment. One is to undertake statistical tests for the hypothesis of parameter transferability. The other method is to assess a model's predictive ability. These methods could also be used in the assessment of STM model transferability. Given this study is a preliminary study, the assessment at this stage only focuses on the travel behaviour change in the long run.

1.1 Sydney Household Travel Survey

The analysis in this paper is based on data from the Sydney Household Travel Survey (HTS). This survey is the largest and most comprehensive source of personal travel data for the Sydney Greater Metropolitan Area (GMA).

The HTS has been running continuously covering each day of the year since 1997, and is now the longest running household travel survey in Australia. It collects detailed trip and socio-demographic information by face-to-face interview.

About 5000 households are approached each year, of which over 3000 participate in the survey. Data from three or more years are typically pooled to produce a larger sample for analysis based on a methodology that was developed by the Australian Bureau of Statistics (ABS). For further details about the HTS and its expansion methodology, see BTS (2013).

The full geographic scope of the HTS data covers the Sydney and Illawarra Statistical Divisions, as well as the Newcastle Statistical Sub-Division. The analyses featured here focused on the Sydney Statistical Division only to achieve greater homogeneity given that travel in the Illawarra and Newcastle areas are quite different (BTS, 2012).

The analyses in this paper used:

(a) the 2001/02 estimates derived from five years of pooled data collected from June 1997 to June 2002, weighted to the 30 June 2001 population; and,

(b) the 2011/12 estimates which were derived from five years of pooled data collected from June 2007 to June 2012, weighted to the 30 June 2011 population.

The total samples for the Sydney Statistical Division for these two datasets are as follows:

Table 1 Total samples used for 2001/02 and 2011/12 datasets

Dataset	Households	Persons	Linked trips	Unlinked trips
2001/02 HTS estimates	14,054	36,908	131,441	186,656
2011/12 HTS estimates	13,357	34,933	123,655	175,144

Note: the sample counts in this table include five waves for each dataset.

1.2 Sydney Strategic Travel Model

The Sydney Strategic Travel Model (STM) is owned and operated by the Bureau of Transport Statistics (BTS) within Transport for NSW, which combines the understanding of travel behaviour with likely population and employment size and distribution, and likely road and public transport networks and services to produce travel demand forecasts for the GMA under different land use, transport and pricing scenarios. It is the primary tool used to test alternative settlement and employment scenarios; and determine the travel demand impacts from proposed transport policies, transport infrastructure or services (BTS, 2011).

The STM is implemented in two sections:

- Population Model

  This part involves the segmentation of the population into groups based on the socio-demographic characteristics that influence travel choice, car ownership and licence holding. These segments are 'grown' into the future based on the BTS population and workforce forecasts, as well as other projections and trends indicated by the HTS and Census data. This segmentation occurs at the model wide level and the travel zone level.

- Travel Model

  This is implemented in the EMME transport modelling software. It is comprised of a series of travel models by purpose, travel frequency, mode and destination choice. It is calibrated using the Journey-to-Work and HTS data. Freight movements are integrated to reflect the total travel demand which is then assigned to the road and public transport networks.

2. Data description

As mentioned in the previous section, the population is segmented into groups based on socio-demographic characteristics. Table 2 lists the segments applied in the latest Sydney Strategic Travel Model (i.e., STM3).

Table 2 Variable Segments in the STM

Target	Group	Category
1	Age-Gender	Males aged 0-19
2		Males aged 20-39
3		Males aged 40-59
4		Males aged 60+
5		Females aged 0-19
6		Females aged 20-39
7		Females aged 40-59
8		Females aged 60+
9	Household Types	Couples with children
10		Couples only
11		Single parent
12		Single person
13		Other types
14	Workers	Full time workers
15		Part time workers
16	Income Bands	Children (aged <15)
17		$ 0 – 20,799
18		$ 20,800 – 31,199
19		$ 31,200 – 41,599
20		$ 41,600 – 67,599
21		$ ≥ 67,600
22	Students	Whether Tertiary Education Student*

*Tertiary education students include students in TAFE, colleges and universities.

