

Analysis of Journey to Work Travel Patterns In Sydney

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Abstract

The Journey to Work (JTW) data, collected through the Census of Population and Housing every five years in Australia, provides important information on commuting needed for urban transport planning and modelling. This paper analyses JTW travel patterns in the Sydney Statistical Division (SD) using the JTW data derived from the 1981 to 2006 Census collections (1986 omitted), summarising some key transport travel characteristics including mode share, access mode to public transport and trip length.

This paper also undertakes analysis of the changes to land use including residential and work location changes. Travel between Statistical Sub-Divisions (SSDs) is also analysed. This investigation is motivated by the Metropolitan Transport Plan (NSW Government, 2010) which aims to connect the City of Cities.

1. Introduction

JTW, or commuting, is predominately a weekday activity in cities like Sydney. JTW travel mainly occurs during the morning and evening peak periods (Transport Data Centre, 2010), and often represents the key component of the peak period travel demand. In current practice, transport decision-makers often rely on the peak travel demand derived from modelling or surveys, including Census JTW data, to identify transport supply constraints, assess transport operational arrangements, prepare congestion mitigation measures and develop transport financial initiatives. On the other hand, transport modellers often use the JTW data to calibrate base models and validate optional model results.

The Census is the key source of JTW information. In the Census of Population and Housing, JTW data is derived from place of work, mode for commuting, and other employment information collected in small areas where jobs are located (Transport Data Centre, 2008). The advantage of the JTW data from the Census is that it is a complete enumeration of the population. As Census obtains details on many topics, the breadth and depth of information collected is limited compared with tailored transport surveys.

The Sydney Household Travel Survey (HTS) is a major sample survey which also collects JTW information in Sydney. However, the sample size for an individual survey year is approximately a quarter of one percent. The advantage for the HTS is that it is conducted continuously every year and it includes additional information about the respondents that allows for a more detailed analysis of travel patterns such as traveller's socio-economic profile, time of day and day of week. This paper's focus is on the analysis of JTW travel patterns over time at a strategic level and it is therefore based on the Census JTW data only.

JTW data has been widely used for various research purposes around the world. Mees et al (2008) focused on the modal share of the travel to work from 1976 to 2006 in Australian Capital Cities and found that car travel had grown and carpooling had decreased. Forster (2006) was interested in the analysis of the location of employment and residents in relation to journey to work patterns to challenge the current metropolitan planning strategies in Australian cities. Other recent examples in literature include use of JTW data to study the

relationship between changes in land use and commuting patterns in Beijing (Shan and Bin, 2008), use of JTW trip duration data to analyse associated non-work trips and other activities in Paris (Aguilera et al, 2009), and preparation of Census JTW statistics for peak commuting travels in America (McGuckin and Contrino, 2010).

Based on the work previously undertaken by Milthorpe and Raimond (1998) who analysed the Census JTW data from 1981 to 1996, this paper first examines some key travel characteristics and trends from the 1981 to 2006 Census collections for the Sydney SD as a whole (the 1986 Census was excluded due to its unavailability). The Australian Bureau of Statistics has traditionally referred to commuting travel data collected as part of the Census of Population and Housing as Journey to Work data. For the 2006 Census they have adopted new terminology; Place of Work (POW) (ABS, 2007). For the remainder of this paper we will use the traditional terminology. The analyses then focus on the SSD level to investigate some cross-regional JTW travel patterns. Due to the differences between Census years in terms of geographic coverage and formulation of JTW related questions, caution has been taken in the analyses to ensure any comparison is made on a consistent basis. The differences between the 1981, 1991 and 1996 Census data collections have been discussed in detail in Milthorpe and Raimond (1998). The changes in the scope of the Census surveys analysed for this paper are summarised in Table 1.

Table 1: Changes in scope of JTW data set, Sydney 1981-2006

Scope Issue	1981	1991	1996	2001	2006
Geographic coverage	Sydney SD, Newcastle and Wollongong SSD	1981 area plus Wingecarribee SLA and Part of Shoalhaven SLA	1991 area plus remainder of Shoalhaven SLA	Sydney & Illawarra SD, Newcastle SSD	Sydney & Illawarra SD, Newcastle SSD
Destinations outside the Study Area	Included	Excluded	Included	Included	Included
No fixed workplace	Respondents instructed to write "N/A"	Respondents instructed to provide address of depot or head office	Respondents instructed to write "No fixed address"	Respondents instructed to provide a depot address	Respondents instructed to provide a depot address or write 'None'
Employed Persons	Included if residents of the Study Area	Included if residents of the Study Area	Included if enumerated in the Study Area (ie including visitors)	Included regardless of where enumerated in Australia	Included regardless of where enumerated in Australia
Destination under-reporting	141,000 unknown (not stated)	135,000 unknown (not stated)	69,000 unknown (not stated)	116,000 unknown (not stated)	130,000 unknown (not stated)
Travel zone changes	842 zones	1083 zones	1134 zones	1154 Zones	2690 zones

2. Key travel characteristics

JTW travel patterns can be analysed in many ways. Three of the key JTW travel characteristics reported in this section are mode share, access mode¹ to public transport and trip length.

2.1. Mode share

The Sydney population has been increasing since 1980s (Australian Bureau of Statistics, 2009). The annual average population growth rate from 1999 to 2007 in the Sydney Statistical Division has been estimated at approximately 1.0% (Transport Data Centre, 2009). With the rate of population growth, what does the JTW mode share trend show?

Where multiple modes are used to travel to work, the main mode is defined according to the priority mode hierarchy as specified in Table 2 (Transport Data Centre, 2008). Figures 1 and 2 present the mode share in volume and percentage by main mode from 1981 to 2006.

Table 2: The mode hierarchy

Priority	Mode
Highest	Train
	Bus
	Ferry
	Tram
	Taxi
	Car as driver
	Car as passenger
	Truck
	Motorbike
	Bicycle
	Other mode
Lowest	Walked only

Figure 1 indicates that the largest portion of JTW trips was made by private car (including car driver and car passenger) and this finding has been consistent since 1981. While the number of public transport users (including train and bus) has been rising (from 275,200 in 1981 to 317,100 in 2006), the number of private car users also increased (from 734,000 in 1981 to 1,051,800 in 2006), and at a rate higher than public transport users (43% growth for car vs. 15% growth for public transport). The mode shares are shown in Figure 2, which indicates that the mode share for public transport has dropped from 25% in 1981 to 22% in 2006.

¹ Access mode is the mode used before the main mode and egress mode is the mode used after the main mode.

