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The Future Direction of Household Travel Surveys Methods in Australia

Li Shen[1], Sherri Fields[1], Peter Stopher[2], Yun Zhang[1]

[1] Innovation, Research and Reform, Transport for NSW. [2] PlanTrans LLC

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

Abstract

Household Travel Surveys (HTS) are conducted in transport jurisdictions worldwide to provide data for transport modelling and planning. The HTS survey methods that have been used over the past five decades have ranged from face-to-face interviews to GPS/Smartphone surveys. In the past decade, data collection methods have been changing rapidly, alongside the rapid development of technology and the application of big data. In Australia, Household Travel Surveys have only been conducted at the State (Capital city) level, with the majority of states using face-to-face interviews or mail out/mail back methods, while Sydney recently adopted computer assisted personal interviews (CAPI).

The aim of this paper is to use both the outcomes of the recent HTS review and an analysis of Opal smartcard data to provide direction for conducting surveys in Australia in the future. This paper reviews up-to-date national and local travel survey methodologies implemented worldwide in the past decade, in order to provide recommendations for improving HTS in Australia. These improvements include improving data quality and other methodological frameworks such as involving additional data sources while retaining the transport modelling requirements. The paper also undertakes a case study of Sydney CBD using data from Sydney's Opal smartcard ticketing system to validate the results of public transport travel from the Sydney HTS against Opal data. The results show that there are some differences between train and bus on a typical weekday and also in certain time periods in the CBD, which suggests that HTS weights may need to be readjusted to correct the estimation. However, the distribution of train and bus trips during the day is not significantly different between Opal data and HTS estimates.

1. Introduction

Travel surveys have been used for transport planning and modelling in transport since the 1950s. There have been a number of papers that review the development of travel survey methods in the last 60 years from face-to-face interviews, which were used first in the 1950s, to passive data collection methods (such as GPS or Smartphone surveys) introduced in the late 1990s (Tsui, 2005; Bricka et al., 2009). Stopher et al. (2011) provided a detailed review of national household travel surveys and proposed a framework for conducting an Australian National HTS. However, an Australian NHTS has not been conducted to date. One of the reasons is that population density is relatively high in capital cities in Australia, so travel surveys are conducted more efficiently in metropolitan areas of capital cities. While there has been no NHTS conducted in Australia in the past decade, each capital city still conducts its own HTS to collect travel data to support transport planning.

In the past five years, Smartphone and GPS devices have been increasingly used in travel surveys around the world. Since the late 1990s, new technologies were mainly adopted in pilot surveys or research projects until a GPS-only travel survey was conducted in the Greater Cincinnati region in the late 2000s (Stopher and Wargelin, 2010). In the next section, recent HTS trends are discussed. Section 3 provides an up-to-date review of HTSs in Australia. Some suggestions for the conduct of future HTS, such as including GPS or smartphone data and other data resources, is proposed in section 4, followed by a case study of HTS validation.

2. HTS methods and trends around the world

A review of household travel surveys conducted at both the metropolitan and regional/national level within the past decade has revealed two new approaches evident in almost every survey: 1) a multi-mode approach to retrieving data and 2) a GPS component. While some traditional survey methods are still undertaken in several surveys (e.g., Japan used mail-out/mail-back in their latest national travel survey), there has been an increasingly heavy reliance on telephone surveys. Nevertheless, this trend may prove to be short lived, primarily due to the rapid penetration of mobile phones and the increasing movement away from land lines. In place of the telephone, web-based surveys are becoming increasingly popular, although they are restricted to populations where there is a high penetration of computers and Internet use. Thus, in place of face-to-face interviews, there is increasingly heavy use made of CATI (Computer Assisted Telephone Interviewing), CAPI (Computer Assisted Personal Interviewing), TAPI (Tablet Assisted Personal Interviewing), and CAWI (Computer Assisted Web Interviewing). Germany uses a combined method including both CATI and CAWI, whilst the Netherlands has adopted a multi-mode approach to retrieve data where the web-based survey was used as the main method and face-to-face interviews were conducted for those households who do not have internet access.

