Detailed Analysis of the Travel Patterns of Rail Users in Sydney

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Abstract

Rail is a critical transport mode for travel in large cities, especially for journeys to and from the CBD. Analysis of travel surveys commonly report aggregate statistics such as mode shares by purpose. These aggregate statistics provide an overview of the level of rail usage, however much more detailed analysis is needed to answer questions such as:

- Do the access mode shares to rail vary by distance from the CBD?

- What proportion of the total journey distance is by rail?

- What proportion of people travel to their nearest station?

- How far are people travelling to access their rail station?

- What proportion of people who use rail for their outward journeys from home also use rail for their return journey?

- Do people use the same mode for access for their outward journey as their egress mode for the return journey?

This paper analyses data from the Sydney Household Travel Survey to answer the above questions for rail users in Sydney. Rather than just looking at single estimates the analysis will look at distributions recognising that people have a variety of travel patterns.

1. Introduction

There have been rising social, environmental, and economic concerns, resulting from ever increasing traffic congestion, leading to the increasing production of air and noise pollution in most urban areas around the world. With the aim of reducing car use and encouraging the use of more 'sustainable transport' modes, including public transport, walking and cycling, interests have been directed towards in the relationship between land use and travel behaviour and in the development and implementation of Travel Demand Management (TDM) principles. In Australia, most cities have a metropolitan transport strategy providing the overall policy setting for achieving balanced mode shares within a certain period of years NSW Department of Planning (2005); James et al, (1999).

Researchers have been trying to understand the factors that most influence the use of public transport, such as the relationship between the distance from where people live to public transport stops, as well as the household social economic aspects. Cervero (1994) found that residents living within a kilometre of a Bay Area Rapid Transit (BART) train station were five times more likely to commute by train than for the rest of San Francisco, and those who lived within 120 metres were twice as likely as those who lived a kilometre from the station to commute by train. On the other hand, Black (1996) reported that a survey in Sydney found no relationship between the proximity of a dwelling to a train station and the probability that its inhabitants would have a car.

The remainder of this paper is structured as follows. Section 2 provides a strategic overview of the Sydney Rail system and a brief outline of its role in the Sydney transport system. Section 3 reports on detailed analysis of the travel patterns of Sydney rail users using data from the Household Travel Survey. Section 4 contains a number of conclusions.

2. Sydney Rail System

The Sydney rail system is an important component of the Sydney transport system. A brief overview of the development history of the Sydney rail system can be found in Norley (2010). Today it includes 330 metropolitan and 720 non-metropolitan route kms (RailCorp 2010).

In 2009 there were 302.3 million annual journeys with 999,000 journeys undertaken on a typical weekday (Tuesday, Wednesday, Thursday during school term time) (RailCorp 2010). RailCorp patronage has experienced modest growth in recent years. Figure 1 shows the trend in annual patronage from 1969 to 2008.

Figure 1: CityRail Annual Patronage 1969 - 2008
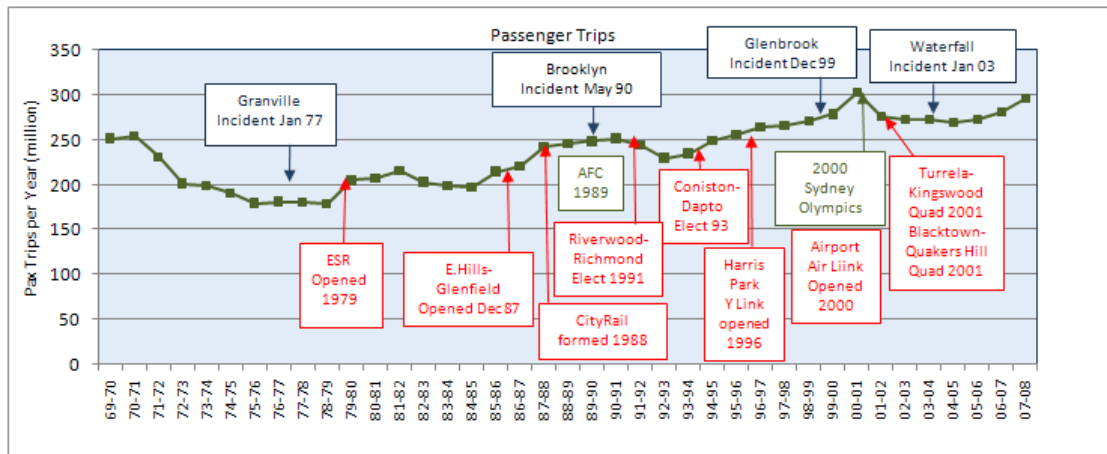
Source: Douglas and Karpouzis (2009)

Figure 2 shows the annual percentage change in patronage from 1994/95 onwards. The large increase in 2000/01 and subsequent decline in 2001/02 is a consequence of the large number of Olympic and Paralympic journeys in 2000. Over the ten year period 1998/99 to 2008/09 the average annual growth rate has been 1.2%.

Figure 2: Percentage Change in CityRail Annual Patronage 1994/95 – 2008/09

Source: Derived from Table on page 22 RailCorp (2010)

Figure 3 shows the growth in rail patronage in Australia's 5 big cities since 2001/02. It can be seen that Perth has had a significant increase in rail patronage since 2006/07. There has been a consistent growth in rail patronage in Melbourne from 2003/04. Rail patronage in South East Queensland dropped in 2009/10 after a steady increase between 2004/05 and 2008/09, while rail patronage in Adelaide has been quite flat. Sydney demonstrated a very modest increase in rail patronage since 2001 with growth significantly less than that observed for Perth, Melbourne and South East Queensland.