Figure 1: Mode share in volume

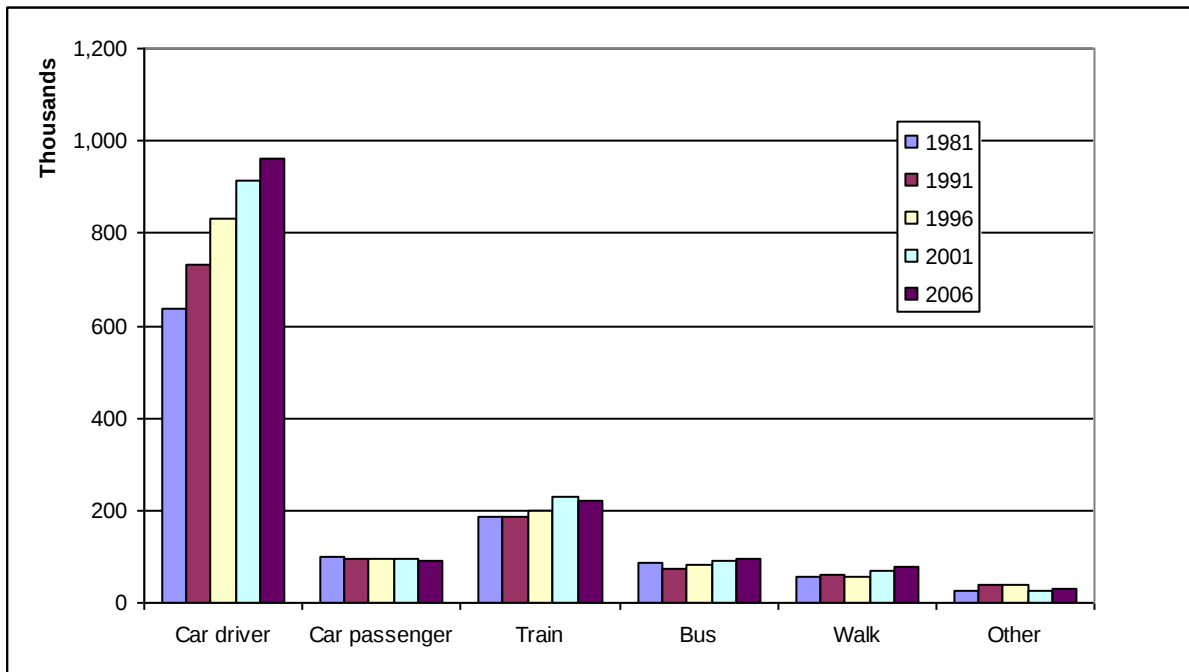
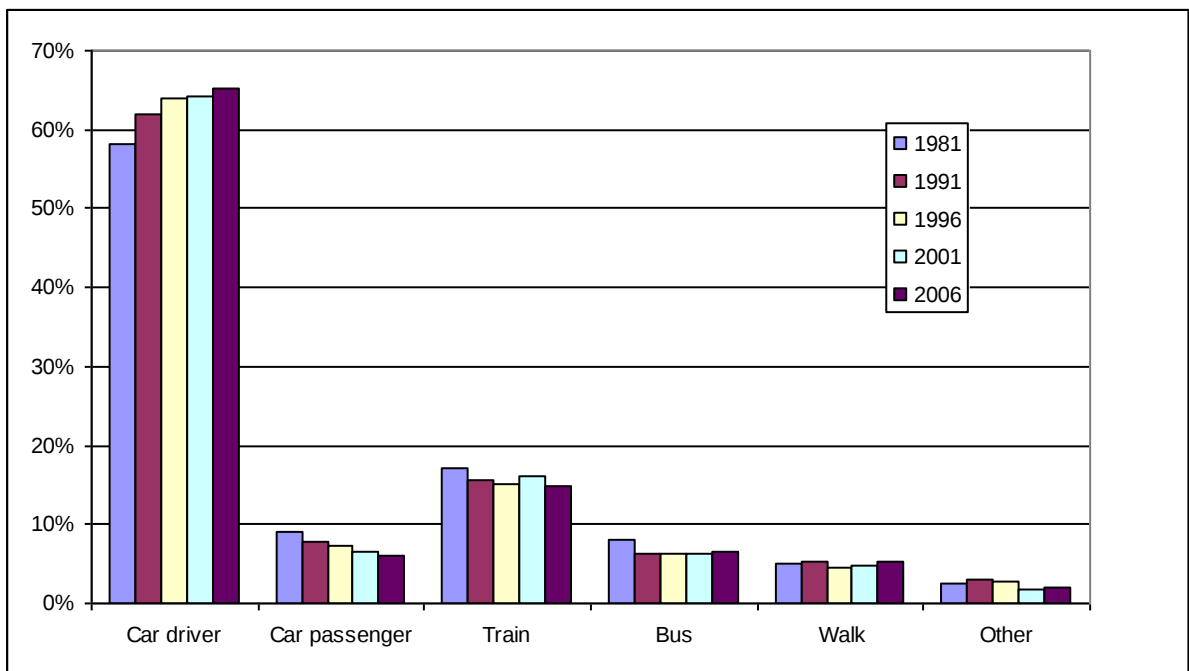


Figure 2: Mode share in percentage



2.2. Access mode to public transport

The Census records all modes used to travel to work. However, it is unknown in which order the modes are used. For some journeys using car and train, for example, it is reasonable to assume that the car is used first when they leave home as most people do not have access to a car at their destination rail station. Independent analysis of the HTS confirms this assumption. For some combinations such as train and bus, either mode could be the mode first used. Figures 3 and 4 present the access mode in volume and percentage from 1981 to 2006. Whilst these figures report access mode, in some situations it is actually the egress mode.

