

# Employment Centres and the Journey to Work in Sydney: 1981-2001

**Bruno Parolin**

University of NSW

Email: b.parolin@unsw.edu.au

## ABSTRACT

Like other large metropolitan areas, Sydney has experienced rapid decentralisation of homes and workplaces since 1981 with increasing use of the car for the journey-to-work. Previous research (Parolin and Kamara, 2003) has shown that at least half of the employment growth is concentrated in employment clusters or sub-centres that display a spatial patterning and hierarchy that is likely to affect commute distances and the spatial separation of homes and workplaces. The aims of this paper are twofold; first, to identify employment centres (ECs) in 1981 and 2001 across the Sydney metropolitan area and, secondly, to examine shifts in commuting to employment centres by car and public transport. In this process one is able to test the co-location hypothesis which maintains that employment decentralisation over time leads to a jobs-housing balance (co-location) and fairly constant average commuting distances and durations. Only distances are examined in this paper. The analysis proceeds by using journey-to-work data at the travel zone level and the calculation of statistics on shifts in average distances, and VKT for car and public transport between 1981 and 2001. Patterns in shifts in commute distances and VKT by car and public transport for identified centres are examined.

Analysis of journey-to-work data for 1981 and 2001, and identification of ECs in these years, has demonstrated the significance of centred employment and polycentric urban growth in the Sydney metropolitan area. A total of 28 centres were identified in 1981 and 39 in 2001. Moreover, it has been shown that the co-location hypothesis does not hold for the Sydney area; this was true for 1981 and 2001. The shifts in mode split over the 20 year period indicate the increased use of the car for the journey-to-work in identified ECs and the relatively low use of public transport (bus and train) for travel to jobs in these centres.

For planning and policy relevance, these findings suggest that prescriptions of higher levels of self-sufficiency in new growth areas (better co-location of jobs and people) are not likely to generate lower average distances for the journey-to-work. More polycentric urban growth, even that focussed on public transport corridors, is not likely to reduce average commute durations; the evidence suggests that they will increase – on average. All this strongly suggests that factors other than proximity to workplace have influenced and will continue to influence where workers reside. It is of paramount importance for metropolitan and transport planners to better understand what these other factors are likely to be if we are to move towards achieving sustainability.

## INTRODUCTION

Transitions from monocentric to polycentric urban growth patterns have been the subject of intense empirical investigations over the past twenty years with case studies of US cities (e.g. Gordon et.al., 1989; Giuliano and Small, 1991; Cervero and Wu, 1998), European cities (e.g. Schwanen et.al., 2001; Giuliano and Small, 1993) and some Asian cities (e.g. Alpkokin et.al., 2005) highlighting the key drivers of employment decentralisation and car dependency. Several aspects of this research - the spatial dimensions of urban commuting, the growth of employment centres in suburban locations, the job-housing balance, and how journey-to-work travel contributes to an understanding of urban sustainability - are of relevance to the present study given the relative absence of similar research for the Sydney metropolitan area.

One of the recurring themes in the urban commuting literature is the relationship between polycentric urban growth and commute durations and times. The 'co-location' hypothesis, as it has come to be called, maintains that market mechanisms lead households and firms to relocate periodically to minimize commuting costs (Gordon et.al, 1989). Over time, jobs and housing co-locate so as to maintain fairly constant average commuting durations and times (Levinson and Kumar, 1994). The study by Sultana (2000) is somewhat different to that of Gordon et.al. (1989, 1991) and Levinson and Kumar (1994) in that interest was on the variation of commuting times by types of employment centres within a city rather than comparison among cities. Using the 1990 census data of the Atlanta metropolitan area, the influence of four variables representing types of employment centres, i.e., total employment, employment density, distance from the CBD, and dummy central/suburb on commuting times were investigated. The findings indicated that the average commuting times to suburban employment centres and subcenters were shorter than to employment centres and subcenters located closer to the central city. In general, it was concluded that average commuting times to subcenters were shorter than to employment centres for the whole metropolitan area.

Contradictory evidence for co-location theory has been reported by Cervero and Wu (1998), Ewing (1997), and Schwanen et.al. (2002). Using the San Francisco Bay Area as the case study, Cervero and Wu (1998) found that all classes of employment centres in the region experienced increases in average commute durations and times during the period 1980-1990. The increase in commuting times was only less than 1% for downtown San Francisco, compared to a 25% increase for centres located in suburban areas.

Schwanen et.al. (2002) investigated the impacts of urban structure on commuting in the Netherlands. Four categories of urban systems were examined - centralised, decentralised, cross commuting and exchange commuting - where the latter three represent different forms of polycentric urban patterns. Their findings indicated that commuting times as car driver are significantly longer for the majority of polycentric urban structures than for the monocentric case. In general, the study concluded that polycentrism does not contribute to the reduction in commuting times. One explanation proposed by the authors is that the relative proximity among subcenters encourages cross commuting between suburbs, contributing to increased commuting times.

The study by Cervero and Wu (1998) is of additional relevance to the present paper as they use a more robust measure of transport outcomes - vehicles miles travelled (VMT) per employee - to examine shifts in commuting to employment centres. Their hypothesis that increases in VMT per employee have been attributable primarily to a lengthening of work trips and secondarily to reduced transit and ridesharing market shares was accepted in the case of the San Francisco Bay area in relation to commuting to suburban employment centres. The transport externality effects of increases in VMT per employee were highlighted in the context of further public policy attention.

A recent paper by Black and Suthanaya (2002) on vehicle kilometres travelled (VKT) in Sydney during the period 1981-1996 has also highlighted very significant increases over this period, particularly in those suburbs greater than 20km from the Sydney CBD. Their study used the local government area as the unit of analysis. Increasing use of the car for the journey-to-work and increasing spatial separation of homes and workplaces were two drivers of increased VKT at the local government area level. It is very likely that a focus on VKT to suburban employment centres will highlight similar trends to those reported by Cervero and Wu for San Francisco. Their use of VKT has highlighted its importance as a performance indicator of sustainable urban travel.

This paper follows from the work of Cervero and Wu (1998) and examines the journey to work impacts of the emergence of suburban employment centres in the Sydney metropolitan area. In doing so we are able to test the co-location hypothesis to determine if growth of a polycentric urban pattern is associated with reductions in average journey to work commute distances. We use VKT as our policy-relevant measure of commuting performance and examine shifts in VKT by mode type (car and public transport) to identified employment centres. In this sense, our paper provides new insights into the role of suburban employment centres on modal choices.

## **STUDY AREA, DATA AND METHODS**

This study employs journey-to-work tables for 1981 and 2001 travel zones in Sydney which comprises the continuously built-up areas of the city at each respective census year, but excludes that part of the Greater Sydney Metropolitan Region (GSMR) which extends north to the central coast and up as far as Newcastle, south to Wollongong, and west to the Blue Mountains. The study area is commonly referred to as the Sydney Metropolitan Area (SMA) or the Sydney basin. These data record the number of people employed and the employing industry (one-digit ANZIC) for each travel zone. The study area comprises a total of 649 travel zones in 1981 and 813 zones in 2001. This area is composed of two primary commercial centres (Sydney CBD and Parramatta CBD) and nine secondary commercial centres nominated in the New South Wales Government's joint metropolitan strategies of 1995 "Cities for the 21<sup>st</sup> Century" and the "Integrated Transport Strategy (ITS)" which contain a significant proportion of GSMR employment (NSW Government, 1995). However, this study also considers other non-commercial centres with equally (if not higher) employment levels. The major employment centres identified in this study may include several of these nominated centres, or may include part of the travel zones that comprise the commercial boundary of a centre.