Figure 3: Growth in Rail Patronage in Australian Cities Since 2001/02
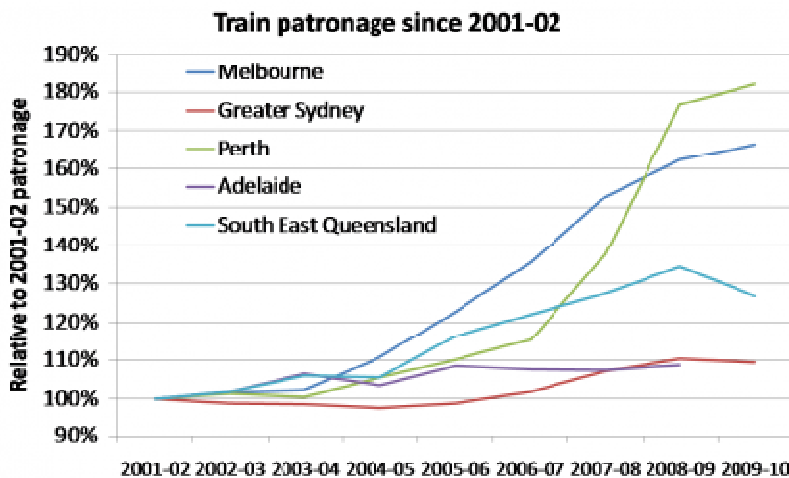
Source: Charting Transport (2010)

Mees et al (2008) used Journey to work Census data to examine the modal share of the travel to work from 1976 to 2006 in Australian Capital Cities, and found that there has been a large decline in public transport's share of travel since 1976, but a modest increase in the mode shares for public transport and walking for almost every large city from 2001 to 2006, except for Sydney, though Sydney still had the highest rate of public transport use and the lowest rate of car driving in 2006.

The 2008/09 analysis of the Household Travel Survey for Sydney shows that rail accounts for 5% of the trips, 13% of the distance and 9% of the time of the travel undertaken by Sydney residents (TDC, 2010).

3. Analysis of Sydney Household Travel Survey Data

3.1 Background to Household Travel Survey

Household travel surveys have been undertaken in Sydney for many years. These include one-off surveys in 1971, 1981 and 1991. These surveys generally comprised approximately 10,000 responding households with travel for all members (or for some surveys those aged five year of age and older) were surveyed (TSG 1993). Since 1997 the Bureau of Transport Statistics (previously known as the Transport Data Centre TDC) has conducted the continuous Household Travel Survey (HTS). Each financial year approximately 5,000 households are approached with a fully responding household response rate of over 60%.

The scope of HTS data reported in this paper is summarised in Table 1. HTS households in the Sydney Statistical Division (SD) interviewed during the 2004/05, 2005/06, 2006/07, 2007/08 and 2008/09 waves on non-public holiday weekdays have been retained. The median survey date of these households is 31st December 2006. The data has been weighted to 2006 Estimated Resident Population (ERP), adjusted to reflect the population living in private dwellings, which is the scope of the HTS. This is comparable to the approach reported in TDC (2010) where three waves of data are combined for that analysis. Five waves of data have been used for the analysis reported in this paper which ensures that a larger sample size is available to undertake the detailed analysis reported in this paper. Table 2 summarises some of the key aspects of the person weight variable used to expand the survey data to the population data.

Table 1: Scope of HTS data analysed

Characteristic	Details
Home Location	Sydney Statistical Division
Survey Waves	2004/05, 2005/06, 2006/07, 2007/08, 2008/09
Median Survey Day	31-Dec-2006
Survey Days	Mondays to Fridays (non public holidays)
Population Control Total	2006 Estimated Resident Population (adjusted to reflect population in private dwellings)

Table 2: Summary of person weighting

Characteristic	Number/Value
Persons Surveyed	23,573
Weighted Number of People	4,217,882
Mean Weight	178.9
Standard Deviation Person Weight	73.4
Inter Quartile Range	79.5

The HTS collects data on an unlinked trip basis. These unlinked trips can be combined to form linked trips and/or tours. More details on the methodology and results of combining unlinked trips can be found in Milthorpe and Daly (2010).

A summary of unlinked trips can be found in Table 3. It can be seen that the largest portion of travel is made by car (including car driver and car passenger). Walk is the second major travel mode, but for short distance journeys. Train comprises 4 percent of the total trips and 11 percent of the total distance travelled by Sydney residents.

Table 3: Summary of trips

Mode	Unweighted Trips	Trips	% Trips	Distance	% Distance
Car Driver	44,463	8,259,000	41.9%	78,803,000	59.3%
Car Passenger	21,147	3,563,000	18.1%	26,554,000	20.0%
Bus	4,961	897,000	4.6%	5,623,000	4.2%
Bicycle	597	111,000	0.6%	349,000	0.3%
Walk	31,834	5,809,000	29.5%	4,719,000	3.6%
Taxi	636	123,000	0.6%	878,000	0.7%
Train	4,312	788,000	4.0%	14,770,000	11.1%
Ferry	225	40,000	0.2%	291,000	0.2%
Light Rail	23	6,000	0.0%	15,000	0.0%
Other	623	114,000	0.6%	801,000	0.6%
Total	108,821	19,708,000	100.0%	132,801,000	100.0%

Public transport is important for commuting, especially for people working in the CBD and other centres. Analysis of the 2006 Census of Population and Housing by Xu and Milthorpe, (2010) shows that whilst only 14% of commute journeys were to the CBD, these accounted for 47% of the public transport commute journeys.