Figure 3: Access mode in volume

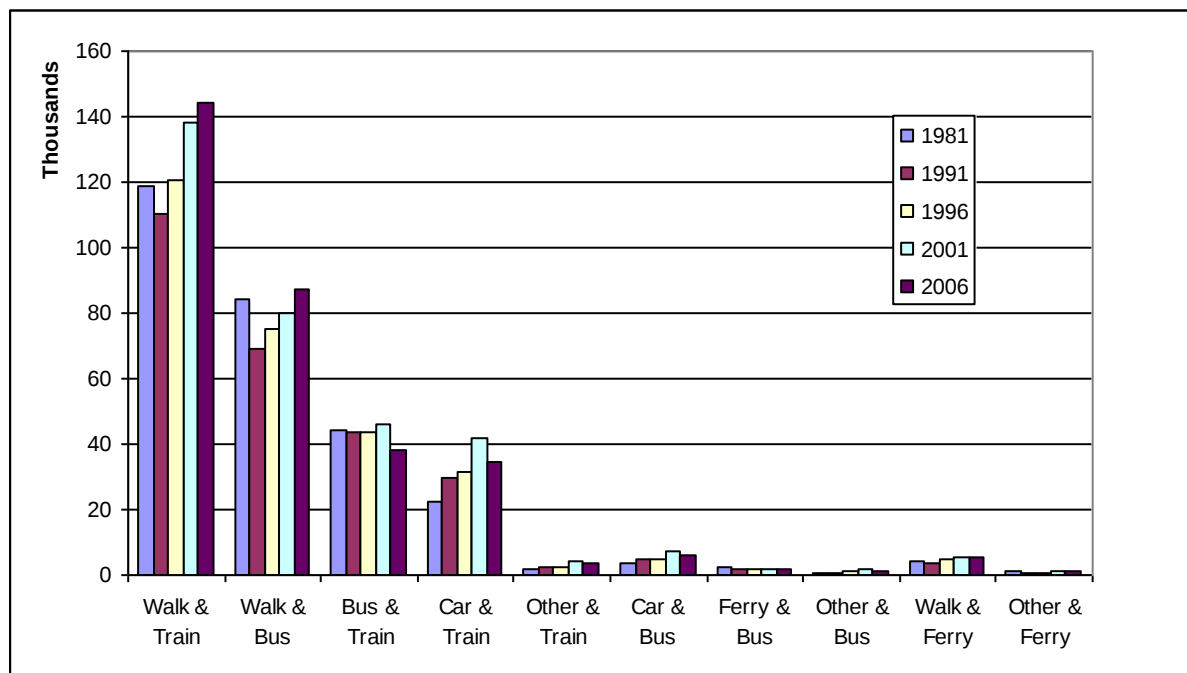
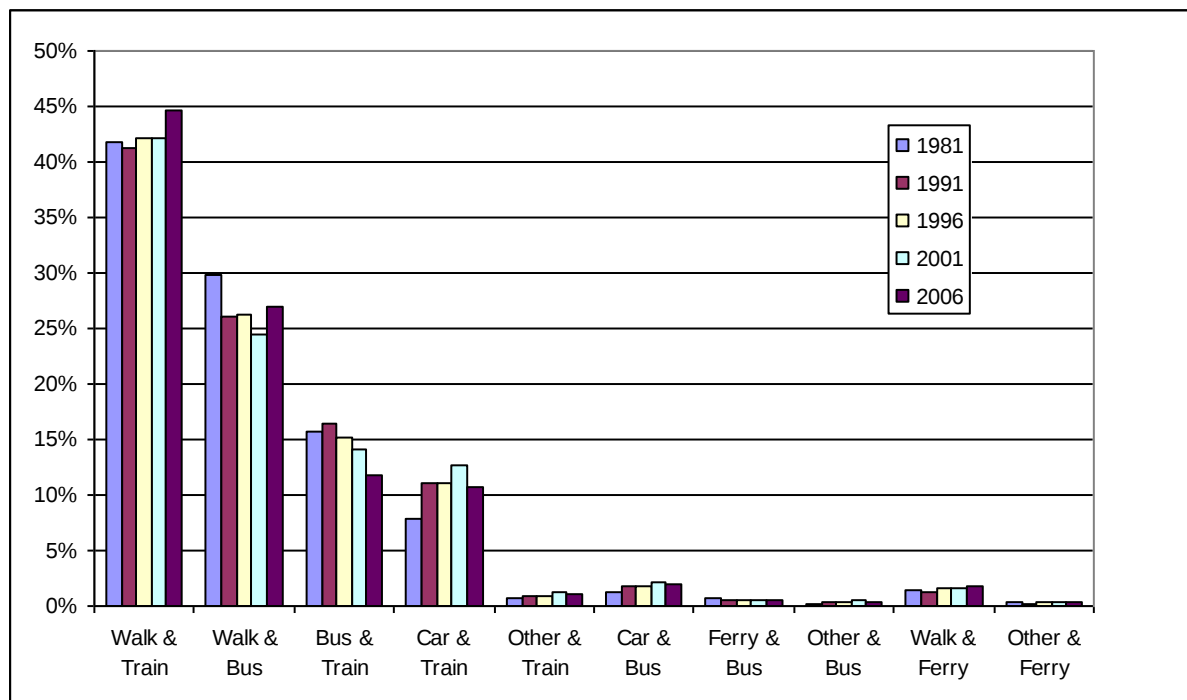


Figure 4: Access mode share in percentage

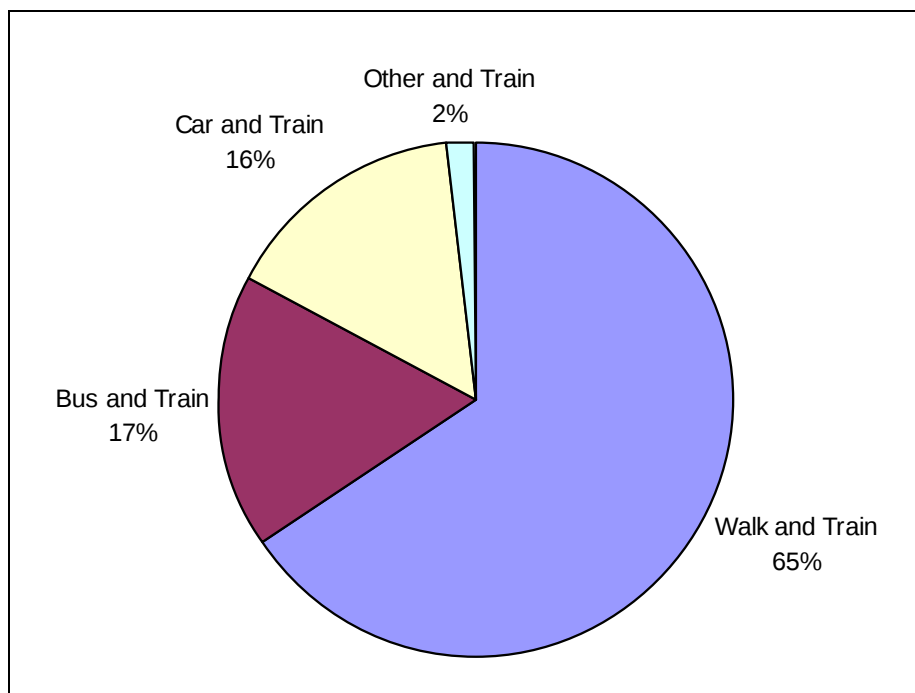


Figures 3 and 4 indicate that a single main mode is the dominant form of public transport journeys, with over 70% of journeys involving a single mode. From Figures 3 and 4 it can be seen that in 2006 compared with 2001 these single mode public transport journeys have increased, whilst the journeys with modal interchanges have decreased. For car and train journeys, the decrease in journeys in 2006 is a major departure from the previous trend of increasing usage of this combination of modes.

Figure 5 shows the access mode used for train journeys for 2006. From Figure 5, it can be seen that approximately two thirds of train journeys have walk access. Also bus and car

access are approximately equal in importance. As discussed earlier, some of these bus and train journeys are bus egress from train rather than access. Separate analysis undertaken of the HTS shows there are many more car and train compared with bus and train trips. Our hypothesis is that some Census respondents do not report the short car access leg journey; rather they report just the main mode. We believe the HTS which is collected via a face to face interview with an explicit aim of capturing each individual trip leg will be more accurate than the Census where details on the mode(s) used is via a “tick all that apply” single self-completion question.

