The Geography of Melbourne's Knowledge Economy

Kevin Johnson

Director, Geografia
E-mail: kevin@geografia.com.au

Purpose – This paper makes a contribution to local economic development planning focusing on the Knowledge Economy workforce. It does this by describing the results of an exploratory analysis of commuting patterns for five subsectors of the Knowledge Economy. Metropolitan Melbourne is used as the case study and the primary data are taken from the 2006 ABS Census. It is argued that taking the time to investigate different permutations of the Knowledge Economy workforce reveals preferences for residential and work locations. In turn, this can point to opportunities to influence job distribution and transport use. In Melbourne's case this can help shift the City towards a polycentric structure. The Knowledge Economy is an industry sector in which people can and do work outside of established employment nodes (including, for example, working at home). The more we understand existing patterns; the better positioned we are to shape their evolution. This has important implications for the way our cities' economies and transport systems function.

Design/methodology/approach – The approach used in this analysis makes use of the large database manipulation capacity that is now commonly available. Starting with some simple premises that there will be distinctive spatial distribution patterns to the Knowledge Economy, we first assembled and then categorised the Knowledge Economy workforce by job location and place of residence. The Australian Bureau of Statistics place of work data from the 2006 Census was used for this. These boundaries place some restrictions on developing economically meaningful geographical spaces, but they do provide a large enough sample set to generate useful findings. Preliminary statistical analysis and GIS mapping were used to both numerically and visually identify unique distribution patterns.

Originality/value – This methodology looks at the spatial distribution of Knowledge Economy jobs and workers broken down by location and industry of employment subsector. By taking the time to look at and model specific locations and sectors, rather than in the aggregate, we can build a more useful evidence base for metropolitan planning, local economic development and transport planning. In turn this can improve policy interventions designed to address social and economic polarisation that can grow to undermine a city's efficiency. In Melbourne's case, there is scope to improve policy intervention to encourage the development of a polycentric urban form.

Practical implications – This work is useful for local economic development and through this, transport planning. Closer analysis and modelling will improve our understanding of how different components of the Knowledge Economy workforce cluster and disperse:

both relative to other subsectors and to the rest of the economy. As this sector of the economy may have above average potential for localised employment, fostering these patterns can enhance local economies; reduce the total metropolitan commuting traffic load; and, by implication, reduce pressure on transport infrastructure. There are also additional economic and social benefits in the dispersion of highly skilled, white collar jobs. This first step in the analysis is exploratory, largely involving the assembly of and preliminary evaluation of the data. Ultimately, the aim is to build a systems-based understanding of the Knowledge Economy workforce. This understanding can then be used to guide policy interventions that will help guide the evolution of an urban economic system that is more efficient, more polycentric and fundamentally more sustainable.

Keywords – Commuting, Employment Self-Containment, Geography, Melbourne, Clustering

1 Introduction

Many statistical and geographical dimensions of the Knowledge Economy and its workforce warrant close examination. Much is well covered in the literature, particularly: the workforce's composition; the sector's functional role; and productivity issues, most notably in relation to agglomeration economies (e.g. Glaeser, 2010; Overman & Puga, 2009). My own contribution relates to a question that I try to ask in much of the work I undertake. That is, what planning and policy interventions will enable more people to live and work in closer proximity? This is generally seen as a desirable outcome as it reduces pressure on transport systems and addresses some of the concerns associated with the creation of dormitory suburbs, or the economic polarisation associated with high-income, high-skill inner city economies and low-income, low-skill outer metropolitan areas.

To answer this requires careful scrutiny of demographic, geographical and economic parameters so that local economic development strategies are well thought through. These will then have greater potential for improving the local employment self-containment (ESC) ratio[1].

Fortunately there is a large and accessible database that indicates where people live and work in Australia. With some effort these data can be evaluated, albeit with limits to the spatial accuracy[2]. As most researchers in Australia know, Australian Bureau of Statistics (ABS) Census data at the level of the Statistical Local Area (SLA) can be used to map both the employment and residential distribution of the workforce. These data can be broken down into 'subsets', including components of the Knowledge Economy. The patterns of commuter movement in these subsets can then be examined.

1.1 The Knowledge Economy Subsectors

Using the 2006 ABS Census data for Melbourne, the Knowledge Economy workforce of some 244,000 people is segmented into five subsets[3]:

1. Telecommunications, IT and Media (around 31,000 jobs or 13% of the metropolitan Knowledge Economy workforce is identified as IT/Media)
2. Finance and Banking (111,000 or 45% Finance)
3. R&D and Higher Education (71,000 or 29% R&D/Higher Ed)
4. Design-related industries (e.g. architecture) (27,000 or 11% Design)
5. Cultural Industries (e.g. performing arts) (6,000 or 2% Cultural Industries).