3.2. Trip length analysis

With the HTS data it is possible to undertake analysis of the unlinked rail trip records. A number of rail journeys require a passenger to make an interchange between services. The HTS methodology instructs interviewers to obtain details about interchanges which involve the same mode if the interchange involves a walk of more than 100 metres (TDC 2009). The standard definition of a rail journey used by CityRail is defined as one station entry and one

exit of the system (RailCorp 2010). This definition is consistent with ticket sales which are based on travel from one station to another and ignore whether a passenger does or does not make an interchange. To enable consistency between RailCorp and HTS analysis, HTS trip records which involved a rail interchange have been linked to provide data on a consistent basis. Figure 4 shows a distance distribution of rail trips. The mean, median and standard deviation of trip length are 19.9 km, 15.7 km and 18.4 km respectively. From Table 3 the average unlinked trip distance for each mode can be calculated. Rail with an average distance of 18.7 kms is the highest of any mode. As expected this value is slightly lower than for the 19.9 kms calculated based on data with rail interchanges combined.

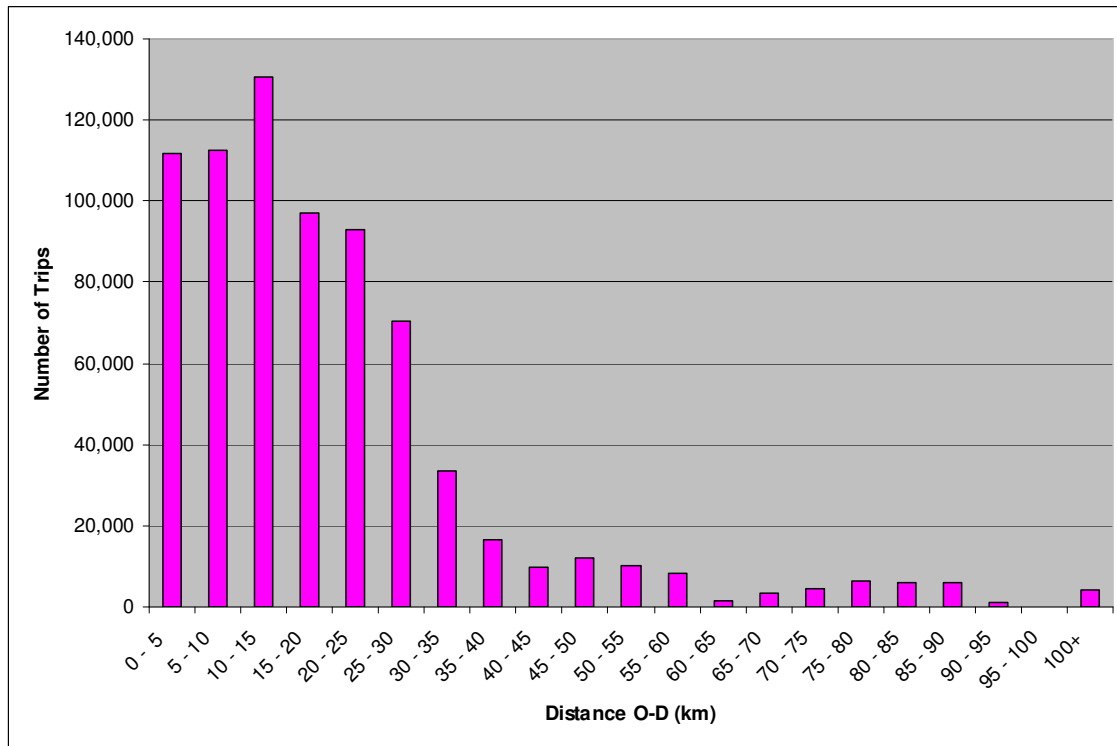**Figure 4 Rail trip length distribution**

Figure 5 shows the mode share for different trip lengths in five kilometre distance bands. This analysis is based on linked trips (combining sequential trip records involving change mode) and priority mode. Figure 5 shows that walk is an important mode for journeys less than 5 kms. For journeys of up to 10 kms, bus is the dominant public transport mode, whilst for journeys longer than 10kms, rail is the dominant public transport mode. For most distance bands of journeys between 25 and 90kms, the rail mode share is in the range of 10% to 30%.

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Figure 5 Mode share by journey length
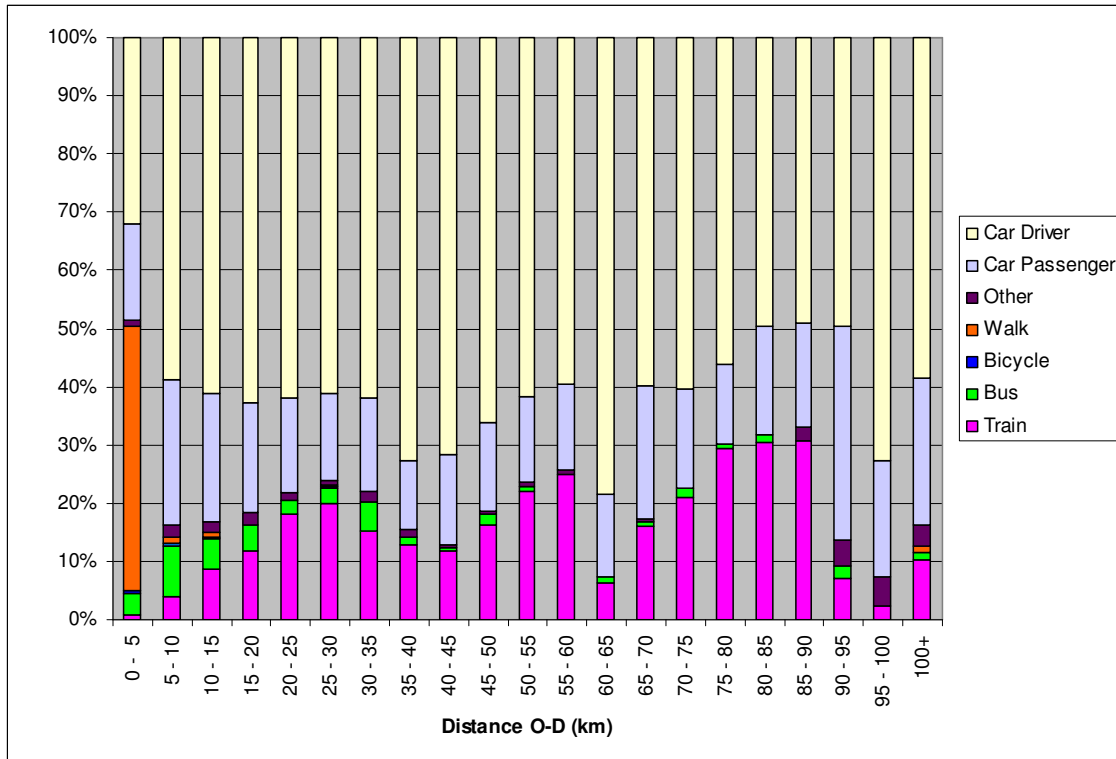
This analysis is based on linked trips and priority mode