Figure 5: Access mode share to train in 2006



2.3. Trip length

The JTW trip length reported in this section has used GIS calculated network distance between travel zone centroids instead of straight line distance, which was previously used for the 1981 to 1996 trip length analysis reported by Milthorpe and Raimond (1998). Table 3 shows key statistics for the average trip length for each Census year. Figure 6 shows the trip length distribution for each year. The number of zones in 2006 is more than double the number of zones used for the 2001 zone system. The decrease in mean and median trip length in 2006 may be a result of the changes to the zone system, rather than a genuine change. The standard deviation of the trip length in 2006 has increased considerably compared with earlier years.

Table 3: Average trip length in km

	1981	1991	1996	2001	2006
Mean	13.7	15.5	16.2	17.4	16.6
Median	10.2	10.8	11.1	12.1	10.8
Std Deviation	12.9	17.1	18.5	18.0	21.1

Figure 6: Distribution of trip length

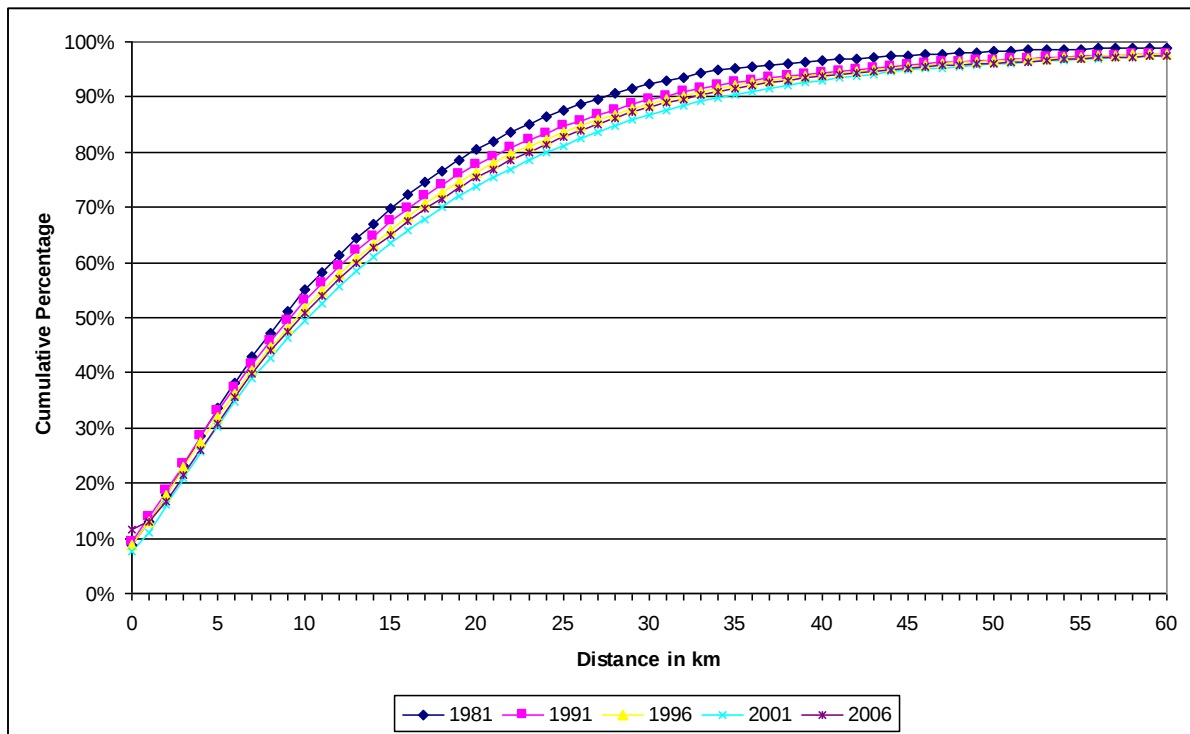
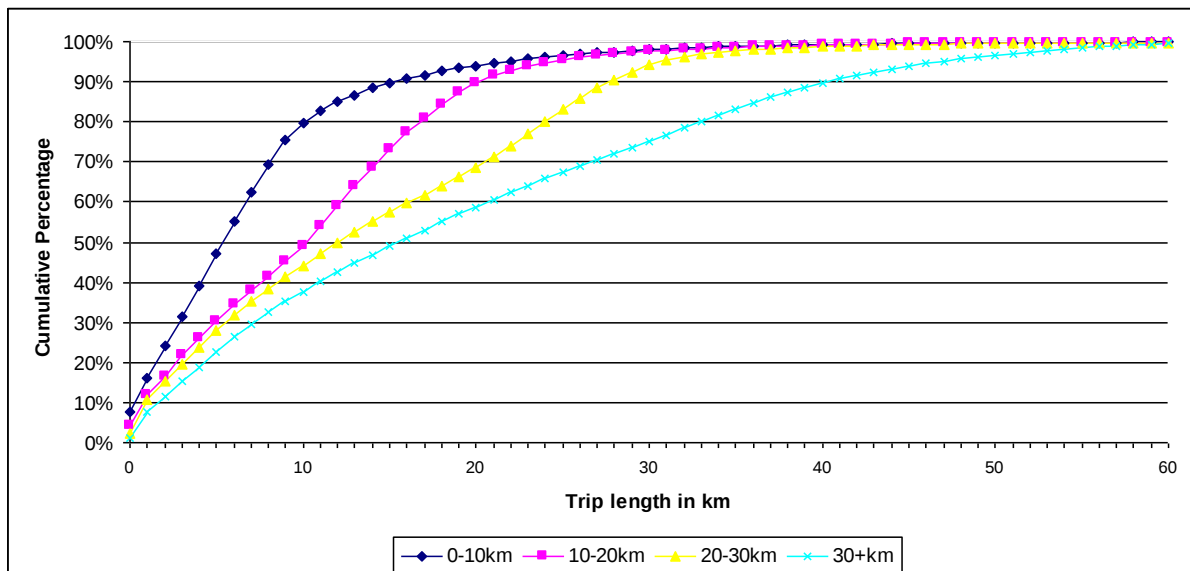