In the early 2000s, while new technologies (e.g., GPS and Smartphone) have been tested in a number of surveys in different countries (Shen and Stopher, 2014), most of them have been pilot surveys or research projects. However since 2010, a GPS component is becoming increasingly popular in national or metropolitan travel surveys. In the latest national travel survey in Britain, France, Israel, and Singapore, a subsample has been drawn from a GPS or Smartphone survey where respondents were asked to carry a GPS/Smartphone device with them when they were travelling. New Zealand, different from the countries listed above, is using both GPS units and online forms together as a main method to collect travel data for seven days. Respondents are given the option of carrying a small GPS unit and they can record the travel information using an online interface. China’s capital city, Beijing, and a number of regions in the US also have conducted a GPS survey as a subsample of their main survey, although the US national household travel survey does not include a GPS component.

There have been two GPS-only travel surveys conducted in Ohio, USA (Stopher and Wargelin, 2010; Wilhelm et al., 2014). In a GPS-only travel survey, respondents only need to carry a GPS unit or Smartphone when they travel and provide socio-demographic information via interviews or online-forms. The challenge with using a GPS-only approach to collect data is that information on trip ends, travel modes, and trip purpose cannot be directly recorded in the devices, which will be detected either in a “real time” detection system or a “post-processing” procedure (Shen and Stopher, 2014). Table 2.1 provides a summary of the regional or national HTSs conducted worldwide.

Table 2.1 Regional and national household travel surveys around the world

Location	Survey Name	Year of First Survey Ran	Reconvened Surveys	Data collection method (latest)	Sample Size	Area Covered
Finland	National Transport Survey/ National Travel Survey	Started in 1974	Repeated 6 times	CATI	16,000 persons	Nationwide
France	National Household Travel Survey (NHTS)	Started in 1966	Repeat surveys in 1973, 1981, 1993, 2007	Face-to-face interviews with a GPS subsample	22,000 households	Nationwide
Germany	Mobility in Germany	Started in 1976	Repeated in 1982, 1989, 2002 and 2008	CAWI and CATI	50,000 households	Nationwide
Japan	Nationwide Person Trip Survey	Started in 1987	Repeated in 1994, 1999, 2005, and 2010	Mail-out/mail-back in 2010	38,000 persons in 2010	Nationwide
Israel	National Travel Habits Survey	Started in 1973	Repeated 4 times	CATI with a GPS sub-sample	56,000 households	Nationwide
Netherlands	National Mobility Survey	Started in 1978	Annually until 2008 and then 2010	Web based survey and face to face interviews	21,500 households	Nationwide
New Zealand	New Zealand Household Travel Survey (HTS) renamed as the Domestic Travel Survey (DTS)	Started in 1989	Repeated twice then annually since 2003	GPS and online-forms	2200 households	Nationwide
Norway	National Travel Survey	Started in 1984	Repeated 6 times	CATI	60,000 persons in 2013/14	Nationwide
Singapore	Household Interview Travel Survey	-	Repeated every four to five years	Face to face interview with a Smartphone subsample	about 10,000 households in 2012	Nationwide
Switzerland	The Swiss Microcensus on Mobility and Transport	Started in 1974	Repeated 8 times, every 5 years	CATI	63,000 persons in 2010	Nationwide
UK	National Household Travel Survey (NHTS)	Started in 1965	Annually since 1989	Face-to-face interviews with a GPS subsample	8,000 household a year	Nationwide
USA	Nationwide Personal Travel Survey (NPTS) recently known as the National Household Travel Survey (NHTS)	Started in 1969	Repeat surveys in 1977, 1983, 1990, 1995, 2001, 2009	CATI	150,000 in 2009	Sample drawn from every state
Beijing	Household Travel Survey	Started in 1986	Repeated in 2000, 2005, 2010 and 2014	Face to face interview, with a GPS subsample	46,000 households in 2010	Metropolitan Area
California	California Household Travel Survey	Started in 1991	Repeated every ten years	CATI with a GPS sub-sample	42,431 households in 2010	State-wide
Chicago	Chicago Regional Household Travel Inventory	Started in 1990	Repeated in 2007	CATI with a GPS sub-sample	10,552 households	Greater Chicago Area
Ohio	The Cleveland GPS Household Travel Survey	2011	-	GPS-only	6,542 households	Five counties in Ohio