The majority of outward (away from home) rail journeys are to the CBD and adjoining areas. Therefore, there is a correlation between the distance of the rail journey and the distance of home from CBD. Figure 6 presents the trip length by the distance between the residential location and the Sydney CBD. It can be seen that the further the home location is from the CBD, the longer the trip is. From Figure 6, it can be seen that the median journey length is approximately the distance the household is from the CBD. For households located within 10kms of the CBD, the median rail journey length is 12.76 kms.For home locations between 10 and 20 kms from the CBD the median journey length is 16.26 kms, for locations between 20 and 30 kms from the CBD, the median journey length is 23.11 kms, for locations between 30 and 40kms from the CBD the median journey length is 29.23 kms and for locations more than 40kms from the CBD the median journey is 50.46 kms.

Figure 6 Rail journey length by home location distance from CBD
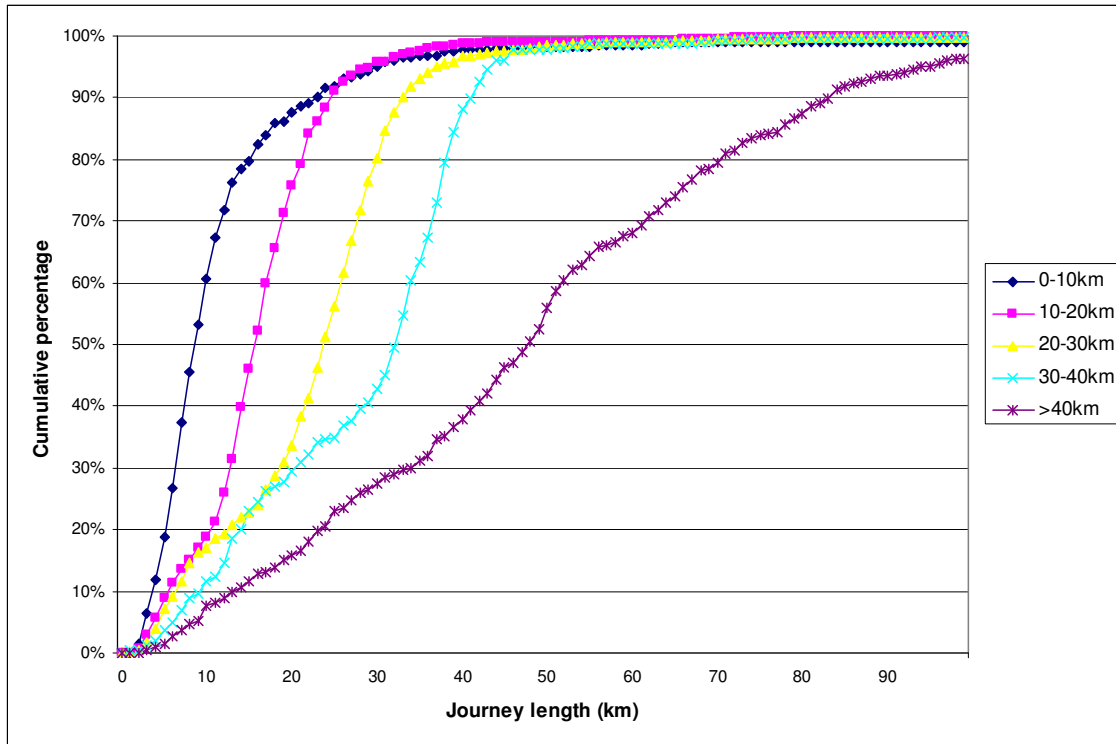
3.3. Rail component of the journey

For journeys which involve rail there will be other modes used to access and egress the rail. For some journeys this will be walk, however other modes will also be used, for example car and bus. To undertake this analysis it is necessary to look at linked trips to obtain details of the whole journey. Figure 7 shows a plot of the rail distance compared with the distance of the whole journey for individual journeys. The distance from the virtual diagonal line is the distance of the non-rail components of the journey. The mean, median and standard deviation of the whole journey length are 24.5 km, 19.9 km and 20.2 km respectively. There is an average of 4.6 km distance of travel that is used by other modes for access and egress to the rail, which indicates that car and bus are the main access modes for the contribution of the longer journey in which train is used as the main mode of travel.