There are five socio-demographic segmenting variables used to form the groups. In order to manage the analysis in this study, we focused our investigation on three characteristics (i.e., age-gender, household types and income). Children in the income bands was not specifically analysed because most of these children would be included in the age-gender analysis. Travel patterns were investigated at each of the eighteen groups within these three characteristics.

Since five-year pooled data was used in this research, samples in the five waves for each survey year were weighted to population. Table 3 shows the weighted number of people for each category.

Table 3 The weighted number of people for each group

Group	Category	Number of people_2001	Percentage	Number of people_2011	Percentage
Age-Gender	Males aged 0-19	563,783	28.5%	609,107	27.4%
	Males aged 20-39	582,239	29.4%	624,205	28.0%
	Males aged 40-59	543,881	27.5%	622,695	28.0%
	Males aged 60+	291,025	14.7%	370,945	16.7%
	Females aged 0-19	526,217	26.0%	554,220	24.5%
	Females aged 20-39	594,223	29.4%	638,013	28.2%
	Females aged 40-59	558,673	27.7%	669,286	29.6%
	Females aged 60+	341,194	16.9%	403,072	17.8%
Household Types	Couples with children	2,165,549	54.1%	2,433,069	54.2%
	Couples only	744,137	18.6%	822,803	18.3%
	Single parent	492,647	12.3%	538,836	12.0%
	Single person	336,384	8.4%	376,957	8.4%
	Other types	262,518	6.6%	319,877	7.1%
Income Bands	$ 0 – 20,799	1,433,966	35.8%	1,463,348	32.6%
	$ 20,800 – 31,199	418,976	10.5%	363,549	8.1%
	$ 31,200 – 41,599	330,651	8.3%	429,369	9.6%
	$ 41,600 – 67,599	579,772	14.5%	729,170	16.2%
	$ ≥ 67,600	442,851	11.1%	661,234	14.7%
	Children (aged <15)	795,019	19.9%	844,874	18.8%

From Table 3, it can be noticed that while the majority of the population were still less than 40 years old, Sydney is experiencing aging issues because the distributions of age in both males and females were starting to skew to the left. The distribution of household types was similar between 2001 and 2011. In terms of personal income, annual income[1] has increased over the ten year.

3. Data Analysis

The primary purpose of this study is to investigate whether travel behaviour for the same segments is like to change in the long term. The key indicators used in this study to examine travel behaviour change were:

- The number of total trips per person per weekday;
- The number of driving trips per person per weekday;
- The number of public transport trips per person per weekday;
- Person kilometres travelled (PKT) per person per weekday;
- Vehicle kilometres travelled (VKT) per person per weekday; and
- The total distances travelled by public transport modes (train and bus only in this study) per person per weekday.

[1] Annual personal income has been adjusted (based on Sydney CPI).

Analysis involved the use of 95% and 99% confidence intervals. These were constructed using data that were weighted but normalised to execute proper statistical tests of significance particularly when comparing means (Shaz and Corpuz, 2008). The estimates were normalised by using a factor equal to the sample size divided by the population size or the sum of weights (n/N). According to Table 1 and Table 3, the factors for 2001 and 2011 are 0.0092 and 0.0077.

The weighted mean can be calculated by the formula (1):

$$\bar{y}_w = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i} \tag{1}$$

Where

$\bar{y}_w$ = weighted mean,
w_i = weight for each observation,
y_i = each observation.

In this study, samples are independently drawn[2] from the population, so the variance of the weighted mean can be calculated by:

$$Var(\bar{y}_w) = \frac{V(y)\sum_{i=1}^{n} w_i^2}{\left(\sum_{i=1}^{n} w_i\right)^2} \tag{2}$$

$$= \frac{V(y)}{n_w} \tag{3}$$

Where

$V(y)$= Variance of the observations,
$n_w = \frac{\left(\sum_{i=1}^{n} w_i\right)^2}{\sum_{i=1}^{n} w_i^2}$, adjusted weighted sample size.

Therefore, designating two independent datasets (i.e., 2001/02 and 2011/12 in this study) by subscripts *a* and *b*, according to the equation (3), the sampling error for the difference in the weighted means between the two waves is given by:

$$s.e.(\bar{y}_{wa} - \bar{y}_{wb}) = \sqrt{\frac{V(y_a)}{n_{wa}} + \frac{V(y_b)}{n_{wb}}} \tag{4}$$

Where

$\bar{y}_{wa}, \bar{y}_{wb}$= Weighted means for year 2001/02 and 2011/12.