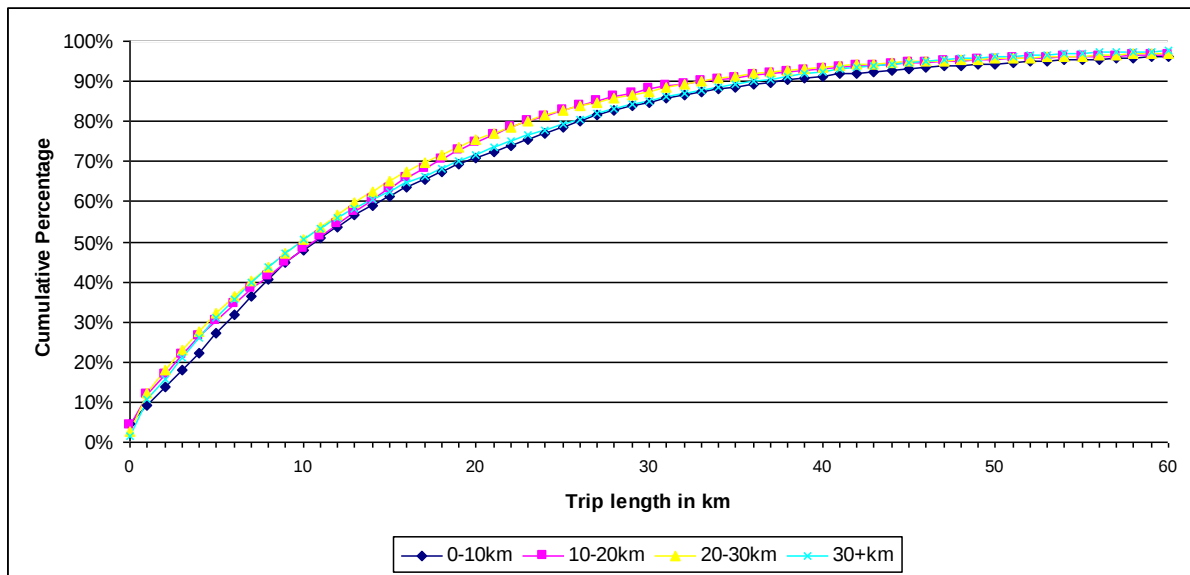
Figure 7 presents the trip length by the distance between the residential location and the Sydney CBD in 2006. It indicates that the closer the home location is to the CBD, the shorter the trips. For people living within 10 km of the CBD, the median trip length is 5.7 km, whilst for those living more than 30 km from the CBD, the median trip length is 15.5 km. That is, the distribution of the trip length is different from different residential locations.

Figure 7: 2006 trip length by home location distance from CBD



In contrast, Figure 8 shows analysis looking at the distance of the employment location from the Sydney CBD for 2006. There is no significant difference between the different employment location distance bands in Figure 8. That is, the distribution of the trip length is similar for different employment locations. Figure 7 and Figure 8 demonstrates a difference between the residential and employment location perspectives.

Figure 8: 2006 trip length by employment location distance from CBD



3. Land use changes

The JTW is essentially dependent on where workers live and where the employment opportunities that they choose to access are located. Figure 9 indicates the trend of the distribution of workers residential location by distance from the Sydney CBD over time. The percentage of worker population in outer suburbs, specifically in the 30-40 and 40-50 km bands, has increased significantly from 1981 to 2006. In 2006 more than 50% of the workers lived more than 20 kilometres away from the CBD, an increase of more than 10% from 1981.

Figure 10 indicates the trend of the distribution of employment opportunities in relation to the employment distance to the CBD. Nearly 40% of the opportunities were located at least 20 kilometres away from the CBD in 2006. The increase of jobs has mainly occurred in outer suburbs, specifically in the 30-40 and 40-50 km bands, which matches the increasing pattern of the workers' residence.

Figure 9: Residential location by distance band from CBD

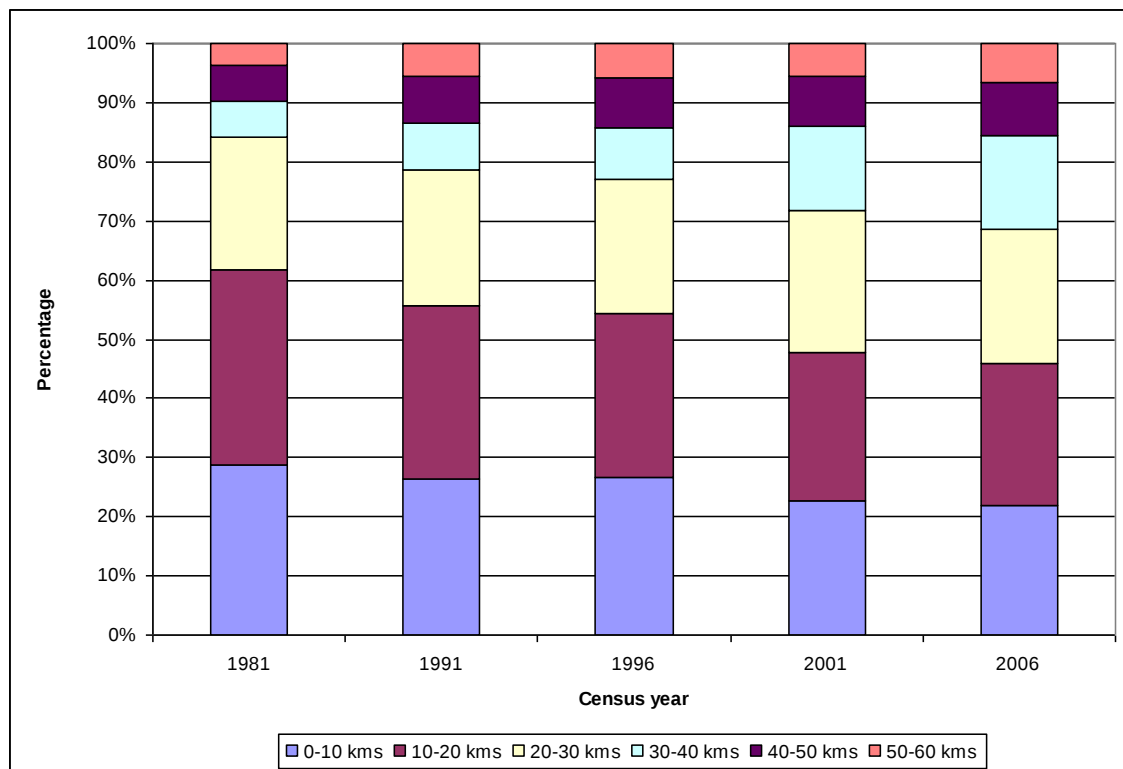
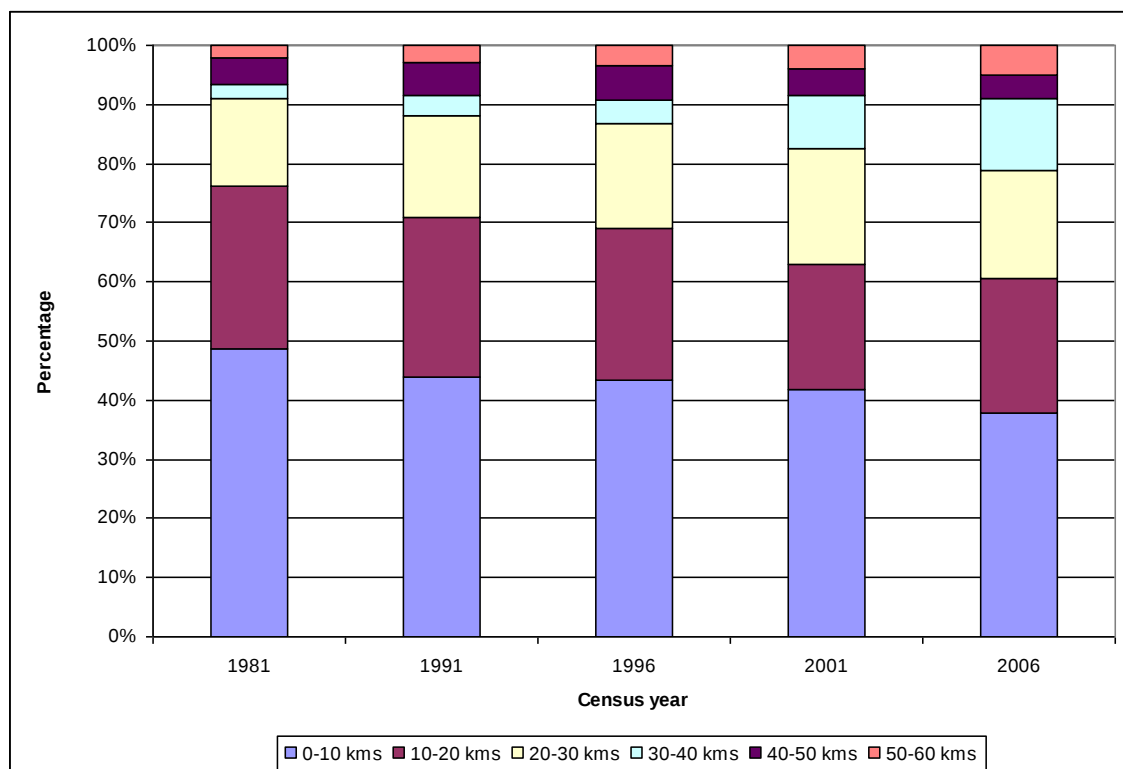