Figure 7 Scatter plot of rail distance vs linked trip distance
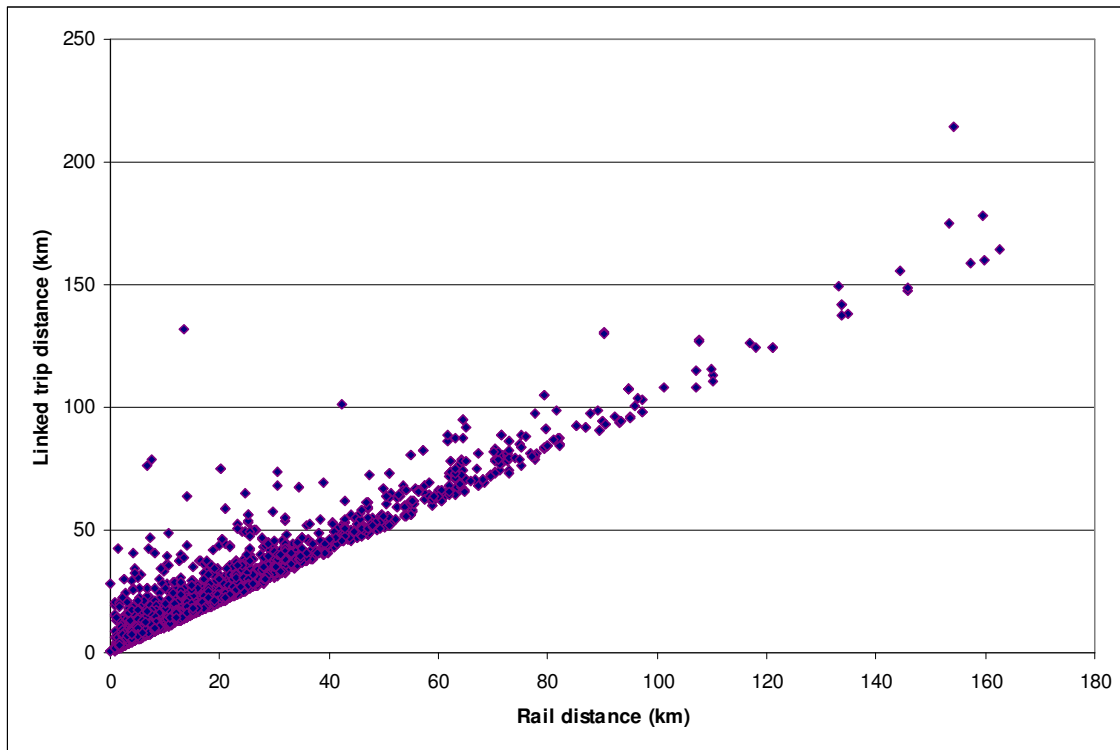
3.4. Access mode to rail journeys

For journeys originating at home, car is a potential access mode to rail for most people. However, for the egress legs of these journeys car is generally not available. Table 4 shows the access and egress modes used for outward (away from home rail journeys). From Table 4 it can be seen that walk is the access mode for approximately half of all rail journeys whilst car is the access mode for just over one third of journeys. For the egress leg walk is the dominant mode used by over 80% of journeys with bus used just over 10% of journeys.

Table 5 shows the access mode for outward (away from home) and the egress mode for return (towards home) rail journeys. This analysis shows the correlation of the mode used to travel to/from home and the rail station. From Table 5 it can be calculated that 86 percent of people use the same mode to travel from home to the station and from the station to home.

Table 4: Access and egress mode of outward rail journeys

| | Access | | Egress | |
Mode	Number	Percentage	Number	Percentage
Car Park/Ride	66,091	18.8%	1,113	0.3%
Car Kiss/Ride	65,519	18.6%	7,838	2.2%
Bus	47,723	13.5%	41,416	11.7%
Bicycle	2,385	0.7%	1,674	0.5%
Walk	169,182	48.0%	294,902	83.7%
Taxi	1,339	0.4%	1,409	0.4%
Other	246	0.1%	4,132	1.2%
Total	352,484	100.0%	352,484	100.0%

Table 5: Egress mode of return rail journeys vs access mode of outward rail journeys

		Return egress modes							
		Car Park/Ride	Car Kiss/Ride	Bus	Bicycle	Walk	Taxi	Other	Total
Outward access modes	Car Park/Ride	59,231	2,017	0	0	301	0	0	61,549
	Car Kiss/Ride	2,025	35,535	5,630	0	10,182	88	0	53,460
	Bus	159	4,844	28,656	0	2,967	472	0	37,098
	Bicycle	0	0	0	1,970	0	0	0	1,970
	Walk	511	7,000	3,508	0	134,223	688	0	145,930
	Taxi	0	215	364	0	0	761	0	1,340
	Other	0	0	0	0	0	0	246	246
Total		61,926	49,611	38,158	1,970	147,673	2,009	246	301,593

Cells shaded in green indicate use of the same mode for the outward access and return egress legs

Not surprisingly there is a spatial distribution to the mode used to access the rail. Figure 8 shows the access mode by distance of the rail journey. From Figure 8 it can be seen that for the shorter distance rail journeys, walk is the dominant access mode. As journey distance increases, park and ride becomes an increasingly important access mode.