### **Defining Employment Centres**

The methodology described in Parolin and Kamara (2003) has been used in the present paper. This approach proceeds as follows. First one identifies "potential" employment centres (ECs) for use in further analysis. A "potential" centre is defined as a zone with total employment that is significantly higher than the regional mean. Employment data were standardised by subtracting each zonal value from the regional mean and then dividing the difference by the standard deviation. All zones with standardised employment values (Z-scores) above 0 were considered as "potential" centres. This approach identified 155 zones in 1980 and 245 in 2001. Potential zones are then further refined by selecting only those which met the criteria of employment density greater than 2470 jobs per sq km or an employment-population ratio greater than 1. This identified 91 zones in 1981 and 129 zones in 2001; these zones are treated as ECs in our definition. Single or contiguous zones were then merged to produce 28 ECs in 1981 and 39 ECs in 2001. This methodology does not necessarily allow one to map changes in the sizes and densities of the same ECs in 1981 and 2001 as some of the 1981 ECs may drop out if their total employment is below the regional mean in 2001. Notwithstanding, there were 20 centres identified for 1981 that were present in 2001.

Shifts were also examined among four hierarchical classes of ECs that were determined from their locational characteristics relative to the CBD of Sydney.

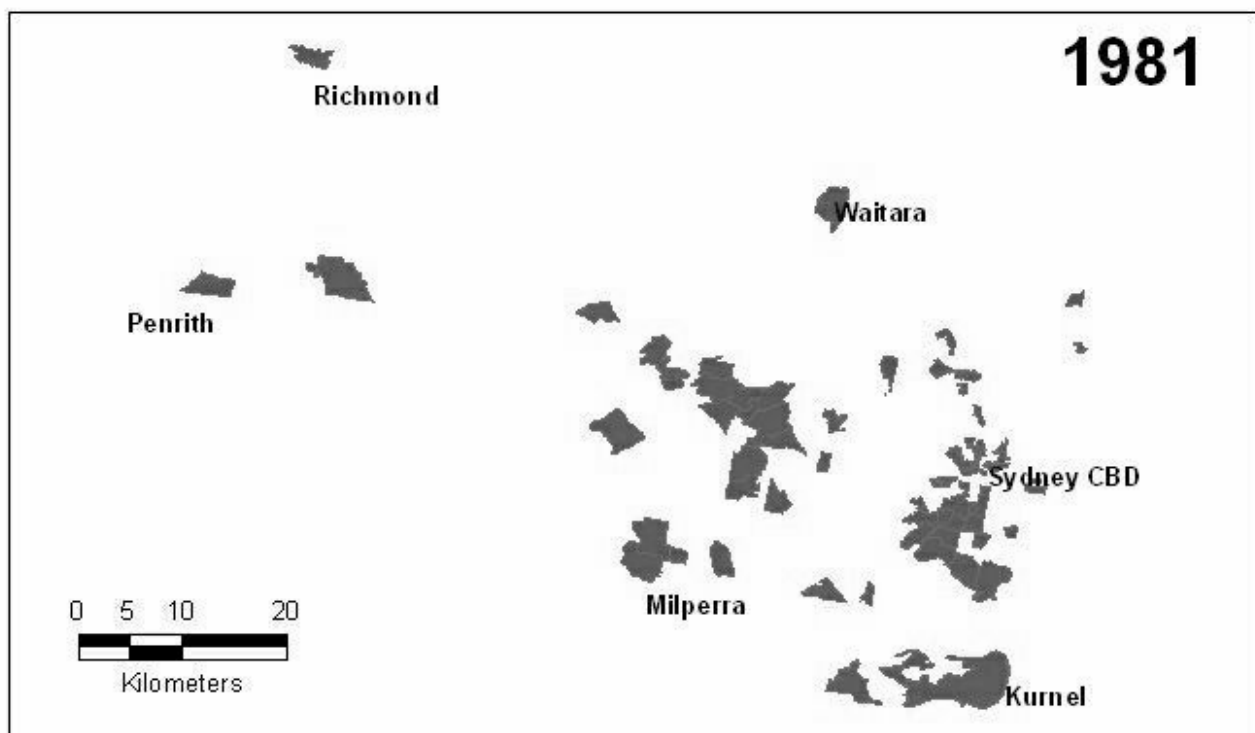
### **Journey to Work Statistics**

Journey-to-work statistics were generated for the 28 ECs in 1981 and 39 ECs in 2001. This analysis considers three output measures of commuting impact; average one-way distances; average one way distances by main mode, and; total VKT. Average journey-to-work distances were calculated based on highway and public transport network distances using the EMME/2 software program and skimming the 1981 and 2001 Sydney networks. This approach generates centroid-to-centroid actual journey-to-work distances.

The total amount of journey-to-work travel for an EC is the total number of journey-to-work trips from any of the origin zones within the Sydney Statistical Division (SD) to that EC based on the centroid-to-centroid distances. Summing over all trip interchanges destined to an EC generates total person kilometres or VKT. Dividing this by the ECs employment total gives an average journey-to-work distance for that EC.

### **SYDNEY EMPLOYMENT CENTRES: 1981 and 2001**

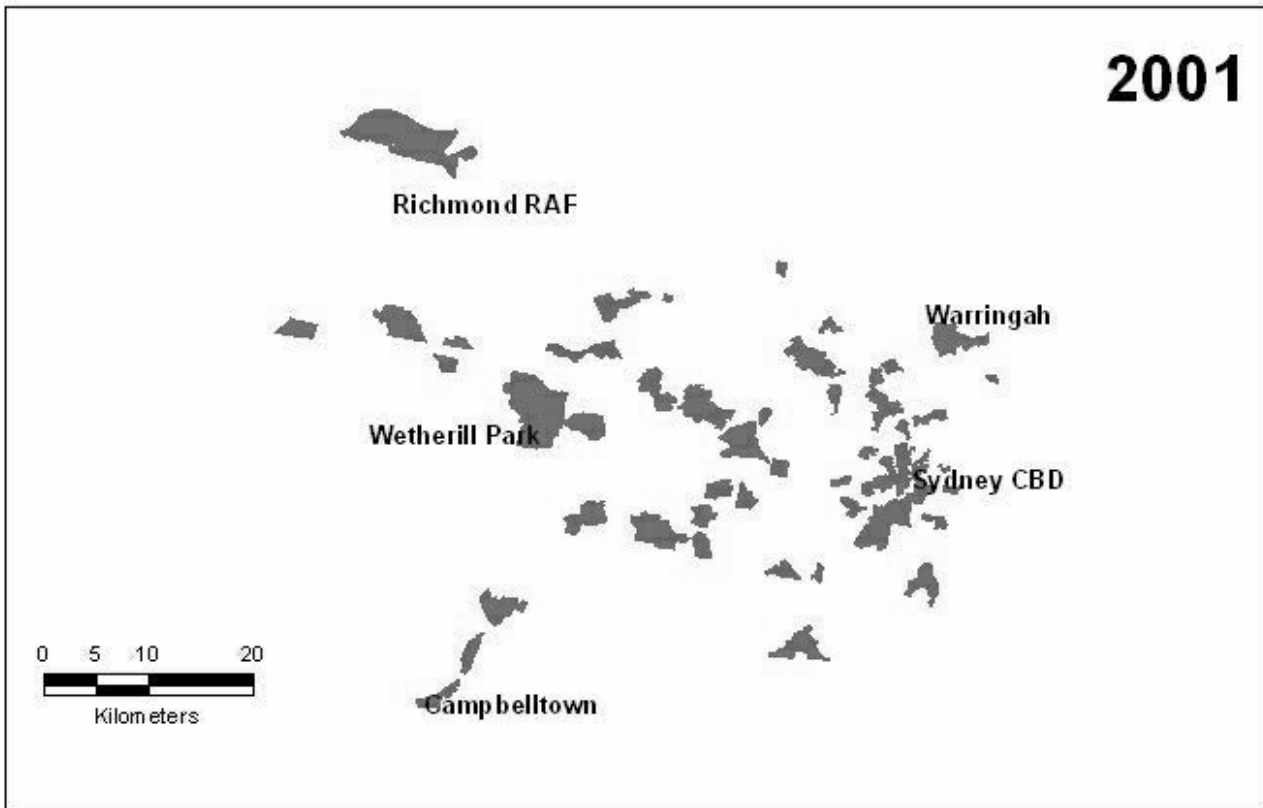
The location of ECs in 1981 and 2001 are shown in Figures 1 and 2. Tables 1 and 2 provide summary statistics. Several major characteristics of employment concentration are evident from the figures and tables. The CBD remains the single most important employment node in the Sydney area despite a decline in the region's share of total employment. However, the number of people employed in the CBD increased over this period. When coupled with growing CBD fringe areas, which are precincts contiguous to the CBD to the south, east and west (Darlinghurst-Woolloomooloo, Surry Hills, Central-Redfern, and Pyrmont-Ultimo) and the Central Industrial Area/Airport the dominance of the central core for employment and density is overwhelming.