3.1 Analysis of Age-Gender Groups

As mentioned above, six key transport indicators were compared to see if there is significant travel behaviour change between 2001 and 2011. Tables 4 and 5 show the results of an analysis of travel behaviour change for age-gender groups.

In Table 5, a positive value for the differences of means indicates that the mean has increased in 2011 compared with 2001; a negative value indicates the mean of that indicator has dropped from 2001.

According to equation (4), one can calculate the 95% confidence limits. Results from Table 5 show that none of the indicators have significantly changed between 2001 and 2011 at the

[2] Technically, HTS sample is not strictly independently drawn because people from the same selected household are sampled. The test was based on the assumption of simple random sampling while HTS uses cluster sampling. Therefore, 99% confidence interval was also used to take into consideration the larger sampling error due to the cluster effect.

aggregate level; however, there are a number of key indicators that are significantly different for each age-gender group, with some significant at 99% level. Twenty-four out of 48 categories shown in the table are statistically significant at 95% level, and 17 of them are significant at 99% level. These findings indicate that travel behaviour has changed between 2001 and 2011 based on the analysis for age-gender groups.

By investigating age-gender category in detail, main findings for the age-gender analysis are as follows:

- Travel behaviour for males has changed more significantly than females from 2001;
- Most of the groups have not significantly changed the number of public transport trips per person per day;
- The number of daily driver trips for most groups are significantly different;
- Younger people (both male and female) travelled less and older people travelled more in 2011 according to the number of total trips per person per day for most of groups;
- Daily driver trips per person has increased for females (especially for older females according to the percentage change of the mean) but decreased for their male counterparts;
- The average daily public transport trips were similar between 2001 and 2011 for all groups.

Table 4 Mean values for each key indicator per person per weekday for age-gender groups

Age-gender category	Total Trips				Driver Trips				PT (Bus and Train) Trips			
	Number of trips		Distance (kms)		Number of trips		Distance (kms)		Number of trips		Distance (kms)	
	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011
Males aged 0-19	3.44	3.20	21.84	20.87	0.30	0.21	3.03	2.29	0.50	0.44	4.44	3.85
Males aged 20-39	4.29	4.08	45.56	42.24	2.75	2.34	34.23	29.21	0.47	0.57	6.51	8.11
Males aged 40-59	4.66	4.38	48.08	45.42	3.43	3.08	39.34	37.31	0.32	0.32	5.17	4.88
Males aged 60+	3.41	3.77	23.12	28.74	2.14	2.42	16.35	22.38	0.30	0.26	3.38	2.97
Females aged 0-19	3.44	3.30	19.79	20.15	0.17	0.13	1.60	1.38	0.54	0.47	4.69	4.26
Females aged 20-39	4.40	4.30	32.10	31.75	2.39	2.25	18.84	18.91	0.48	0.51	6.02	6.40
Females aged 40-59	4.36	4.50	30.27	33.17	2.74	2.96	19.92	23.74	0.33	0.30	4.20	3.85
Females aged 60+	2.62	3.16	15.52	20.91	0.84	1.32	5.27	9.83	0.38	0.32	3.65	3.43
Total	3.93	3.89	30.8	31.19	1.90	1.88	18.18	18.67	0.43	0.41	4.93	4.89