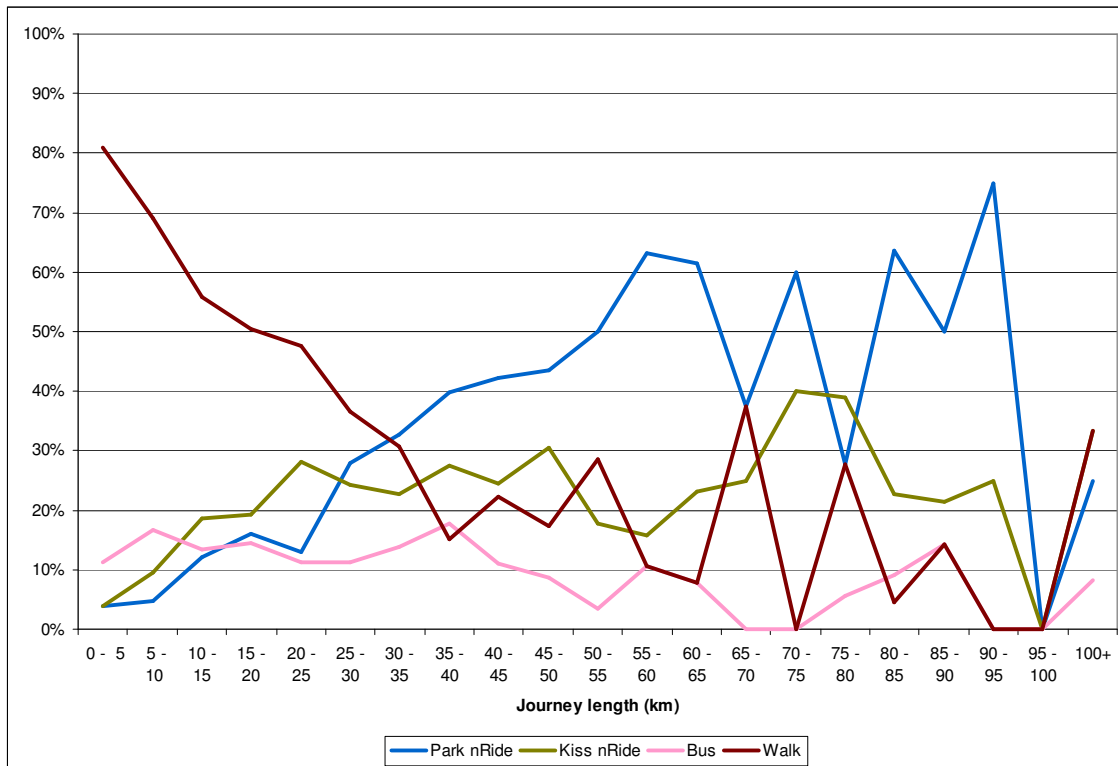**Figure 8 Access modes by distance of rail journey**

Figure 9 shows the access mode by home zone. Figure 10 presents the access mode by station. From these two Figures it can be seen that walk is an important access mode for the inner locations. For residents living further away from the CBD, car access becomes

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increasingly important. This spatial analysis matches the empirical results presented in Figure 8.

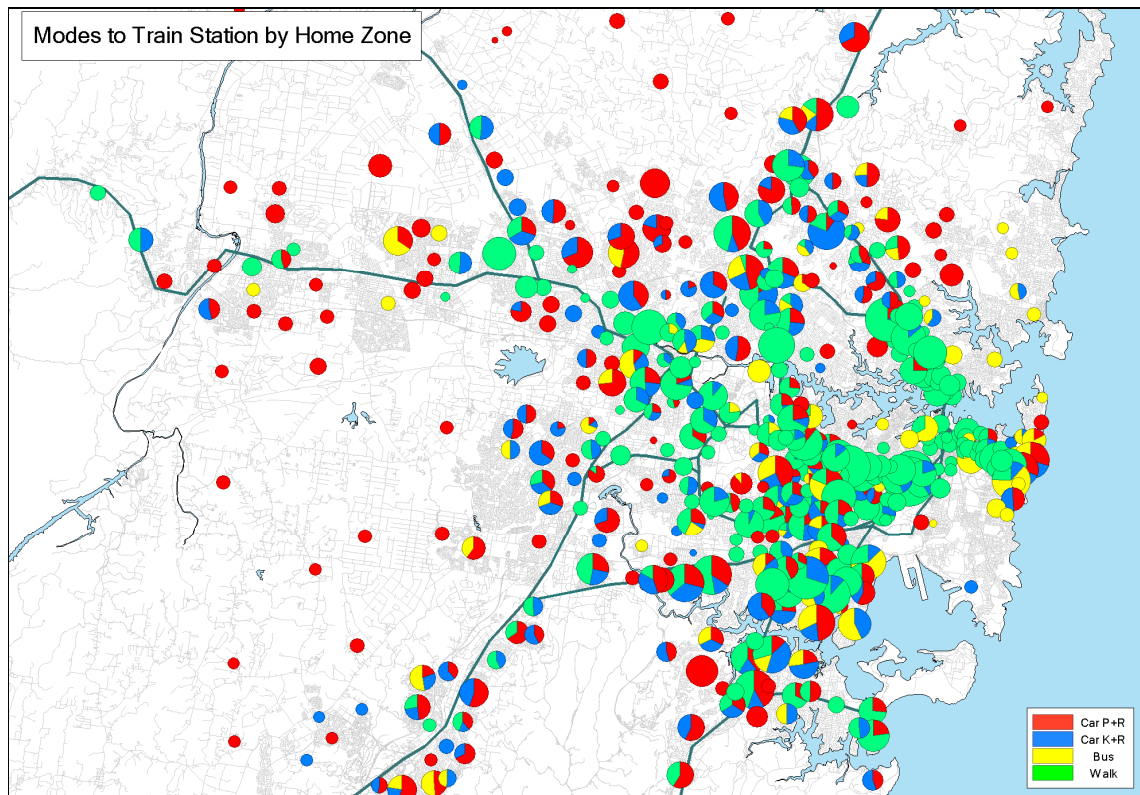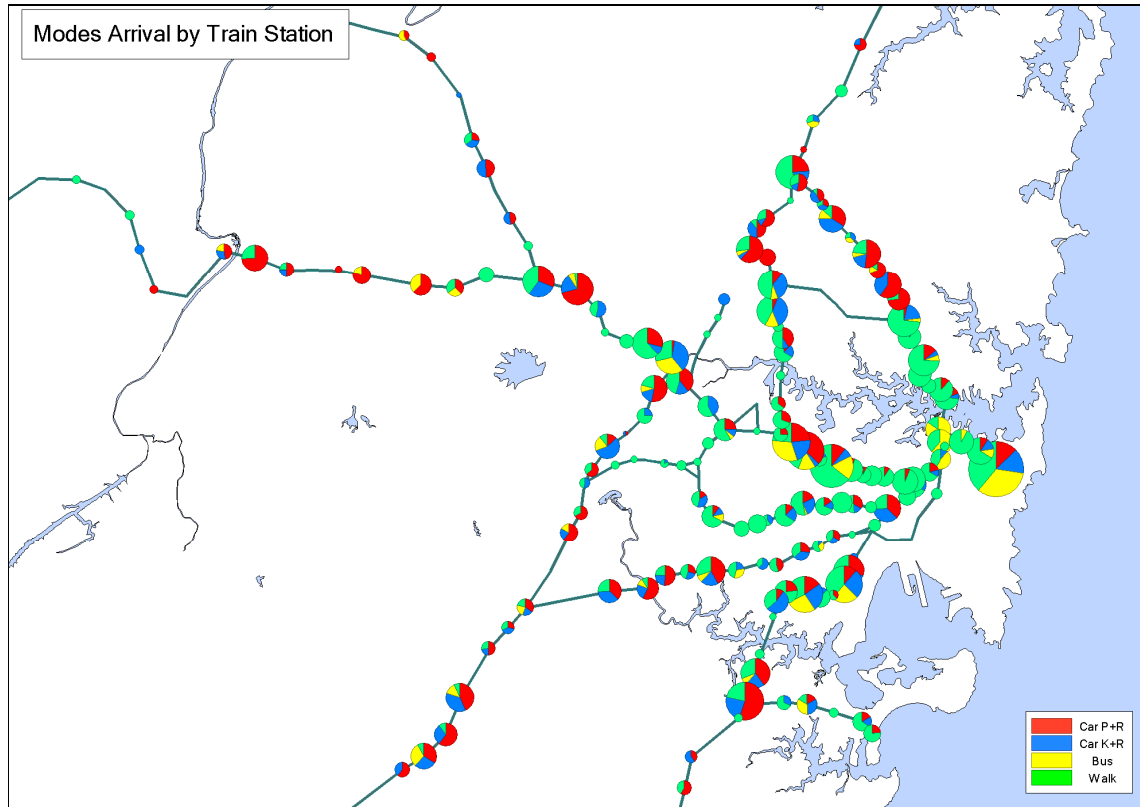**Figure 9 Access mode by home zone**