**Figure 1 Employment centres in 1981**

Employment opportunities gradually decline away from the central core. Employment-population ratios remain extremely high in the central core relative to other concentrations indicating low

levels of intermixing of population and employment up to 2001. Since this time, however, there has occurred considerable population growth in the central core (CBD, CBD fringe areas, and Central Industrial Area/Airport) due to residential developments of a high-rise nature that will generate high levels of intermixing of population and employment. The lower North Shore area (Milson's Point and North Sydney) is an extension of the Sydney CBD but generally exhibits lower densities and a great deal of intermixing of population and employment. A North Shore corridor of concentrations had developed by 2001 between Crows Nest and St. Leonards and the Chatswood EC.



**Figure 2 Employment centres in 2001**

After the first four ranked areas in 1981 and 2001, the remaining concentrations are major suburban nodes which generally appear to fit the typology of office employment centres outlined in Freestone and Murphy (1998). Parramatta is the official second CBD of Sydney, with corporate, state and federal government offices serving western Sydney. The contiguous precinct of Westmead is associated with a specialisation around the hospital. Suburban commercial concentrations (e.g., Hurstville, Liverpool, Kogarah, Manly, Hornsby, Penrith, Burwood, Bondi Junction, Campbelltown) are strong traditional centres located at major rail and bus interchanges. Office corridors are represented by the Lower North Shore, Crows Nest - St. Leonard's and the concentration at Chatswood. Many of the remaining areas represent more traditional business zones with a manufacturing bias (Wetherill Park/Smithfield, Brookvale, Blacktown/Seven Hills, Padstow, Milperra, Silverwater/Flemington/Rydalmere, Banksmeadow). More specialised concentrations are found in Macquarie Park (technoburb), Norwest Business Park, Homebush/Rhodes, Dunheved (ADI site), Kurnell (oil refinery) and University of NSW. (Since 2001, several of these sites have been or are currently being re-developed for residential purposes).

**Table 1 Major employment centres in Sydney, 1981 and 2001**

1981					2001				
Rank	Centre	Emp	Emp Density	Emp/Pop ratio	Rank	Centre	Emp	Emp Density	Emp/Pop ratio
1	Sydney CBD	160853	7,607.86	29.67	1	Sydney CBD	197,004	7,873.86	9.33
2	Central Industrial Area/ Airport	84378	393.01	2.26	2	CBD Fringe	64,379	1,531.01	1.21
3	CBD Fringe	49628	1,060.56	2.13	3	Central Industrial Area/Airport	53,122	367.12	1.96
4	Flemington/Silverwater//Rydalmere	34885	154.13	2.43	4	Crows Nest St Leonard's	47,586	933.24	2.80
5	Lower North Shore	31090	2,034.15	5.80	5	Parramatta Westmead	41,657	794.68	3.15
6	Chatswood	28236	492.90	1.64	6	Lower North Shore	35,361	4,004.64	4.58
7	Parramatta/Westmead	17129	390.98	2.47	7	Macquarie Park	24,221	399.36	2.98
8	Milperra	16221	127.18	2.24	8	Wetherill Park Smithfield	24,029	85.70	2.43
9	Kurnell	12832	44.51	0.74	9	Chatswood	19,014	1451.45	3.59
10	Brookvale	8952	518.57	5.30	10	Silverwater Rose Hill Rydalmere	17,736	203.70	4.71
11	Hornsby	7978	1,587.35	0.71	11	Blacktown Seven Hills	14,874	328.34	3.05
12	Yennora	7291	131.01	1.10	12	Warringah	14,531	211.33	2.96
13	Enfield	6533	183.73	0.85	13	Liverpool Warwick Farm	12,876	241.67	1.20
14	Penrith	6459	179.56	1.71	14	Penrith	12,773	351.58	3.45
15	UNSW	6424	362.28	0.81	15	Bankstown	11,468	136.48	3.60
16	Chullora	6247	88.65	2.41	16	Norwest Business Park	9,167	173.13	4.84
17	Padstow	6149	231.44	3.07	17	Homebush Rhodes	8,062	92.21	1.50
18	Dunhevid (ADI)	5554	76.89	1.16	18	Burwood	7,998	933.26	1.81
19	Bondi Junction	5191	477.38	0.75	19	Campbelltown Macarthur Sq	7,445	273.11	8.80
20	Blacktown/Seven Hills	5147	167.52	2.88	20	Kogarah	7,040	942.44	2.93
21	Manly	3641	483.08	0.70	21	Bondi Junction	6,834	1,156.35	1.23
22	Richmond RAAF	3629	108.06	1.08	22	Taren Point	6,640	148.15	1.18
23	Kogarah	3507	476.24	1.40	23	Padstow	6,189	238.31	2.75
24	Banksmeadow	3489	122.90	34.54	24	Lane Cove	5,599	378.57	4.01
25	Balmain	3042	342.18	0.59	25	Chullora	5,586	217.61	5.70
26	Lane Cove	2915	204.56	2.65	26	Ingleburn	5,225	90.21	1.44
27	Leichhardt	2770	318.21	0.61	27	Dunhevid ADI	5,133	68.60	1.24
28	Rhodes Peninsula (AGL)	2011	173.32	2.76	28	Pymble	5,123	473.91	2.73
					29	Windsor Richmond RAAF	4,872	16.36	1.89
					30	UNSW/ PoW Hospital	4,084	346.98	4.42
					31	Willoughby North	3,976	350.31	1.45
					32	Manly Central	3,327	700.42	1.13
					33	Minto	3,260	115.73	13.33
					34	Sydenham	3,210	478.39	8.61
					35	Enfield Yards	2,467	111.03	1.49
					36	Mt Druitt	2,455	175.73	1.66
					37	Double Bay	2,419	753.58	0.71
					38	Castle Hill	2,232	652.63	4.00
					39	Minchinbury West	2,200	134.15	49.40

The distribution of employment and employment density characteristics for identified centres in 1981 and 2001 indicates a correlation with distance from the CBD and a spatial patterning of the location of centres. The Sydney CBD is the most important class of centre. The cluster of centres located within 10km of the CBD makes up the next layer of employment densities and can be termed an inner core class of centres. Those centres located between 11 and 19km from the CBD make up the middle ring class of centres. A final group of centres are found beyond a distance of 20km. These are classed as being outer centres or outer suburban centres. These four classes of centre are used to examine changes in average journey-to-work distances.