Table 5 Difference between 2001 and 2011 for age-gender groups

Age-gender category	Differences of the means (95% Confidence Limit)											
	Total Trips				Driver Trips				PT (Bus and Train) Trips			
	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference
Males aged 0-19	-0.24 ±(0.15)**	-7.0%	-0.98 ± (1.63)	-4.4%	-0.09 ± (0.06)**	-30.0%	-0.74 ± (0.66)*	-24.4%	-0.06 ± (0.05)*	-12.0%	-0.59 ± (0.64)	-13.3%
Males aged 20-39	-0.21 ± (0.19)*	-4.9%	-3.32 ± (2.72)*	-7.3%	-0.41 ± (0.16)**	-14.9%	-5.03 ± (2.49)**	-14.7%	0.10 ± (0.06)**	21.3%	1.60 ± (1.03)**	24.6%
Males aged 40-59	-0.27 ± (0.22)*	-6.0%	-2.66 ± (2.91)	-5.5%	-0.35 ± (0.19)**	-10.2%	-2.03 ± (2.77)	-5.2%	-0.01 ± (0.05)	0.0%	-0.29 ± (0.92)	-5.6%
Males aged 60+	0.36 ± (0.23)**	10.6%	5.62 ± (2.85)**	24.3%	0.28 ± (0.20)**	13.1%	6.02 ± (2.53)**	36.9%	-0.05 ± (0.06)	-13.3%	-0.40 ± (1.03)	-12.1%
Females aged 0-19	-0.14 ± (0.15)	-4.1%	0.35 ± (1.56)	1.8%	-0.04 ± (0.04)	-23.5%	-0.23 ± (0.46)	-13.8%	-0.07 ± (0.05)*	-13.0%	-0.43 ± (0.70)	-9.2%
Females aged 20-39	-0.10 ± (0.19)	-2.3%	-0.35 ± (2.00)	-1.1%	-0.15 ± (0.15)	-5.9%	0.07 ± (1.60)	0.4%	0.03 ± (0.06)	6.3%	0.38 ± (0.88)	6.3%
Females aged 40-59	0.14 ± (0.20)	3.2%	2.91 ± (2.01)**	9.6%	0.21 ± (0.17)*	8.0%	3.82 ± (1.69)**	19.2%	-0.03 ± (0.05)	-9.1%	-0.35 ± (0.76)	-8.3%
Females aged 60+	0.54 ± (0.19)**	20.6%	5.39 ± (2.11)**	34.7%	0.48 ± (0.13)**	57.1%	4.56 ± (1.24)**	86.5%	-0.07 ± (0.07)*	-15.8%	0.54 ± (1.02)	-6.0%
Total	-0.04 ± (0.07)	-1.0%	0.34 ± (0.81)	1.3%	-0.02 ± (0.05)	-1.1%	0.48 ± (0.68)	2.7%	-0.02 ± (0.02)	-4.7%	-0.04 ± (0.31)	-0.8%

*Significant at 95% level
** Significant at 99% level

3.2 Analysis of Household Types

Household type is usually regarded as an important attribute in travel demand forecasting. Here, we examine how travel behaviour may have changed for different types of households (see Tables 6 and 7).

Based on the mean values for each household type, it seems that households without children travelled more and longer both in 2001 and 2011, however the differences were minor compared to households with children. In terms of differences of mean values between 2001 and 2011, people in all the types of households appear to have travelled slightly longer distance in 2011 than in 2001.

Compared with the age-gender groups, the significant findings occur in much fewer instances. Only four out of 30 categories examined are significantly different at 95% between 2001 and 2011. Overall, the results show that travel behaviour has not significantly changed based on household types.

3.3 Analysis of Income Bands

As mentioned above, STM models' parameters are updated regularly to take into account changes in travel behaviour. Income is one of them. It has been updated in the latest STM. However, income bands are fixed when forecasting future years. Therefore, it is also important to test if travel behaviour would significantly change in the long term. Tables 8 and 9 show the results of testing the travel behavioural change for different income groups.

From Table 8, it is clear that low-income people travelled less than high-income groups, although it appears that the average trip length may be slightly increased. Overall, eight out of 30 indicators are significantly different between 2001 and 2011 with the same income segmentation. Table 9 indicates that the low-income people have not significantly changed their travel behaviour, but the rich have significantly decreased their driver trips.