3. HTS methods in Australia

In Australia, all major metropolitan cities have undertaken independent household travel surveys. Most of the surveys record of one day of travel for each household member or each person sampled, and the survey period varies from a few weeks or months to 365 days. Table 3.1 documents the frequency, data collection method and sample size of the Australian city travel surveys. As outlined in the table, different methods are used to undertake the surveys, different periods of time are covered, and radical differences occur in sample sizes across the surveys. For example, Adelaide mainly uses the face-to-face interviewing method but most of the other surveys use self-completion questionnaires, including Melbourne, Brisbane, Perth, Hobart and Canberra. While the Victorian Integrated Survey of Travel and Activity included a GPS component in 2007, GPS surveys have not since been conducted in Melbourne. Sydney has used a Computer/Tablet Assisted Personal Interviewing approach since 2015, where surveyors record all the travel information in a tablet during face-to-face interviews with respondents.

The first key challenge with city-centric surveys is how to expand them into regional and rural populations, to capture information about the travel behaviour of areas where little is known about travel apart from what is gleaned from the Census. Increasing the sample size and coverage and decreasing the sample cost is increasingly on the agenda to improve HTS surveys (Stopher et al., 2011). As current cutting edge data collection technology such as GPS and Smartphone becomes more reliable and cheaper to run, it becomes more attractive to test these methods to improve data quality and decrease respondent burden in a cost-effective way.

Table 3.1 Household Travel Survey in each capital city in Australia

Metropolitan Region	Survey Name	Year Last Conducted	Current data Collection Method	Sample Size	Area Covered
Sydney	Sydney Household Travel Survey (HTS)	Continuous since 1997	CAPI	3,500 households per year	Sydney Greater Metropolitan Area
Melbourne	Victorian Integrated Survey of Travel and Activity (VISTA)	2012-2016	Self completion questionnaire (delivered/picked up)	10,000 households in Melbourne, 1,000 households elsewhere	Greater Melbourne, Geelong and, periodically, in selected regional centres
Brisbane	South East Queensland Travel Survey (SEQTS)	2011-2012	Self completion questionnaire (delivered/picked up)	10,000 households	Brisbane, Sunshine Coast, and Gold Coast
Adelaide	Metropolitan Adelaide Household Travel Survey (MAHTS)	1999	Face to face, using Memory Joggers	5,886 households	Adelaide Statistical Division
Perth	Perth And Regions Travel Survey (PARTS)	2002-2006	Interviewer drop-off and pick-up of a self-administered diary	10,947 households	Perth Metropolitan Region and the Shires of Mandurah and Murray
Hobart	Greater Hobart Household Travel Survey	2008-9	Self completion questionnaire (delivered/picked up)	2,400 households	Greater Hobart Area
Canberra	Canberra Household Travel Survey	1997	Self-administered diary	3,054 households	Canberra and Queanbeyan
Darwin	2003 Darwin Household Travel Survey	2003	Telephone	1,000 households	Darwin, Litchfield, and Palmerston LGAs

4. The future of HTS methods in Australia

Compared to household travel surveys in other countries around the world, the survey methods adopted in Australia are certainly not advanced. As mentioned in Section 3, there are two general reasons that survey methods need to be improved in Australia, namely reducing survey costs and improving data quality.

One direction to improve HTS methods across Australian cities is to increasingly use computer assisted survey methods. The current Sydney HTS experience has proved that CAPI decreases respondent burden, improves the quality of the geographical location of trips, and increases the flexibility of the survey questionnaire design. Another direction for the future conduct of HTS is to use passive collection methods by introducing new technologies (e.g., GPS and Smartphone), which can provide even more improvement in terms of data quality and respondent burden. There is also increasing interest in using additional data sources (e.g., smartcard and bank transaction information) in travel surveys. It should be noted that these supplementary datasets are mainly used for data validation at this stage.

4.1 GPS and Smartphone

The GPS survey element was initially introduced to support or even replace travel diaries to record travel information due to the lack of accuracy with completing the diary survey. Stopher and Shen, 2011 have proved that traditional diaries underreport about 20 percent of trips and over-report travel duration, by comparing GPS records with diary records. Consequently, it has been widely accepted that recording time and location can improve the accuracy by using GPS technology and as such GPS component is now included in most of the latest travel surveys around the world.