Figure 10: Employment location by distance band from CBD



The distribution of the employment is further investigated by regional centres in Table 4 with Figure 11 showing their location. A consistent centre definition is applied during the analysis, taking into account of the boundary changes from 1981 to 2006. The result indicates that the total employment opportunities in Sydney SD had a steady increase from 1981 to 2006. The

employment in the key centres has remained at 25% during the period 1996 to 2006. While the Sydney CBD remains a critical employment location with a share of employment at 10% from 1996 to 2006, the other centres within the 0-10 km band such as the Central Industrial Area, including Sydney Airport, had a reduction in the employment share. As a result, the overall employment share for the 0-10 km band had declined.

Table 4: Employment in major centres

Centre	1981	1991	1996	2001	2006
Sydney CBD	186,700	145,100	189,500	222,400	227,000
Parramatta	19,800	30,200	34,500	37,200	40,000
Wollongong CBD	9,300	7,200	8,900	9,500	11,600
Newcastle CBD	15,800	5,600	14,200	15,300	16,300
Bankstown	8,600	10,100	11,200	9,800	10,900
Blacktown	6,300	6,300	8,300	8,600	10,400
Campbelltown	4,600	6,600	8,600	10,100	10,800
Chatswood	11,100	16,400	20,300	21,900	21,700
Hornsby	9,900	12,400	13,400	13,800	14,900
Liverpool	8,600	13,200	13,300	13,200	12,200
North Sydney / Milsons Point	27,500	28,100	33,100	36,700	35,800
Penrith	6,800	9,000	10,500	13,100	13,400
St Leonards / Crows Nest	28,600	32,400	36,400	39,600	38,000
Central Industrial Area / Airport	60,200	57,700	63,000	66,100	65,000
Macquarie / North Ryde	10,800	18,700	22,500	29,700	35,900
Remainder	1,012,200	1,208,400	1,343,900	1,419,800	1,477,000
Total	1,634,000	1,782,700	1,986,800	2,212,300	2,271,100
Sydney CBD % of Total	11%	8%	10%	10%	10%
Sydney CBD	186,700	145,100	189,500	222,400	227,000
Other Centres	228,000	253,900	298,200	324,600	337,100
Total Centres	414,700	399,000	487,700	547,100	564,100
Centres % of Total	25%	22%	25%	25%	25%
Non Allocated ²	207,200	175,200	155,300	245,400	230,100

Note: This table is for total employment in the centres regardless of the residential location of the worker (i.e. includes workers who live outside Sydney SD).

² It includes NSW Undefined, Sydney Undefined, No Fixed Address, Unknown / Not Stated, and Outside Study Area

Figure 11: Sydney regional centres



4. Origin and destination travel patterns

Table 5 indicates that in 2006 only 14% of all JTW trips and 47% of all JTW by public transport were to the CBD. The slightly higher percentage of trips to the CBD (14% reported in this section compared with 13.3% in Table 4) is a reflection of the higher proportion of full time jobs in the CBD compared with other locations. 15% of all JTW trips were to other regional centres including Parramatta, Liverpool and Penrith. 71% of the trips were to outside these centre areas, which correspond to 70% of employment opportunities in outside these centre areas. But only 32% of the 15% JTW trips to other regional centres used public transport while the public transport mode share to the CBD was 75%.

Public transport mode share is 75% to the CBD, 32% to other centres and only 10% to other locations. Meanwhile, 47% of all public transport trips (ie, market share) are to the CBD. If higher mode shares for public transport are to be achieved, increasing the mode share to locations other than the CBD will be necessary.

Table 5: 2006 JTW by destination and mode

	Public Transport	Car	Other	Total
<i>Number</i>				
Sydney CBD	152,114	40,913	8,714	201,741
Other Centres	70,356	144,131	6,251	220,738
Rest of Sydney SD	100,012	865,102	82,725	1,047,839
Total	322,482	1,050,146	97,690	1,470,318
<i>Mode Share</i>				
Sydney CBD	75%	20%	4%	100%
Other Centres	32%	65%	3%	100%
Rest of Sydney SD	10%	83%	8%	100%
Total	22%	71%	7%	100%
<i>Market Share</i>				
Sydney CBD	47%	4%	9%	14%
Other Centres	22%	14%	6%	15%
Rest of Sydney SD	31%	82%	85%	71%
Total	100%	100%	100%	100%

The study of the OD patterns at the Statistical Sub-Division (SSD) level helps summarise the JTW travel with a spatial distribution to represent strategic regional travel flows. Figure 12 indicates the percentages of the inter-regional and intra-regional JTW trips by SSD. Except the Inner Sydney SSD, all other SSDs have more than 50% JTW trips leaving the regions. The SSDs having the highest percentages of inter-regional trips are Inner Western Sydney (80%), Eastern Suburbs (73%) and Canterbury-Bankstown (71%). That is, the higher the cross-regional trip percentage, the more likely to establish the demand for a transport corridor.

Figure 13 shows the desire lines³ of all JTW trips in 2006 by SSD OD pairs. There were large numbers of JTW trips to Inner Sydney, and there were also other large JTW movements between other SSDs. Figure 14 presents the desire lines of JTW trips by public transport and it indicates that the majority of JTW trips by public transport were to Inner Sydney. But large JTW movements between other SSDs have not been well served by public transport. The dominating mode is the private car as shown in Figure 15.

³ Desire lines are the demand pattern between origin and destination pairs by direction.