The addition of eleven major centres between 1981 and 2001 is further testimony to the growing polycentric or multi-polarised nature of the metropolitan area, and to the persistence of strong agglomeration forces. Several of these newer centres (Liverpool, Minchinbury West, Mt. Druitt, Castle Hill, Ingleburn, Minto, Norwest business park), which met our criteria for inclusion as centres in 2001, are located in the outer suburbs (beyond 20 kilometres) and are beneficiaries of the suburbanisation of employment opportunities which occurred over the time period of our study.

**Table 2 Aggregate statistics, 1981 and 2001**

	Total employment		Total population		Employment Density (job/sq km)		Population Density (/sq km)		Employment/population ratio	
	1981	2001	1981	2001	1981	2001	1981	2001	1981	2001
Within Centres	532,181 (48%)	784,184 (51%)	214,373 (7%)	293,544 (8%)	2729	3726	1099	1395	2.50	2.67
Not Within Centres	578,559 (52%)	778,689 (49%)	2736456 (93%)	3,462,848 (92%)	184	142	738	630	0.21	0.22
All Zones (SMA*)	1,110,740	1,562,873	2,950,829	3,756,393	336	274	893	658	0.38	0.42

Note: \* Sydney Metropolitan Area (Sydney Basin) is the study area defined for our study.

Minchinbury West and Norwest Business Park, in particular, will see further expansion of employment opportunities associated with completion of the Western Sydney Orbital (M7) link.

A striking feature of Table 2 is that the proportion of employment within identified centres has increased between 1981 and 2001 to 51%, a higher proportion than that reported by Pfister et.al (2000) (36%) and higher (33%) than that reported for Los Angeles (Giuliano and Small, 1991), a city with which Sydney is often compared. Increased values for employment density, population density and the employment/population ratio all indicate the relative importance of socio-economic activity within the polycentric pattern of employment centres.

Closer examination of the spatial location of employment within identified concentrations indicates that 71% in 1981 and 62% in 2001 respectively is located within 10 kilometres of the CBD – an area sometimes referred to as the inner city. Outside of this area, employment and employment densities decline rapidly with distance (with some notable exceptions). Employment density, in other words, is strongly correlated with distance from the CBD. The Spearman rank correlation between employment density and distance for identified concentrations in 1981 and 2001 is  $-0.640$  and  $-0.646$  respectively (significant at the one per cent level). Distance from the CBD accounts for 51% and 54% respectively of the variance in employment density in 1981 and 2001, based on a least squares estimate of a simple power density function (gradient of  $-0.78$  and  $-0.88$  for 1981 and 2001 respectively).

The identified concentrations for 1981 and 2001 also appear to have a size distribution which is consistent with the idea of a hierarchy of functions – the rank-size rule. Giuliano and Small (1991) and Anderson and Bogart (2001) are used as examples of the rank-size rule and characterize this distribution by estimating the following regression for our identified concentrations in 1981 and 2001:

1981:  $\text{Ln}(\text{rank}) = 9.33 - 0.76 \text{Ln}(\text{employment})$   
*(0.176) (0.019)*  
*(Standard errors are given in parentheses)*

2001:  $\text{Ln}(\text{rank}) = 9.99 - 0.80 \text{Ln}(\text{employment})$   
*(0.197) (0.021)*

The coefficient of Ln (employment) for both models was statistically significant at the 99 per cent level. These rank-size rule regressions explain 98% and 97% respectively of the variance in Ln (rank) and assert that the rank-size rule (rank times size is constant throughout the distribution) holds extremely well in Sydney. Following Anderson and Bogart (2001), a coefficient on Ln (employment) less than 1 in absolute value implies that employment is more concentrated in larger employment concentrations than predicted by the rank-size rule – a situation described above.

## **SHIFTS IN COMMUTING TO EMPLOYMENT CENTRES: 1981-2001**

In this section the nature of the relationship between patterns of EC growth and journey-to-work among EC workers is examined for the period 1981-2001. Trends in commuting distances are examined across ECs and across ECs by mode, and the co-location hypothesis is then tested.

### **Shifts in Journey-to-Work Distances**

The average journey-to-work distance to all identified ECs in 1981 and 2001 had increased from 17.93 to 20.66 km – a 15.2% increase over the 20 year time period (Table 3). A smaller (10.9%) increase in average journey-to-work distance occurred for employment destinations not within centres. In many ways these results are not unexpected as they reflect regional growth in employment opportunities, labour and VKT in the metropolitan area. They also reflect the decentralisation of employment, suburbanisation of the workforce and increased use of the car for the journey-to-work. Given that ECs represent the polycentric structure of the metropolitan area, the co-location hypothesis would have suggested a decrease in average distance over this time period.

Table 3 sheds some light on the nature of the increased average distances across all identified ECs over the 20 year time period. For all 28 ECs identified in 1981 there were only small, but statistically significant, differences in average journey-to-work distances across the four classes of ECs. Average distance to the CBD was similar to that for the other three types, and not markedly different to average journey-to-work distances to ECs located in the outer areas. However, the highest average journey-to-work distances occurred in those ECs classed as being in the outer areas, and is evidence that the co-location hypothesis did not hold even in 1981. Use of the average for each class of centre masks some of the interesting variations within those classes. For example, the highest average journey to work distances in the inner areas were recorded for Banksmeadow (19.10km), Rhodes (20.81km) and UNSW (20.22km). In the middle areas, centres such as Brookvale (26.57km), Chullora (22.59km) and Kurnell (20.23km) recorded the highest average journey- to-work distances in 1981. Those ECs classed as being in outer areas in 1981 generally all had lower average journey to work distances that ranged from 13.17km for Parramatta/Westmead to 18.86km for Dunhevid (ACI). The only exception is Milperra that had an average journey-to-work distance of 30.45km. In the case of ECs in the outer areas, the data suggest that they attracted workers from local areas and were characterised by relatively small catchment areas. Decentralisation of employment and suburbanisation of the labour force had yet to make a significant impact on commuting distances for this class of ECs.

**Table 3 Average journey-to-work distances among four classes of employment centre, 1981 and 2001**

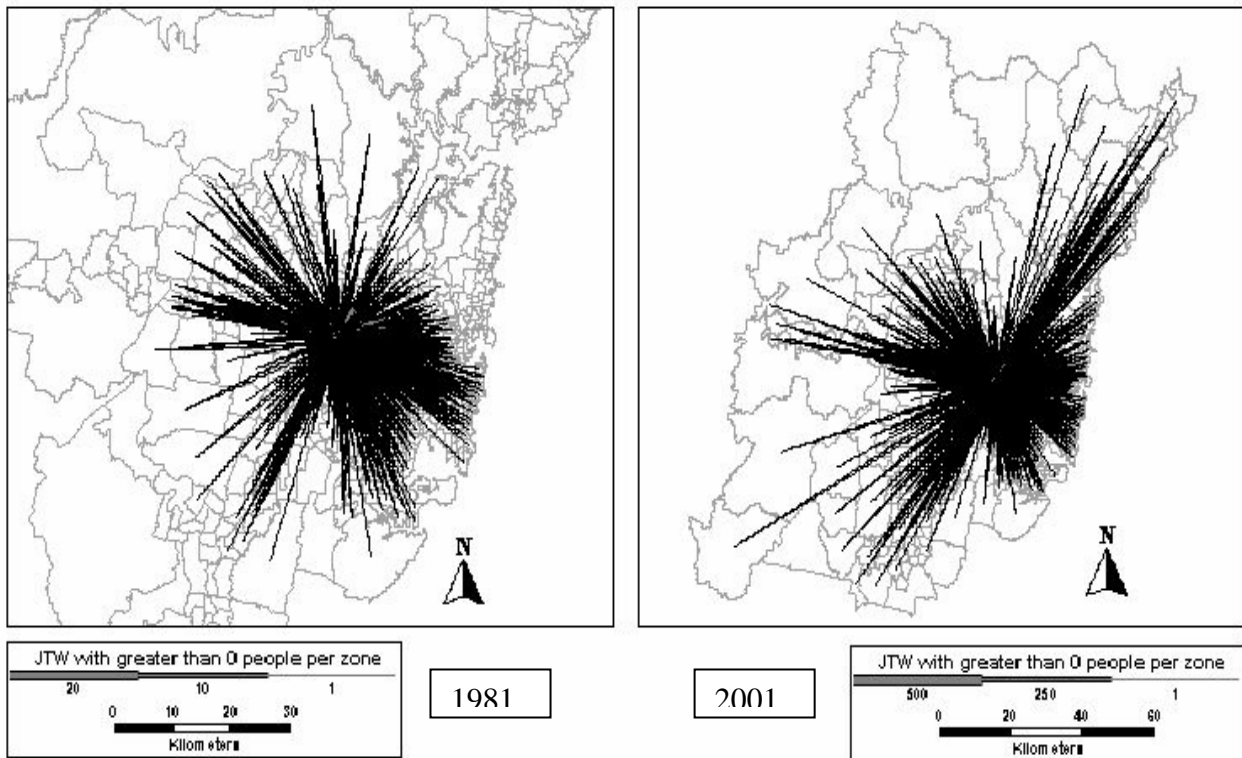
	Employment centre class				ANOVA		Total All Centres	Not in Centres
	CBD	Inner Areas	Middle Areas	Outer Areas	F-statistic	Prob Value		
<i>Mean Journey-to-Work Distance (km)</i>								
<b>1981</b>	18.82	17.22	17.86	19.69	205.09	0.000	17.93	11.99
<b>2001</b>	19.77	20.20	22.48	21.49	72.68	0.000	20.66	13.30
<b>Per cent change</b>	5.04	17.30	25.80	9.10			15.20	10.90