There are two main protocols adopted when using GPS in HTS. In many cases, GPS is used with a subsample of the overall sample, and comparison is made between the GPS results and those of a more conventional diary. From this, estimation factors are determined to adjust diary results for the underreporting that is always found to have occurred in all traditional self-reported travel surveys. In an increasing number of cases, however, the diary is being abandoned and replaced entirely by GPS data collection.

In all GPS cases, there are three different directions in method being pursued. In the first method, the GPS data are collected entirely using dedicated GPS devices. In the second, the GPS data are collected by asking respondents to load an app onto their mobile phones, and the app both records travel data and transmits the data in real time to a server where it is uploaded to survey computers. In the third direction, a combination of both mobile phone and dedicated devices is used, the latter being offered to those who do not have mobile phones and those who are unwilling (or unable) to install the app on their phones.

When only a subsample of respondents are asked to provide GPS data, the subsample size is usually in the order of 10 percent of the sample, or 500 households, whichever is greater. This is about the minimum sample size from which it is reasonably possible to develop factors to apply to the diary data. In these cases, the respondents who are recruited to undertake GPS measurement are also asked to complete a diary for one of the days on which GPS data are being collected.

Because GPS devices or Smartphones cannot automatically record some important travel information, e.g., travel modes and trip purposes, an information imputation process is required. Over the past decade, researchers have focused on accurately processing GPS data, including data from dedicated GPS devices and Smartphones, to improve the accuracy of imputation. According to a systematic review from Shen and Stopher (2014), the overall accuracy of imputation for travel modes can reach as high as 90% by using either rule-based algorithms or machine learning methods. The accuracies of identifying trip purpose vary between 40% and 90% in different studies, partly because trip purposes usually have the most uncertainty in the identification process and also are easily influenced by different inputs. Because of the uncertainty in mode and purpose detection, a prompted recall survey is usually conducted after a main GPS/Smartphone survey where respondents are ASSISTED to recall and verify their travel information (trip ends, travel modes and trip purpose) by receiving GPS-generated map of where and when they travelled.

There have been more discussions on the battery consumption of Smartphones when a Smartphone component is included in an HTS. Smartphones generally have three groups of sensors: motion sensors (i.e., accelerometer, gyroscope and magnetometer), location sensors (i.e., GPS and network-based location services) and ambient sensors (i.e., light sensor, microphone and proximity sensor) (Abdulazim et al., 2013). While smartphone users have the option to switch on motion sensors which improves the accuracy of mode and purpose detection, location sensors are always used to record location information. Due to the battery consumption issue, some studies (Greaves et al., 2015) only use network-based location services (e.g., mobile network location and Wi-Fi location).

4.2 Big data

From 2010 onwards, big data has emerged as an essential element to improve the analytics and information capabilities of almost every industry. Discussions are well underway for using big data to supplement travel data collection. Interrogating smartcard big data in transport is one of the best examples currently taking place within transport jurisdictions around the world. Since Perth first introduced its SmartRider card in 2007, all capital city public transport (PT) networks in Australia have implemented smartcard ticketing systems. Different from survey data, that is usually collected from a sample, smartcard data can show actual network performance from the whole population of public transport users when the smartcard take-up rate is 100%, assuming PT users correctly use their tickets.

There has also been an increasing interest in using commercial mobile data from private companies (e.g., Google and Telstra) in transport planning and modelling. Private companies are recording ever increasingly rich location data points based on their users who activate location sensors on their phones. This data has the potential to be utilised not only in travel behaviour studies, but also in network performance evaluation. Similarly, transaction statistics from bank cards can also provide some level of location information and potentially additional information for trip purpose imputation.

These datasets can be supplemented with travel data. However, there are three main issues with using big data. First, big data is associated with privacy concerns. Users are often not aware that their personal information has been collected by the service providers, and also are not informed by service providers when a third party will use the data. However, strict measures are being put in place and this issue may be addressed in time. Second, the data provided by those commercial companies does not always meet the requirements of transport planning and modelling because the main purpose for collecting these datasets is not to support transport management. Third, even if big data is sizeable, they are still not a representative sample unless they include the entire population (such as a fully implemented smartcard system for public transport users, i.e., no paper ticket); therefore it will lead to bias and increase sampling error. However, this limitation could be addressed with sophisticated statistical validation. In the following section, a case study is presented where Opal card data is used to validate the Sydney HTS data within the Sydney CBD area.