Figure 12: 2006 Inter-region and intra-regional trip percentage

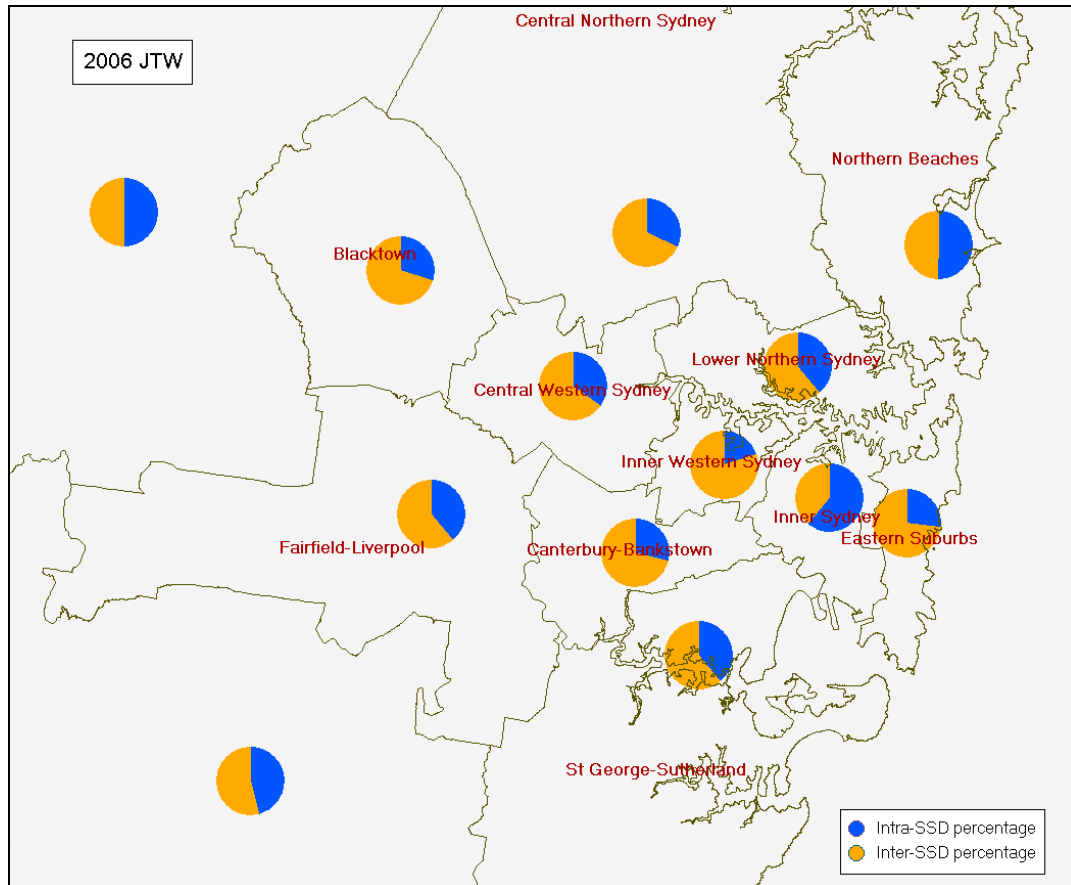


Figure 13: JTW desire lines by SSD OD pair for all trips in 2006

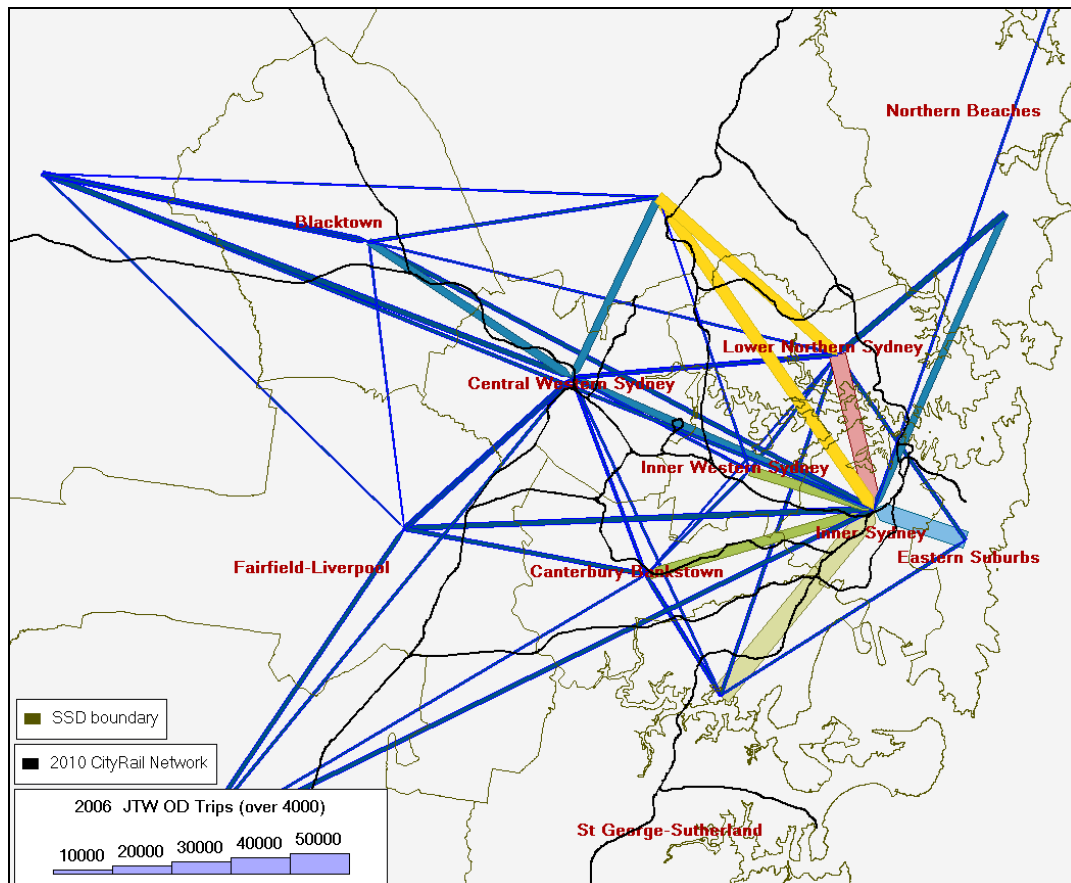


Figure 14: JTW desire lines by SSD OD pair for all public transport trips in 2006