The lengthening of average journey-to-work distances by 2001 is evident across all four classes of EC (among identified ECs for 2001). Some caution is needed in the cross interpretation of average journey-to-work distances as only 20 ECs from 1981 are present in 2001. What can be said is that during the 1980s and 1990s the period of rapid employment decentralisation, workforce suburbanisation and the growth of both existing and new ECs does not appear to have put more Sydneysiders closer to their workplaces in terms of average journey-to-work distances. Despite the movement of employment towards residences during this period, and increased levels of self-sufficiency (at least at the local government area level), polycentric urban growth in Sydney has given rise to longer commutes. This finding is consistent with the results of Cervero and Wu (1998) for the San Francisco metropolitan area, and with the results of other overseas research (Hamilton, 1982; Schwanen et.al., 2002).

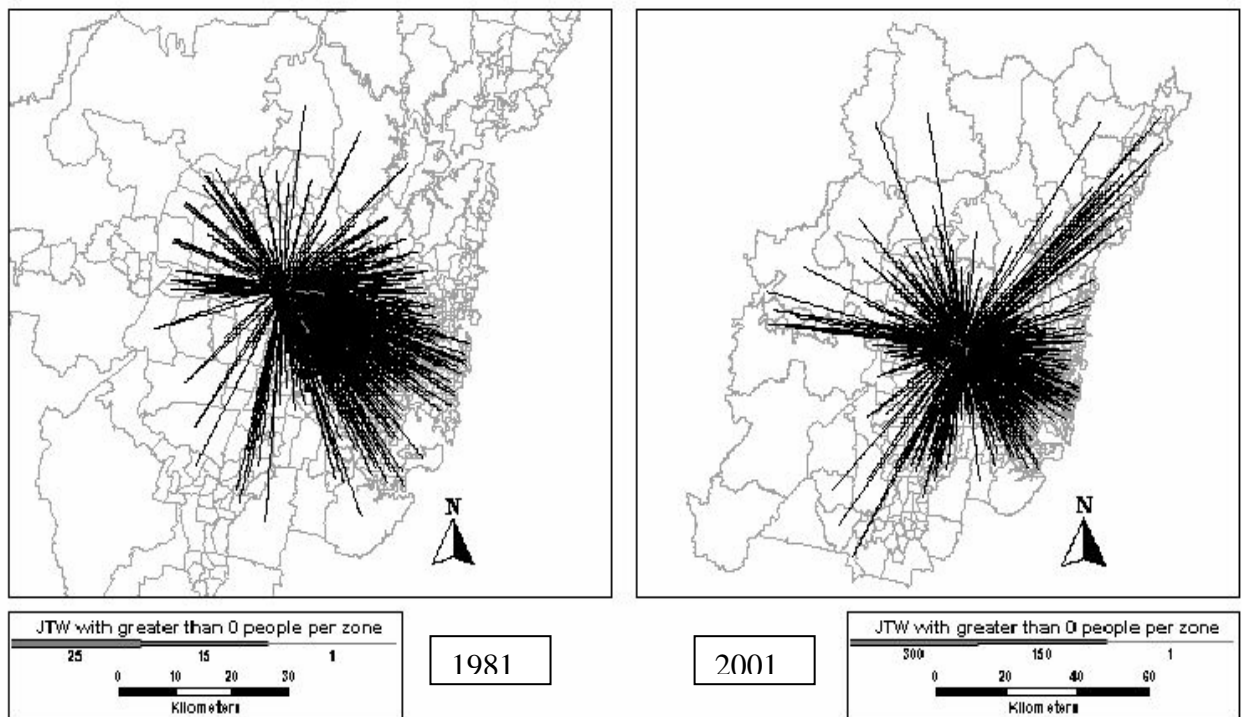
The largest percentage increases in average journey-to-work distances occurs for ECs in the inner and middle areas, among those identified for 2001. In the inner areas, the highest average journey-to-work distances were recorded for Manly (28.70km) and UNSW/POW (30.35km). For the middle areas, centres such as Homebush/Rhodes (24.44km), Kogarah (28.89km) and Pymble (29.86km) recorded the highest average journey- to-work distances in 2001. Both the Homebush/Rhodes and UNSW/POW ECs existed in 1981 and have experienced a 17% and 50% increase respectively in average journey-to-work distances over the 20 year period. Outer area ECs in 2001 all had average journey to work distances that ranged from 18.35km at Minchinbury to 36.21km at Bankstown. The pre-existing Parramatta/Westmead EC increased average journey-to –work distance from 13.1km to 20.33km, while Dunhevid (ACI) increased from 18.86km to 27.83km. The magnitude of the increases for pre-existing ECs, and the size of the averages for new ECs identified in 2001, would indicate the presence of substantial overlaps in the catchment areas of respective ECs, and increases in the size of the catchment areas.