Table 6 Mean values for each key indicator per person per weekday for household types groups

Household types category	Total Trips				Driver Trips				PT (Bus and Train) Trips			
	Number of trips		Distance (kms)		Number of trips		Distance (kms)		Number of trips		Distance (kms)	
	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011
Couples with children	4.07	3.96	32.52	32.32	2.00	1.94	18.99	19.08	0.37	0.35	4.50	4.58
Couples only	3.84	3.85	33.07	32.25	2.06	2.03	20.82	21.23	0.39	0.35	5.25	4.65
Single parent	3.83	3.73	25.64	29.58	1.60	1.63	13.56	15.99	0.53	0.50	5.40	5.27
Single person	3.56	3.79	26.33	27.13	1.67	1.77	17.01	17.48	0.58	0.56	5.84	5.81
Other types	3.65	3.86	26.27	27.34	1.45	1.50	14.24	14.79	0.61	0.65	5.50	6.10

Table 7 Difference between 2001 and 2011 for household types groups

Household types category	Differences of the means (95% Confidence Limit)											
	Total Trips				Driver Trips				PT (Bus and Train) Trips			
	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference
Couples with children	-0.11 ±(0.09)*	-2.8%	-0.20 ± (1.08)	-0.6%	-0.06 ± (0.08)	-2.8%	0.10 ± (0.91)	0.5%	-0.02 ± (0.02)	-5.0%	0.08 ± (0.38)	1.8%
Couples only	0.02 ± (0.16)	0.4%	-0.82 ± (2.04)	-2.5%	-0.03 ± (0.12)	-1.5%	0.41 ± (1.73)	1.9%	-0.04 ± (0.04)	-9.6%	-0.6 ± (0.79)	-11.5%
Single parent	-0.10 ± (0.23)	-2.5%	3.94 ± (2.57)**	15.4%	0.03 ± (0.19)	1.8%	2.43 ± (2.13)*	17.9%	-0.04 ± (0.08)	-7.0%	-0.13 ± (1.05)	-2.4%
Single person	0.24 ± (0.24)	6.6%	0.80 ± (2.75)	3.0%	0.10 ± (0.18)	6.3%	0.47 ± (2.36)	2.7%	-0.01 ± (0.09)	-2.5%	-0.03 ± (1.29)	-0.5%
Other types	0.21 ± (0.17)*	5.8%	1.07 ± (1.99)	4.1%	0.05 ± (0.13)	3.3%	0.56 ± (1.64)	3.9%	0.04 ± (0.06)	6.9%	0.60 ± (0.80)	10.8%

*Significant at 95% level
** Significant at 99% level

Table 8 Mean values for each key indicator per person per weekday for income groups

Income category	Total Trips				Driver Trips				PT (Bus and Train) Trips			
	Number of trips		Distance (kms)		Number of trips		Distance (kms)		Number of trips		Distance (kms)	
	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011	2001	2011
$ 0 – 20,799	3.51	3.48	22.61	23.22	1.61	1.57	11.20	11.58	0.48	0.46	4.80	4.75
$ 20,800 – 31,199	4.27	4.22	36.11	32.61	2.61	2.61	23.62	22.70	0.43	0.35	6.07	4.26
$ 31,200 – 41,599	4.43	4.34	42.07	40.88	2.92	2.87	31.03	29.36	0.40	0.41	5.42	5.74
$ 41,600 – 67,599	4.76	4.44	47.63	44.41	3.21	2.88	35.25	33.10	0.43	0.42	6.72	6.51
$ ≥ 67,600	4.73	4.65	46.61	44.31	3.07	2.79	36.38	33.12	0.42	0.46	5.99	6.86

Table 9 Difference between 2001 and 2011 in terms of income groups

	Differences of the means (95% Confidence Limit)											
	Total Trips				Driver Trips				PT (Bus and Train) Trips			
Income category	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference	Number of trips	% difference	Distance (kms)	% difference
$ 0 – 20,799	-0.03 ± (0.11)	-0.9%	0.62 ± (1.17)	2.7%	-0.04 ± (0.09)	-2.5%	0.39 ± (0.86)	3.4%	-0.01 ± (0.04)	-4.2%	-0.05 ± (0.53)	-1.0%
$ 20,800 – 31,199	-0.05 ± (0.24)	-1.2%	-3.51 ± (2.77)*	-9.7%	0.00 ± (0.20)	0.0%	-0.92 ± (2.38)	-3.9%	-0.08 ± (0.06)*	-18.6%	-1.81 ± (1.04)**	-29.8%
$ 31,200 – 41,599	-0.08 ± (0.25)	-2.0%	-1.19 ± (3.25)	-2.8%	-0.05 ± (0.22)	-1.7%	-1.67 ± (2.88)	-5.4%	0.01 ± (0.07)	2.5%	0.32 ± (1.18)	5.9%
$ 41,600 – 67,599	-0.31 ± (0.19)**	-6.7%	-3.22 ± (2.59)*	-6.8%	-0.33 ± (0.16)**	-10.3%	-2.15 ± (2.36)	--6.1%	0.00 ± (0.05)	-2.3%	-0.21 ± (0.96)	-3.1%
$ ≥ 67,600	-0.08 ± (0.22)	-1.7%	-2.30 ± (2.79)	-4.9%	-0.28 ± (0.18)**	-9.1%	-3.27 ± (2.63)*	-9.0%	0.04 ± (0.05)	9.5%	0.88 ± (0.98)	14.5%