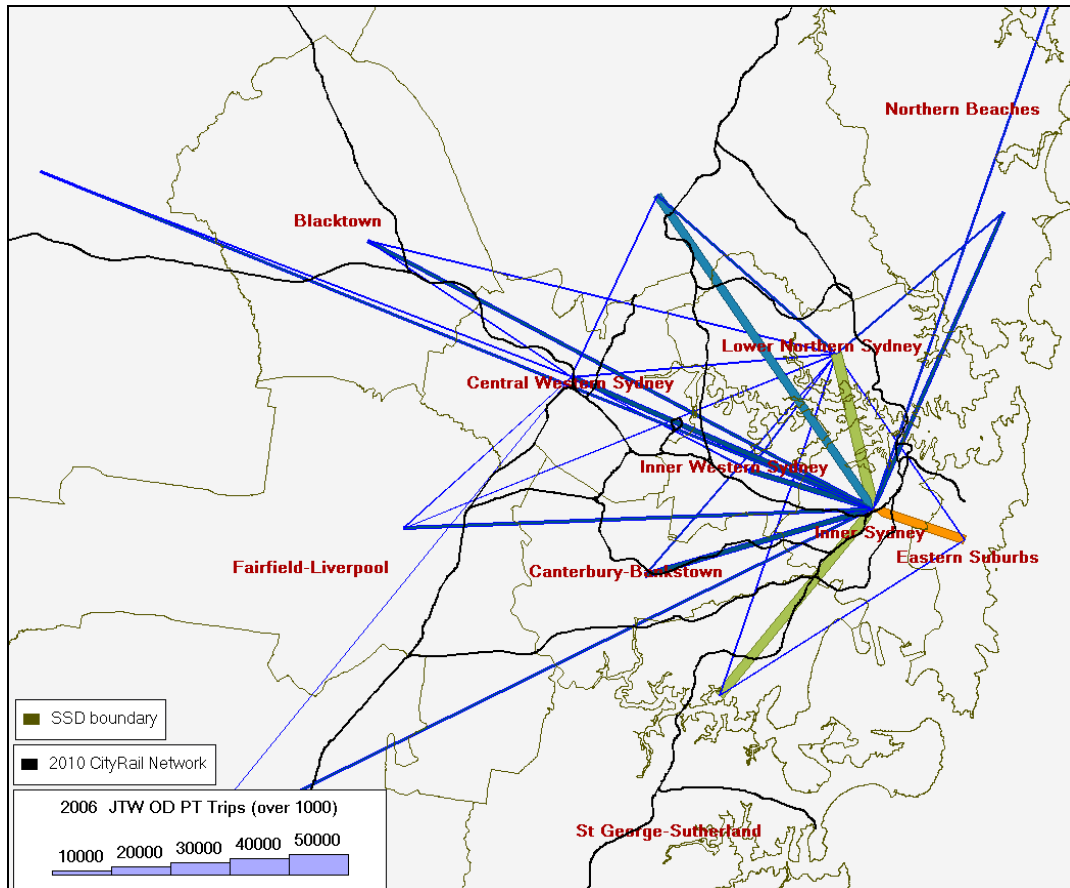
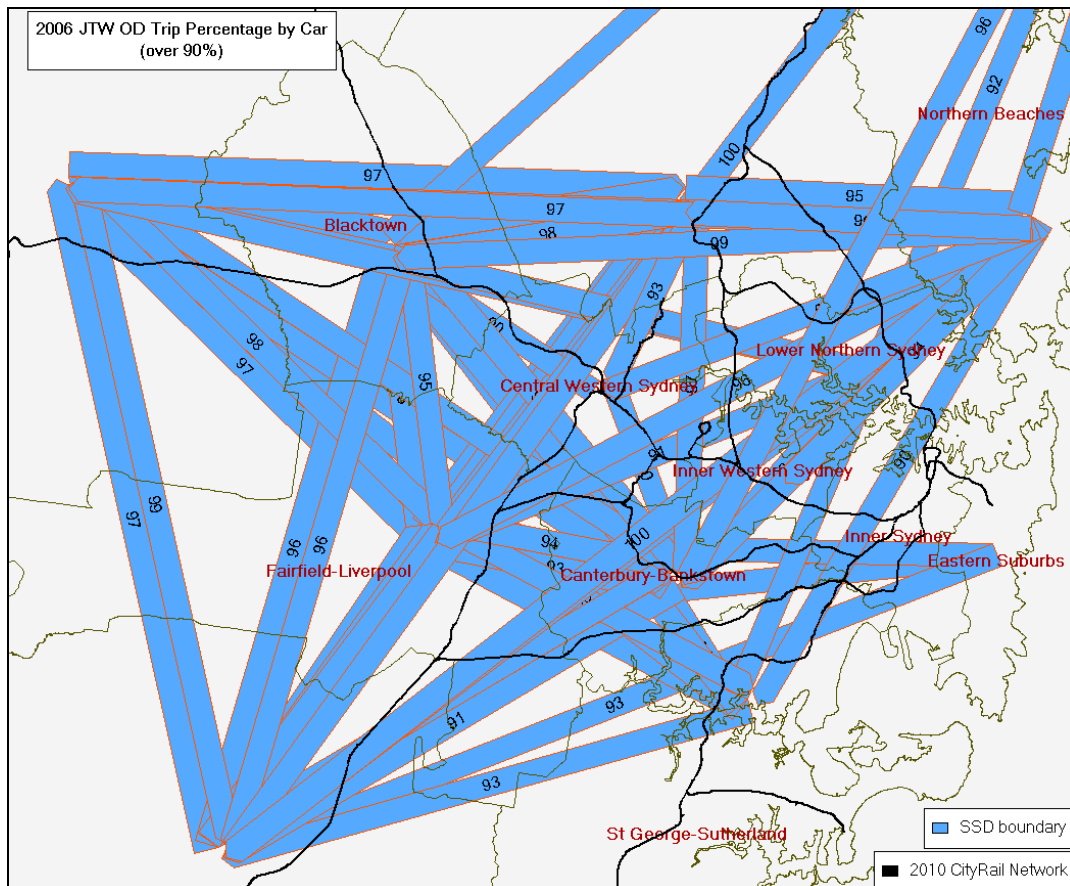


Figure 15: Percentage of car trips in the 2006 JTW by SSD OD pair



5. Conclusions

This paper presents an investigation of the JTW data derived from the 1981 to 2006 Census collections (1986 omitted). Key findings and implications from the analyses are:

- Over time both residential and employment locations have moved further away from the CBD as Sydney has grown.
- The public transport JTW mode share is declining, although the number of public transport trips is increasing. This suggests that the development of public transport network and services may have not adapted to the changing nature of Sydney. Recent travel surveys undertaken in Sydney have shown a significant increase in car ownership rates, a trend similar with other Australian capital cities. Whether this is a lead or lag impact of the public transport provision is an interesting research topic.
- A single mode is the dominant form of public transport usage. However, many public transport journeys involve multiple modes. For these users (and potential users) improved integration of public transport services and expansion of service coverage is likely to increase public transport usage.
- Public transport mode share is very low (around 10%) for travel to non-centre locations.
- The average trip length is increasing over time, closely related to the noticeable land use pattern changes.
- While the share of employment located in the CBD and other regional centres has remained constant over time, the closer people live to the CBD, the shorter their average trip length. However, the average trip length to employment locations is constant irrespective of the distance of the workplace location from the CBD.
- While travel to the CBD has been the dominant public transport market, there is an indication for potential public transport corridors linking between other regional centres.

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