Figure 10 Access mode by station

3.5. Stations that people access

Figure 10 shows the access mode by home zone. However this Figure does not show the actual station where people access the rail system. There are many rail stations in Sydney and not all people access the closest station. More distant stations may have better service provisions either through higher service frequency and/or express services. Also for car users accessibility to the station and the availability of parking can have an influence on the choice of the station. Figure 11 shows the percentage of people accessing the closest station for each access mode. Somewhat surprising is that only 85% of people walk to their nearest station. For car users only about 40% of rail passengers access their nearest station. The calculation of the distance to the nearest station has been established using the straight-line distance from the home to the station. In some situations homes will be approximately equidistant from two stations.

Figure 11 Proportion using closest station by access mode
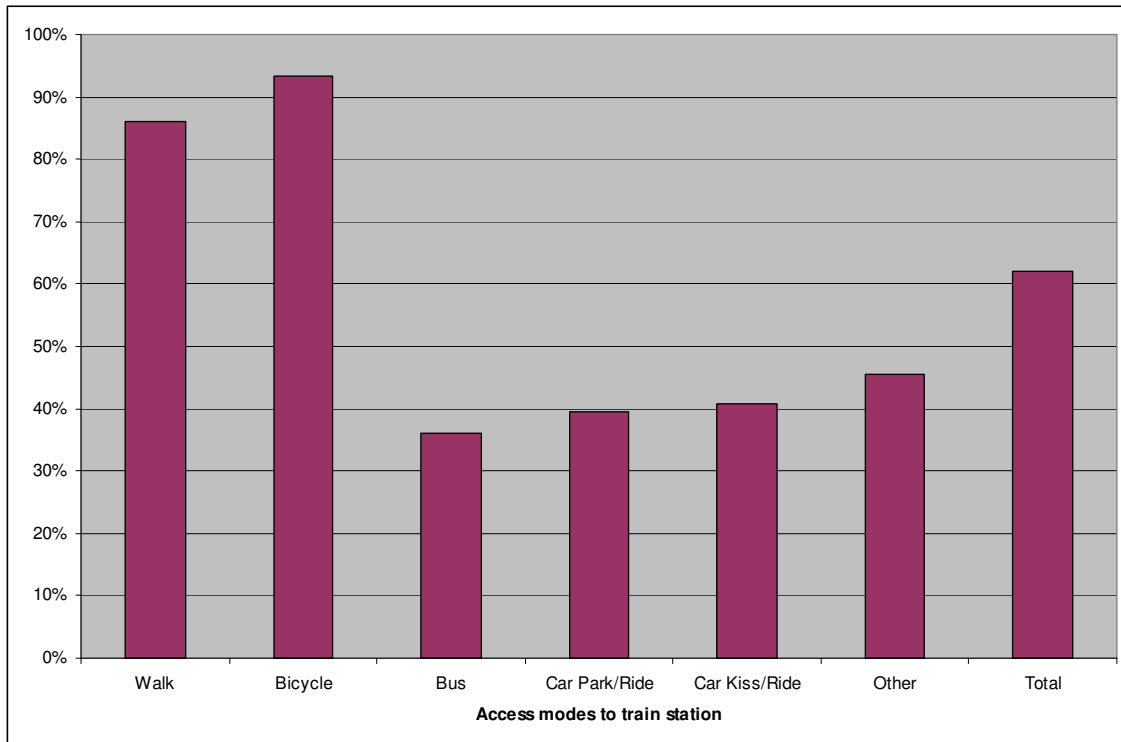
3.6. Mode used to return home