A visual assessment of changes in the catchment areas of ECs can be determined by mapping the straight line distances between all journey-to-work origins and destinations to respective ECs (sometimes referred to as *desire lines*). The advantage of desire line maps over an average distance statistic is that they provide a graphic picture of the spatial extent of journey-to-work flows between origins and destinations, the dispersion or compactness of trip movements and the directionality of trip movements. Figures 3-5 show the desire lines for three selected ECs over the time period of the study: Parramatta/Westmead, Blacktown/Seven Hills and Wetherill Park/Smithfield. In the case of the Parramatta/Westmead EC (Figure 3), where employment growth has more than doubled over the 20 year period, the catchment area has expanded significantly in all directions to include journey-to-work trip origins from the central coast, northern beaches, southwest and the Blue

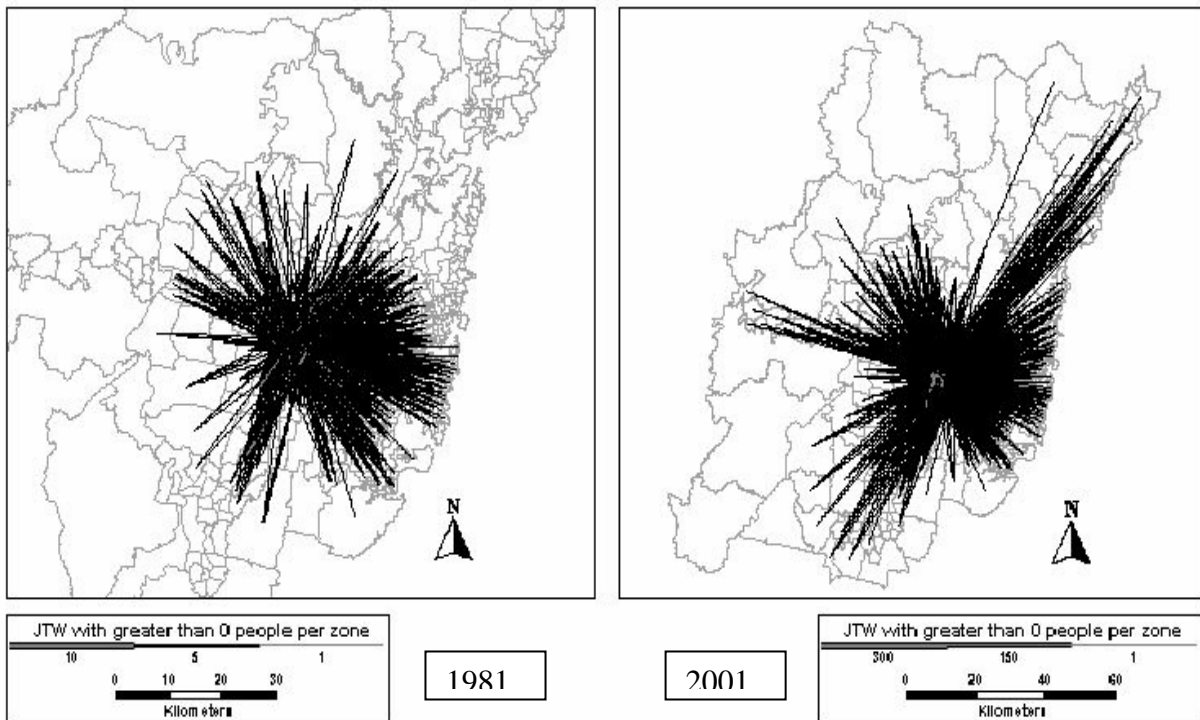
Mountains. The scale of the catchment area for Parramatta/Westmead EC is much larger in 2001 as compared to 1981. Even so, this EC attracts a large number of localised journey-to-work trips which, on average, have been lengthening (from 13.1km to 20.3km) over the 20 year time period.



**Figure 3 Journey to work to Parramatta employment centre**



**Figure 4 Journey to work to Blacktown/Seven Hills employment centre**



**Figure 5 Journey to work to Wetherill Park/Smithfield employment centre**

A similar picture emerges when one examines the desire line maps for Blacktown/Seven Hills and Wetherill Park/Smithfield ECs – an expansion of the catchment areas and an increased spatial spread of trip origins. Furthermore, the figures show very clearly the presence of significant overlaps across the catchment areas of all three ECs, and the fact that the overlap was also present in 1981. These overlaps are also present with respect to other ECs (not shown). All these maps lend further weight to the argument that the co-location hypothesis does not hold in the case of Sydney, and suggest that the idea of self-containment is indeed a long way off as a planning goal.

### Shifts in Modal Splits

For all ECs identified in 1981 and 2001 the only mode to show an increase in journey-to-work is car driver – an increase from 51% to 53% of mode share (Table 4). Clearly, journey-to-work by car as driver is the dominant mode of travel over the 20 year period. Mode shares for bus and train declined across identified centres over this time period, with the sharpest decline (26.4%) being for the bus. Also evident in Table 4 is that commuting shares by the three main modes increased over the time period for journey-to-work destinations that were not in ECs – mainly to smaller centres that did not meet the criteria for inclusion, and to dispersed locations across the metropolitan area. (Some of the smaller centres are located on the public transport network).

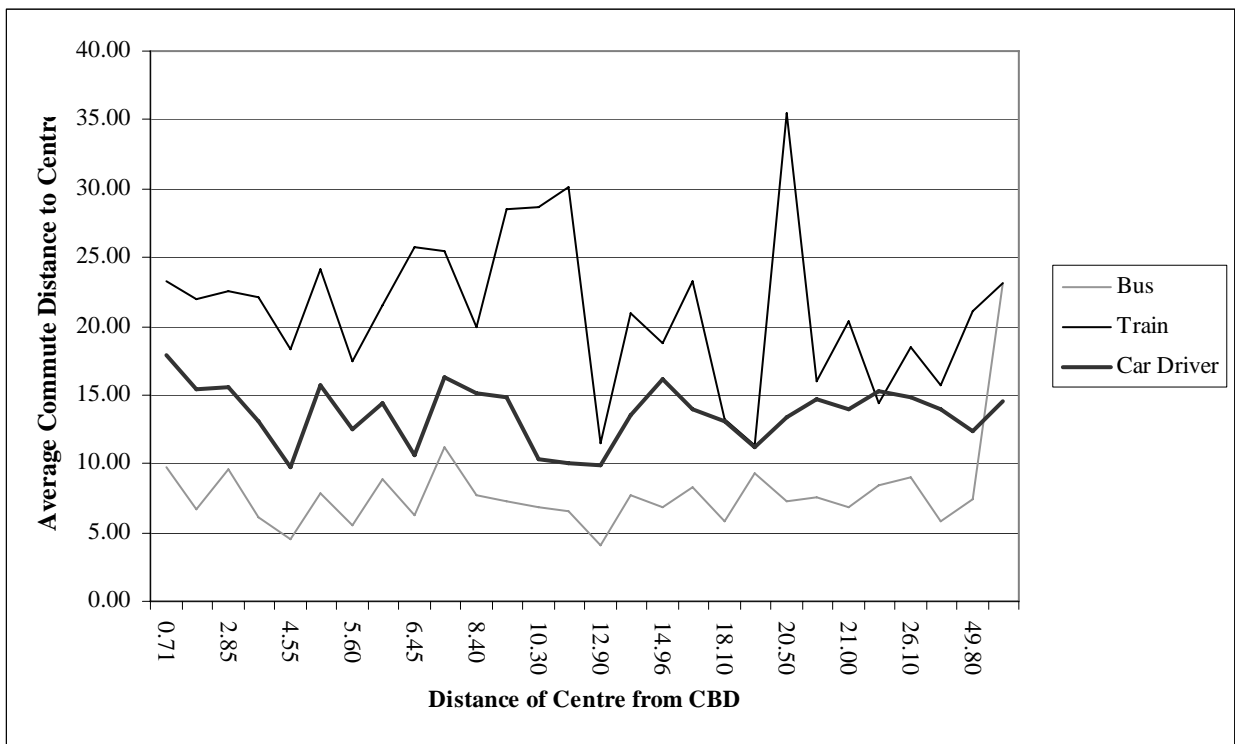
**Table 4 Average journey-to-work distances by main mode among four classes of employment centre, 1981 and 2001**