*Significant at 95% level
** Significant at 99% level

4. Summary and Future Work

This study investigated the travel behaviour change in a ten-year period using the Sydney Household Travel Survey (HTS) data. The rationale is to improve the Sydney Strategic Travel Model (STM) (if needed) given that its model parameters are estimated for the base year from available HTS data and then these same parameters are used when forecasting long-term travel demand. While the segmentation in the STM is more complex and detailed, three main groups (i.e., Age-gender, household types in households and income bands) were chosen to limit the research scope for this preliminary study. Further study may explore the other groups. Also, to be consistent with STM, HTS data from 2001 and 2011 was examined in this study.

Six key transport indicators (i.e., total number of trips per person, the number of driver trips per person, the number of public transport trips per person, PKT, VKT and total travel distance per person) were used in the tests. The results show that a number of those key indicators are significantly different between 2001 and 2011. These changes include:

- the number of daily driver trips are significantly different for most groups;
- younger people travelled less and older people travelled more;
- travel behaviour has not significantly changed in terms of household types;
- high-income people travelled less while low-income people have not significantly change their travel behaviour.

These results indicate that travel behaviour significantly changes over longer time periods within the same population segment. These findings suggest that demand forecasts from the STM may need to be adjusted to take these changes into account. People for the same age-gender groups seem to have more significant changes in their travel behaviour.

While this study has proved that travel behaviour can significantly change in the long term within the same groups used in the STM, this study only focused on pooled data for 2001 and 2011. The definitive tendency and causes of the change need to be investigated in future work. More importantly, whether the tendency and the causes will still affect travel behaviour in the future also need to be assessed to determine what adjustment of the parameters is required for producing better justified future travel forecasts. Given that this study is a preliminary study, and the main purpose is to discover and show if there are any significant changes over time in travel behaviour parameters, it still needs more analyses to draw conclusions on the implications for the STM.

References

Badoe, D. and E. Miller. (1995). Analysis of the temporal transferability of disaggregate work trip mode choice models. *Transportation Research Record: Journal of the Transportation Research Board* 1493: 1–11.

Bureau of Transport Statistics. (2011). *Sydney Strategic Travel Model (STM) Technical Documentation*. Sydney, Australia.

Bureau of Transport Statistics. (2012). *2010/11 HTS Summary Report*, Sydney, Australia.

Bureau of Transport Statistics. (2013). *Household Travel Survey 2011/12 Technical Documentation*, November 2013 Release, Sydney, Australia.

Fox, J., Daly, A., Hess, S. and Miller, E. (2014). Temporal transferability of models of mode-destination choice for the Greater Toronto and Hamilton Area. *Journal of Transport and Land Use,* vol. 7, no.2 (2014) pp. 41–62

Koppelman, F. and C. Wilmot. (1982). Transferability analysis of disaggregate choice models. *Transportation Research Record* 895: 18–24.

Pendyala, R. M. and Bhat, C. R. (2012). Meeting the Travel Behaviour Research Needs of an Evolving World. *Travel Behaviour Research in an Evolving World: Selected Papers from the 12th International Conference on Travel Behaviour Research*, Chapter 1, pp 3-12, Edited by Pendyala, R. M. and Bhat, C. R., Lulu.com publishers, USA.

Shaz, K. and Corpuz, G. (2008). Serving Passengers – Are You Being Served? *4th Annual PATREC Research Forum.* 2 October 2008, Perth, Australia