Most of the analysis reported in this paper has been based on the outward leg of travel from home. The HTS allows the return journey (to home) to be compared with the outward journey (from home). Table 6 shows the modes used for outward tour legs and return tour legs.

Table 6: Main mode for outward and return tour legs

Purpose	Outward Journey	Return Journey						Total
		Vehicle Driver	Vehicle Passenger	Train	Bus	Walk	Other	
Work	Vehicle Driver	791,124	5,690	928	954	315	1,771	800,782
	Vehicle Passenger	4,323	53,632	5,168	5,675	4,222	892	73,912
	Train	1,914	9,546	179,761	3,373	1,745	5,223	201,562
	Bus	2,561	8,672	3,003	73,396	3,577	6,696	97,905
	Walk	1,218	5,940	469	2,775	60,054	2,151	72,607
	Other	634	972	1,712	2,511	517	16,484	22,830
	Total	801,774	84,452	191,041	88,684	70,430	33,217	1,269,598
Business	Vehicle Driver	281,360	451	235	0	202	326	282,574
	Vehicle Passenger	662	16,373	469	79	194	0	17,777
	Train	1,011	1,296	18,243	655	0	463	21,668
	Bus	858	575	780	5,066	236	137	7,652
	Walk	0	221	0	0	7,468	0	7,689
	Other	357	210	820	279	475	1,917	4,058
	Total	284,248	19,126	20,547	6,079	8,575	2,843	341,418
Education	Vehicle Driver	35,551	0	226	0	0	0	35,777
	Vehicle Passenger	267	224,473	7,473	37,858	17,952	861	288,884
	Train	395	3,073	51,848	3,097	120	0	58,533
	Bus	0	11,003	1,236	80,645	818	223	93,925
	Walk	0	8,812	311	1,215	75,600	0	85,938
	Other	0	404	0	356	0	9,415	10,175
	Total	36,213	247,765	61,094	123,171	94,490	10,499	573,232
Shopping	Vehicle Driver	439,481	1,952	201	0	0	218	441,852
	Vehicle Passenger	2,081	99,372	0	422	568	222	102,665
	Train	275	282	11,321	899	235	558	13,570
	Bus	0	912	810	31,406	976	1,140	35,244
	Walk	371	948	232	2,091	139,005	1,469	144,116
	Other	0	288	0	745	0	4,866	5,899
	Total	442,208	103,754	12,564	35,563	140,784	8,473	743,346
Other	Vehicle Driver	1,166,204	12,377	995	906	2,923	1,746	1,185,151
	Vehicle Passenger	12,973	684,457	803	4,206	4,868	4,538	711,845
	Train	620	5,896	39,570	1,358	1,190	1,446	50,080
	Bus	431	6,161	2,226	39,926	940	2,962	52,646
	Walk	1,326	12,117	219	3,254	443,041	3,025	462,982
	Other	1,289	2,876	2,200	2,255	1,337	37,708	47,665
	Total	1,182,843	723,884	46,013	51,905	454,299	51,425	2,510,369

Cells shaded in green are tours where train is used for both the outward and return tour leg.

In Table 6 the people who use rail for both the outward and return tour legs are highlighted in green. Nearly 90% of commuters who travel to work by train also return home by train. At the other extreme, travel for other travel purposes (not work, business, education or shopping) approximately 80% of people who use train for the outward journey also use train to return home. For all travel purposes with the exception of education, fewer people use train for the return leg than for the outward leg. For commuters, 201,000 people travel to work by train, whilst only 191,000 return home by train.

4. Conclusions

This paper presents the train use behaviour of Sydney residents by the data analysed from the HTS2004 – HTS2008. The summary of the key findings from the analysis is of the following:

- The majority mode of the travel is by car, including car driver and car passenger. Walk is the second main mode, but with only short distance journeys. Public transport modes only accounts for 8.8% of the total trips, in which 4% is by rail. Within the total rail trips to the CBD, 75% of them are for commuting.

- Rail trips are longer than those for other modes, the average of a rail trip length is 19.9 km, and the average of a rail journey (including access and egress travel) is 24.5 km.

- Approximately 48% of the access modes to the rail station for the outward journey are made by walk, and 50% of them are made by car and bus. Approximately 85% of the residents who use rail for outward journey also use rail for their return journey, within these who use rail as the return mode, 86% of them have their return egress modes the same as their access modes for their outward journey.

- Walk is an important access mode for the inner locations, while car becomes a gradually more important access mode for the residents who living further away from the CBD.

- Approximately 62% of the residents use the rail stations closest to their home for their outward rail journey, within them, nearly 67% use walk as the access mode to the rail stations, followed by car park/ride, car kiss/ride and bus, which are 12%, 12% and 8% respectively. For the rest of people who don't use the rail stations closest to their home, the access modes used to the rail stations are about 30% for car park/ride, 29% for car kiss/ride, 23% for bus and 17% for walk.

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