5. Case study: HTS validation using smart card data confined to Sydney CBD

In some cities around the world, smartcard is the only payment means for public transport travel. As these datasets capture all public transport trips taken on the network, it can be used as “ground truth” to validate other travel data. Researchers in Montreal have undertaken a number of comparisons between smart card data and HTS data (Spurr et al., 2014; Trépanier et al., 2009), mainly focussing on the whole metropolitan area.

This section will outline the case study conducted to validate HTS data confined to the Sydney CBD, by using Opal data to evaluate HTS results. It will also demonstrate the application of big data in household travel surveys.

Opal, launched in December 2012, is a smartcard ticketing system for public transport services in Sydney, the Blue Mountains, Central Coast, Hunter, Illawarra and Southern Highlands (i.e. the Opal card network) allowing passengers to keep, reload and reuse their card to pay for travel on public transport anywhere within the Opal network. A trip is automatically recorded when a customer taps on and taps off using their Opal card. While more than three million of Opal cards were in use in August 2016 and all the paper tickets have been retired since August 2016, there were still some trips made by paper tickets during the periods of HTS 2014/15. As a result, Opal take-up rates, calculated using both Opal trips and paper ticket trips, were factored in the calculation of total public transport trips.

For the purposes of this study, a typical week in May 2015 (11th May to 15th May) was selected, which represented Opal data with a relatively high take-up rate (close to 80% for train and bus) and allowed, for the comparison between Opal data and HTS data. The HTS data used in this study was the weighted 2014/2015 five-year pooled data (TPA, 2016), which had a large enough sample for the purpose of this analysis. The data are weighted to the June 30, 2014 population. Table 5.1 shows the number of daily public transport (train and bus) trips on a typical weekday within the entire transport network from HTS and Opal data. Light rail was not included in this study because the sample size for light rail trips in the HTS was too small. In Table 5.1, it appears that train trips from HTS estimates were very similar to Opal data after weights were applied to the HTS samples, while bus and ferry trips from HTS were overestimated.

Table 5.1 Typical weekday public transport trips from HTS data (estimates) and Opal data (estimates)

	Opal	HTS	Difference %
Train	1,069,506	1,079,425	0.9%
Bus	908,679	1,084,497	19.3%
Ferry	32,231	48,283	33.8%
Total	2,010,417	2,212,204	10.0%

Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

Given highly aggregated level comparison across the entire Opal network may not represent HTS data quality, the Sydney CBD, which represents a smaller Opal data segment, was chosen for this validation study. A recent Transport for NSW CBD taskforce defined both the Sydney CBD boundary and also peak (5 am to 10 am as a morning peak and 3 pm to 8 pm as an afternoon peak) and inter-peak times (10 am to 3 pm). Inbound trips to the CBD were based on arrival time while outbound trips were based on departure time. Ferry trips were not compared in the CBD analysis because the sample counts for ferry were not enough to undertake a reliable hourly analysis.

Comparing inbound PT trips (Table 5.2), HTS trip estimates were almost the same as Opal data trip estimates for the total number of trips for the three time periods. However, there were some large differences when comparing single PT modes. The HTS underestimates train trips in the morning peak and inter-peak times (7.2% and 14.4% lower than Opal, respectively) while train trips in the afternoon peak were very closely aligned between HTS and Opal. On the other hand, it seems that HTS reports higher patronage than Opal data for bus, which is consistent with the findings comparing total PT trips across the network.