	Employment centre class						
	CBD	Inner Areas	Middle Areas	Outer Areas	Total All Centres	Mode Share (%) <sup>1</sup>	Not in Centres
<b>Mean Journey-to-Work Distance (km)</b>							
<b>Bus</b>							
<b>1981</b>	9.71	7.35	6.99	9.74	8.22	7.48	7.65
<b>2001</b>	9.83	7.49	8.64	7.72	8.90	5.50	8.10
<b>Per cent change</b>	1.20	1.90	23.60	-20.00	8.27	-26.4	5.88
<b>Train</b>							
<b>1981</b>	23.32	23.04	20.58	18.48	22.01	15.35	19.59
<b>2001</b>	23.72	23.51	20.69	19.45	23.20	13.80	21.80
<b>Per cent change</b>	1.70	2.03	0.50	5.20	5.40	-10.0	11.28
<b>Car Driver</b>							
<b>1981</b>	17.94	13.62	12.64	14.23	13.89	51.06	13.23
<b>2001</b>	17.12	14.94	16.88	16.12	15.60	53.00	14.90
<b>Per cent change</b>	-4.50	9.69	33.54	13.28	12.30	3.79	12.62

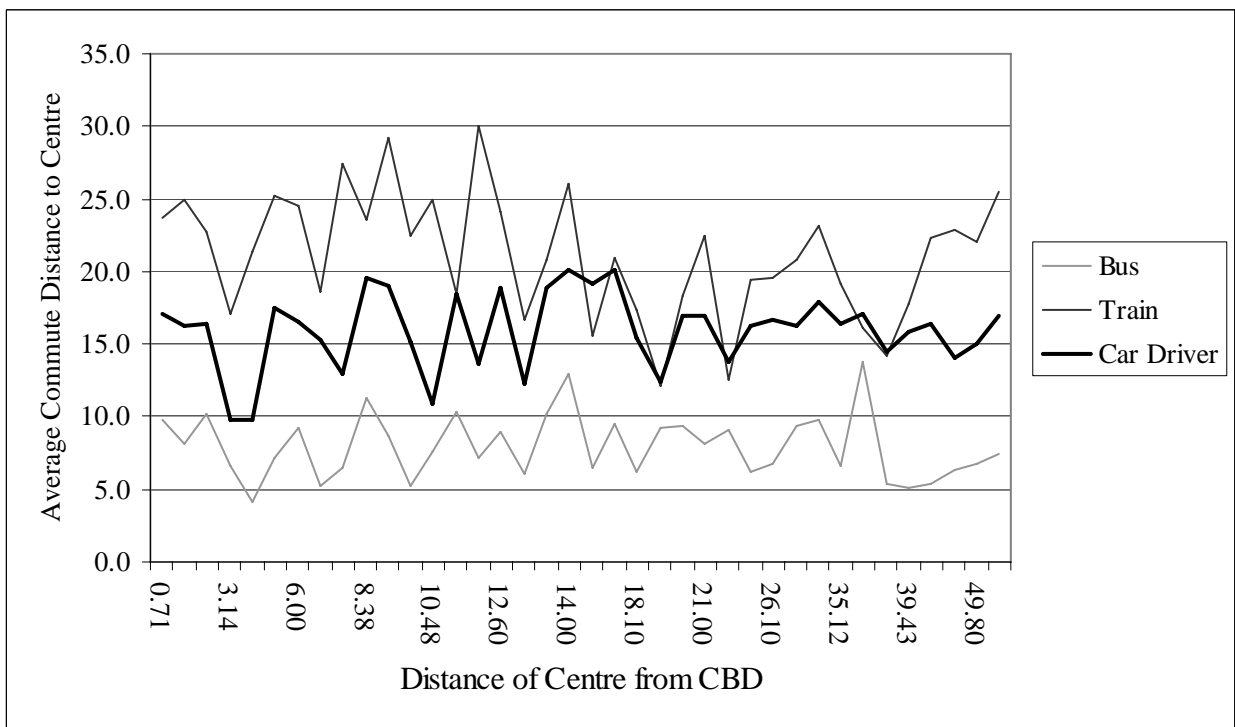
Note: <sup>1</sup> Values do not sum to 100 as the mode share represents the per cent of all O-D pairs for all modes used.

Despite the decline in bus and train mode shares, the average distance by bus and train across all ECs actually increased – the largest increase (12.3%) being for car driver. Examining the average journey-to-work distances for the main modes across classes of ECs (Table 4) indicates that commute distances generally increased over the 20 year period. The average journey to work distance for bus declined (-20.%) in ECs identified for the outer areas. Some of the decline may be due to fewer persons using the bus to access ECs in the outer areas or to the unsuitable locations of ECs identified for 2001 relative to bus networks for the journey-to-work. The increase in average journey-to-work distances for the train mode is especially strong for ECs in the outer areas. This indicates that use of the train was mainly oriented towards the CBD, and other major ECs in the CBD fringe and inner areas that are located on the rail network.

Figures 6 and 7 provide additional insight into the variations of average journey-to-work distances with distance from the CBD. For identified ECs in 1981, the highest average distance in the inner areas was for the train mode – at ECs such as Brookvale, Manly and Banksmeadow (Figure 6). In the outer areas, the highest average distance (30.5km) was for the journey-to-work by train to the Hornsby EC. The highest average distance for the journey –to-work by bus (23.18km) was for travel to Richmond. For 2001, the pattern in average journey-to-work distances shows less variability by comparison to 1981, but apparent is the decline in average distances by bus in the outer areas. Average distances for the journey-to-work by car indicate higher values for identified ECs in 2001 in the inner and middle areas. In the inner areas, centres such as Central Industrial Area, Lane Cove and Willoughby North have high average distances by car. Homebush/Rhodes and Pymble in the middle areas have high average journey-to-work distances by car.



**Figure 6 Average commute distance to employment centre by main mode, 1981**



**Figure 7 Average commute distance to employment centre by main mode, 2001**

Another interesting aspect of average distance for the journey-to-work by main mode is the proportionate share that occurs in each of the identified ECs for 1981 and 2001. This was examined for 1981 and 2001 and similar trends were evident. Figure 8, which is for ECs in 2001, is also representative of the situation in 1981. The standout trend in Figure 8 is that use of bus and train for the journey to work is highest for the CBD and inner ECs and declines very rapidly for ECs outside this higher density part of the city. The only exception is the Parramatta/Westmead and Burwood

ECs where use of train for the journey-to-work is higher than for other ECs. Outside of the CBD and inner areas the overwhelming trend is for use of the car driver mode for the journey-to-work. The situation may have changed a little since 2001 for Parramatta and Liverpool ECs as a result of the opening of the bus transitway connecting the commercial core areas of these two ECs. Notwithstanding this change, the picture presented in Figure 8 is problematic for policy and planning. It suggests that even with future additions to public transport infrastructure, as part of the long-term planning for the *Metropolitan Strategy*, public transport is not likely to see major improvements in mode share for centred employment, and for employment not within centres. The challenge is for future infrastructure planning to be integrated with future locations of employment centres.