Table 5.2 CBD Inbound PT Trips

	Arrive 05:00 am-9:59 am			Arrive 10:00 am-2:59 pm			Arrive 3:00 pm-7:59 pm		
	Opal	HTS	Dif %	Opal	HTS	Dif %	Opal	HTS	Dif %
Train	178,915	166,006	-7.2%	55,942	47,894	-14.4%	44,511	45,361	1.9%
Bus	61,348	67,210	9.6%	22,828	26,895	17.8%	28,926	27,825	-3.8%
Total	248,640	242,460	-2.5%	82,200	79,168	-3.7%	76,456	77,164	0.9%

Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

In terms of the outbound train and bus trips, HTS trip estimates were very similar to Opal data trips in the afternoon peak; while HTS train trip estimates were 44.8% more than Opal records in the morning peak. While the order of magnitude of outbound trips in the morning peak was much smaller than the afternoon peak, the total number of CBD outbound train trips during the day were closely aligned between HTS and Opal data.

Table 5.3 CBD Outbound PT Trips

	Depart 05:00 am-9:59 am			Depart 10:00 am-2:59 pm			Depart 3:00 pm-7:59 pm		
	Opal	HTS	Dif %	Opal	HTS	Dif %	Opal	HTS	Dif %
Train	21,390	30,965	44.8%	42,371	35,819	-15.5%	183,880	175,218	-4.7%
Bus	21,669	19,374	-10.6%	23,716	22,620	-4.6%	63,686	66,931	5.1%
Total	44,248	51,429	16.2%	70,226	63,342	-9.8%	255,153	252,356	-1.1%

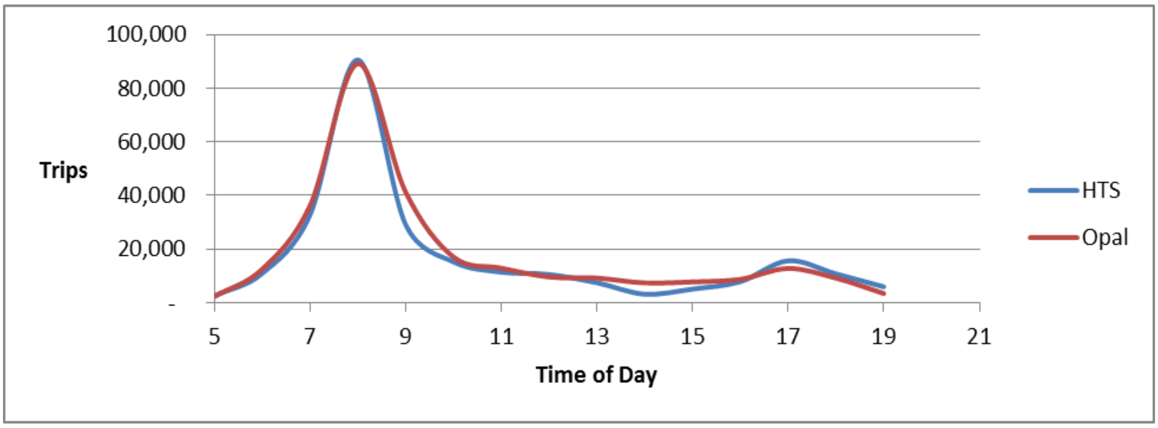
Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

Figures 5.1 to 5.4 below illustrate that the distributions of both train and bus trips from HTS and Opal data seem to be similar during the day. A test was performed to determine whether the distribution of the HTS PT trips and Opal trips were significantly different from each other. The Kolmogorov Smirnov (K-S) test was undertaken for hourly inbound and outbound PT trips between HTS and Opal data. The K-S test statistic D_n was defined by:

$$D_n = \sup_x |F_n(x) - F(x)|$$

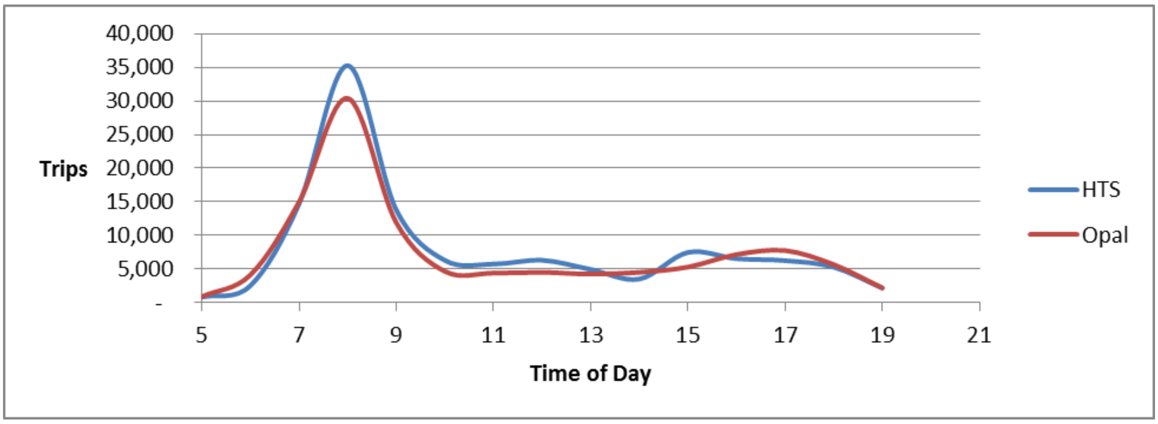
Where $F_n(x)$ is an empirical cumulative distribution function; $F(x)$ is a given cumulative distribution function; and n is the sample size.

Figure 5.1 Sydney CBD train trips - Inbound



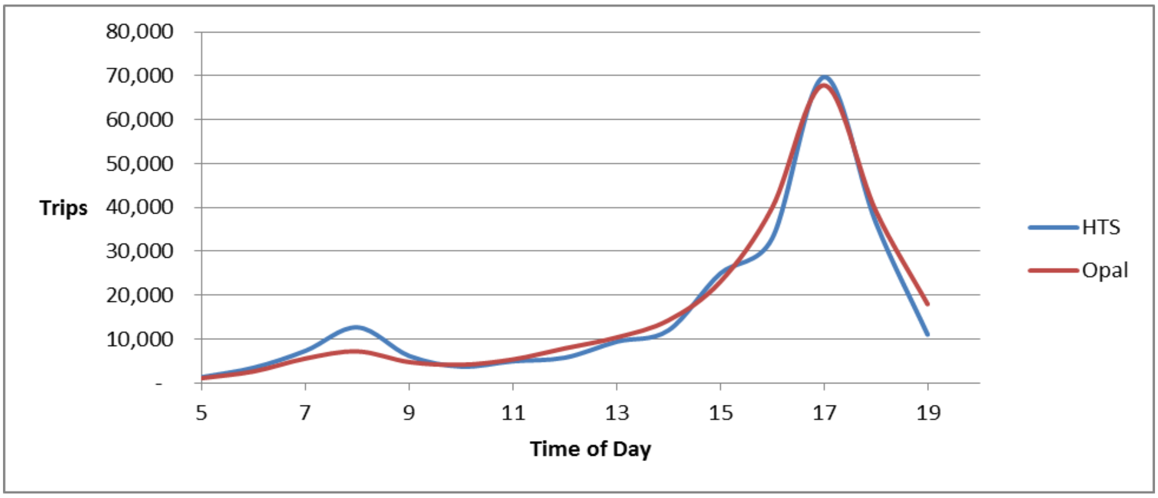
Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

Figure 5.2 Sydney CBD bus trips - Inbound



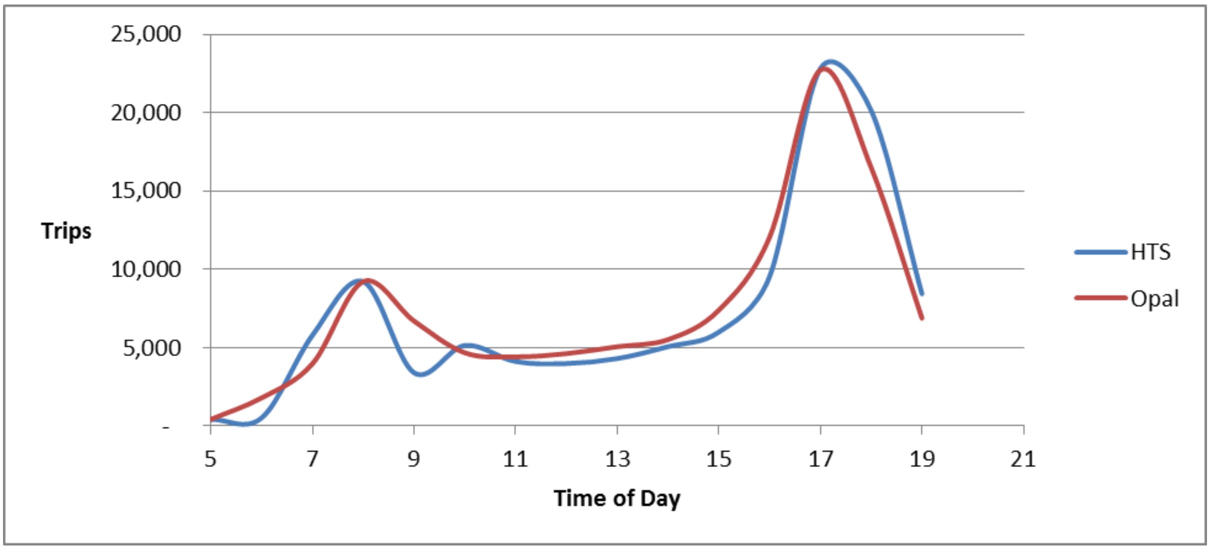
Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

Figure 5.3 Sydney CBD train trips - Outbound



Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

Figure 5.4 Sydney CBD bus trips - Outbound



Note: the data is from a typical week in May 2015 for Opal and 5-year pooled data for 2014/2015 HTS. The trips from HTS are unlinked trips (TPA, 2016).

In this study, trips between 5am and 8pm (15 hours) were tested. D_n values in the K-S test are listed in Table 5.4. Given that the D value is 0.338 at a significance level of 0.05 for 15 categories and all the D_n values in Table 5.4 were less than 0.338, both distributions of inbound and outbound HTS public transport trips were not significantly different from the Opal data. The K-S test also shows that the difference in the inbound trip distributions between HTS and Opal was smaller than the difference in the outbound trips, and HTS train trip estimates seem to be closer to Opal data, compared to bus trip estimates.

Table 5.4 Dn values for K-S test

	Train	Bus
Inbound	0.043	0.060
Outbound	0.034	0.035

Although the K-S test shows there were no significant differences between the HTS and Opal data in terms of distribution of train and bus trips traveling to and from Sydney, some large percentage differences in Table 5.1, 5.2 and 5.3 also suggest that there might be a need to adjust the HTS weights based on actual travel mode figures based on Opal data. This case study demonstrates that Opal data could be a very robust supplementary data source to validate the Sydney HTS data. In addition, weighting factors can be produced which can be applied to certain modes in the weighted HTS data to ensure the HTS results are better aligned with Opal data at a preferred geographical level, such as LGA or SA3.

6. Limitation and conclusions

This paper has reviewed national and metropolitan household travel surveys around the world over the past decade. It can be concluded that there are two main trends in travel data collection – a GPS/smartphone component and multi-mode data collection methods. Most Australian household travel surveys are still using face-to-face interviews based on respondents' travel diaries. New technology should be increasingly used in future HTS surveys in Australia to improve survey data quality. Also, other different data sources can be used as supplementary data for travel behaviour analysis and transport modelling.

The application of Opal data to validate HTS data was used in this case study. Comparing Opal and HTS data in the Sydney CBD area, the differences between train and bus trips on a typical weekday and also in certain time periods in the CBD suggest that HTS weights may need to be reviewed and readjusted to correct the estimation, while the distribution of train and bus trips during the day are not significantly different between Opal data and HTS estimates. Further validation using 2015/16 HTS and Opal data, when Opal uptake is much greater, will be able to conducted once the more recent HTS data becomes available.

It should be noted that there are three limitations to this study. First, since the Opal take-up rate was lower than 80% in the 2014/2015 financial year, total passenger Opal trips have been estimated (factored up) based on the take-up rate by mode. The estimation may not reflect actual patronage because the travel behaviour of those people using paper tickets may not necessarily be the same as those people using Opal cards. Second, HTS respondents are limited to residents only, whereas Opal cards are used by visitors and tourists, which may affect the results being compared. Further research on identifying visitors and tourists from the Opal data should be conducted in the future. Third, the HTS sample size is very small for ferry and light rail and was excluded in this study, yet ferry and light rail are key public transport modes in the CBD. This issue limited the authors to undertake an analysis of these two modes.

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