### **Shifts in VKT**

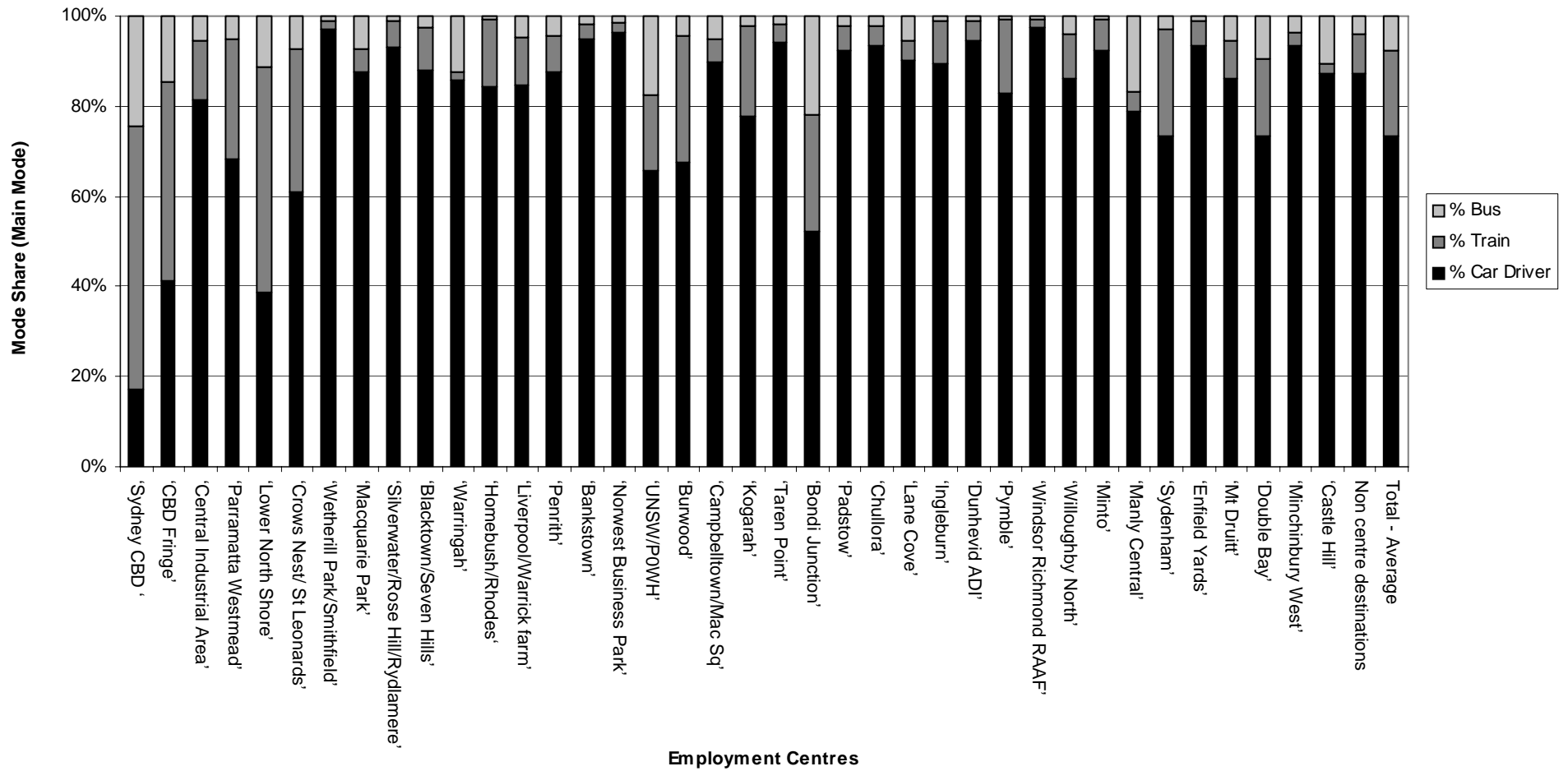
From the above discussion on shifts in average journey-to-work distances and mode splits it is apparent that VKT over the 20 year period has seen very significant increases. For example, the total VKT for all employed persons in the Sydney SD increased from 16.6 million in 1981 to 24.0 million in 2001, a 45% increase. Of the total VKT for all employed persons in the Sydney SD in 1981, approximately 52.2% is accounted for by VKT to identified ECs. In 2001, VKT to identified ECs accounted for 47% of total VKT for all employed persons in the Sydney SD.

It is not surprising that VKT is high across all classes of EC in 2001. Over half (55.9%) of the VKT for ECs in 2001 is accounted for by the car driver mode of transport. In this sense, this finding is consistent with that of Black and Suthanaya (2002) whereby increasing use of the car for the journey-to-work and increasing spatial separation of homes and workplaces were two drivers of increased VKT. Furthermore, their extrapolation of VKT in the year 2011 indicates that it will be 33% higher than the 1996 value – estimated to reach 19 million VKT by 2011. Our data indicate that this predicted value was already surpassed by the year 2001. One can conclude along similar lines as Black and Suthanaya (2002) that the equivalent VKT target currently set at a 15% increase (for all journey purposes) over the 1996 base by 2011 in *Action for Transport 2010* is not achievable. The environmental implications of this growth in VKT are alarming to say the least and point to the need for a better understanding of the impacts of urban form and socio-economic characteristics on growth in VKT.

## **CONCLUSIONS**

Analysis of journey-to-work data for 1981 and 2001, and identification of ECs in these years, has demonstrated the significance of centred employment and polycentric urban growth in the Sydney metropolitan area. Moreover, it has been shown that the co-location hypothesis does not hold for the Sydney area; this was true for 1981 and 2001. The shifts in mode split over the 20 year period indicate the increased use of the car for the journey-to-work in identified ECs and the relatively low use of public transport (bus and train) for travel to jobs in these centres.

For planning and policy relevance, these findings suggest that prescriptions of higher levels of self-sufficiency in new growth areas (better co –location of jobs and people) are not likely to generate lower average distances for the journey –to-work. More polycentric urban growth, even that focussed on public transport corridors, is not likely to reduce average commute durations; the evidence suggests that they will increase – on average. All this strongly suggests that factors other than proximity to workplace have influenced and will continue to influence where workers reside. It is of paramount importance for metropolitan and transport planners to better understand what these other factors are likely to be if we are to move towards achieving sustainability.



**Figure 8 Mode share to employment centres by main mode, 2001**

## ACKNOWLEDGEMENTS

Thanks are extended to the Transport and Population Data Centre, NSW Department of Planning, for providing the relevant journey-to-work tables upon which the analyses reported in this paper are based.

## REFERENCES

- Alpkokin, P., Hayashi, Y., Black, J., and Gercek, H. (2005) 'Polycentric employment growth and impacts on urban commuting patterns: case study of Istanbul', *EASTS 2005 (forthcoming)*, Bangkok.
- Black, J. and Suthanaya, P. (2002) 'Statistical and spatial modelling of vehicle-kilometres of travel by car for the journey-to-work in Sydney, 1981-1996'. *Papers, 25<sup>th</sup> Australasian Transport Research Forum*, Canberra, 2002.
- Cervero, R. and Wu, K. L. (1998) 'Sub-centring and commuting: evidence from the San Francisco Bay Area, 1980-1990', *Urban Studies*, 35 (7), pp 1059-1076.
- Ewing, R. (1997) 'Is Los Angeles-style sprawl desirable?', *Journal of the American Planning Association*, 63(1), pp 107-126.
- Giuliano, G. and Small, K. (1991) 'Subcentres in the Los Angeles region', *Regional Science and Urban Economics*, 21, pp 163-182.
- Gordon, P., Kumar, A., and Richardson, W. (1989) 'The influence of metropolitan spatial structure on commuting time', *Journal of Urban Economics*, 26, pp 138-151.
- Hamilton, B. (1982) 'Wasteful commuting', *Journal of Political Economy*, 90, pp 1035-1053.
- Levinson, D. M., and Kumar, A. (1994) 'The rational locator: why travel times have remained stable', *Journal of the American Planning Association*, 60(3), pp 319-332.
- Parolin, B. and Kamara, S. (2003) 'Spatial patterns and functions of employment centres in Metropolitan Sydney, 1981-1996', *State of Australian Cities National Conference*, Carlton Hotel, Parramatta.
- Pfister, N., Freestone, R., and Murphy, P. (2000) 'Polycentricity or dispersion?: changes in centre employment in metropolitan Sydney, 1981 to 1996', *Urban Geography*, 21(5), pp 428-442.
- Schwanen, T., Dieleman, F., and Dijst, M. (2001) 'Travel behaviour in Dutch monocentric and polycentric urban systems', *Journal of Transport Geography*, 9, pp 173-186.
- Sultana, S. (2000) 'Some effects of employment centers on commuting times in the Atlanta Metropolitan Area, 1990', *Southern Geographer*, 41(2), pp 225 - 233.