[1] This refers to the proportion of people in the labour force whose jobs are located in the same defined region as their place of residence. Due to ABS collection procedures, SLAs are the most commonly used geographical area for this metric. Note that employment self containment can also refer to the proportion of local jobs taken up by local residents (defined here as ESC- jobs).

[2] The scale at which place of work data is available does place some restrictions on the analysis. SLA boundaries do not necessarily conform to areas that are meaningful in an economic sense.

[3] With minor exceptions these groupings align with the ABS industry groups. A sixth subset encompassing the health sector was considered but rejected as it would require aggregation of both industry and occupational data to differentiate Knowledge Economy from other health sector workers. A complete list of the four-digit industry classifications is included in Appendix 1.

The objective of this categorisation is to explore some of the geographical relationships between the location of workers and jobs in different parts of the Knowledge Economy and, from this, further examine particular elements of the commuting patterns. The subsets were selected on the basis of assumptions about distinctive geographical patterns.

Simply as a descriptive effort, this work can be useful for reminding us that employment self-containment is subject to a range of influences and can vary within industry sectors. More detailed statistical and spatial analysis can contribute to building a systemic understanding of the Knowledge Economy and the movement of people in the city. By helping to define the way in which subsets of this workforce spatially interact with one another and with the rest of the economy we can eventually gain a clearer conception of how the Knowledge Economy functions within the urban setting, the major drivers of this and, therefore, how to plan for it.

1.2 Who is a Knowledge Economy Worker

In this exercise, data on industry sectors have been used to define the Knowledge Economy. The ABS categorises industries using a 4-level hierarchical classification structure called the Australian and New Zealand Standard Industrial Classification (ANZSIC[1]). The most detailed level of industry classification is comprised of 717 specific industry classes, 79 of which were included in the Knowledge Economy category.

An alternative, commonly used approach is to define Knowledge Economy *workers*, rather than the Knowledge Economy *sectors*. This is done using occupational classifications, rather than industry of employment. The ABS has a 5-level hierarchical classification system that can be used for this (Australian Standard Classification of Occupations, or ASCO). In many respects defining the Knowledge Economy by a person's function, rather than their industry of employment is easier and, arguably more accurate. However, the intention of this study was to explore the locational distribution of subsectors of the Knowledge Economy industry. In this case, the presence of Knowledge Economy activities is being defined by the output of economic activity, not necessarily the function of individuals contributing to it. This can only be fully achieved by using the ANZSIC, rather than ASCO, codes. Moreover, using high-detail industry classes made it possible to exclude most people who may be working in a Knowledge Economy enterprise (for example, R&D), but who may be performing other duties, such as general office work. Where there was some ambiguity about the likely function, the ABS classification manual (ABS, 2006a) was referred to for clarification.

It is true that the two approaches generate different data compilations. Testing of Victorian data found an overall 4.5% variation in the total number of Knowledge Economy workers between the two classification methods. However, most of the differences occur in primary and secondary industries (e.g. agricultural research being carried out on a farm). This is obviously not an issue in an analysis of metropolitan Melbourne. That said, as noted earlier, further effort would make it possible to extract those health sector workers who form part of the Knowledge Economy into another subset. In the current analysis, while health researchers are included (in R&D/Higher Ed), occupations such as surgeon and psychiatrist are not. Using a cross-tabulation of

[1] The 2006 revision of this classification system is used in this analysis.

occupation and industry to more accurately define the Knowledge Economy by both sector and function may be a worthwhile, if time consuming, task as it is likely to reveal subtle differences in the spatial patterns described in this paper. On the other hand, it is not the intention of the work that this paper is part of to describe what the Knowledge Economy is and it can be argued that this is a somewhat fruitless endeavour. Knowledge imbues most economic activities, so the boundaries of the Knowledge Economy workforce are always going to be fuzzy. It is arguably just as effective to assume we are focusing on 'white-collar' jobs.

2 Background

According to 2006 Census data, Metropolitan Melbourne[1] is an employment sink (Figure 1). While a little over 10,000 people commute to work outside of Melbourne, more than 40,000 commute in. More labour force participants work in the metropolitan area than live there and overall metropolitan ESC is 98%. At the more commonly used scale, around 22% of all workers in the metropolitan area live in the same SLA as they work (ABS, 2006). Research that aggregated SLAs into larger groupings has found that most commuting occurs within a number of large intra-metropolitan regions that make up the greater urban area (O'Connor & Healy, 2002).

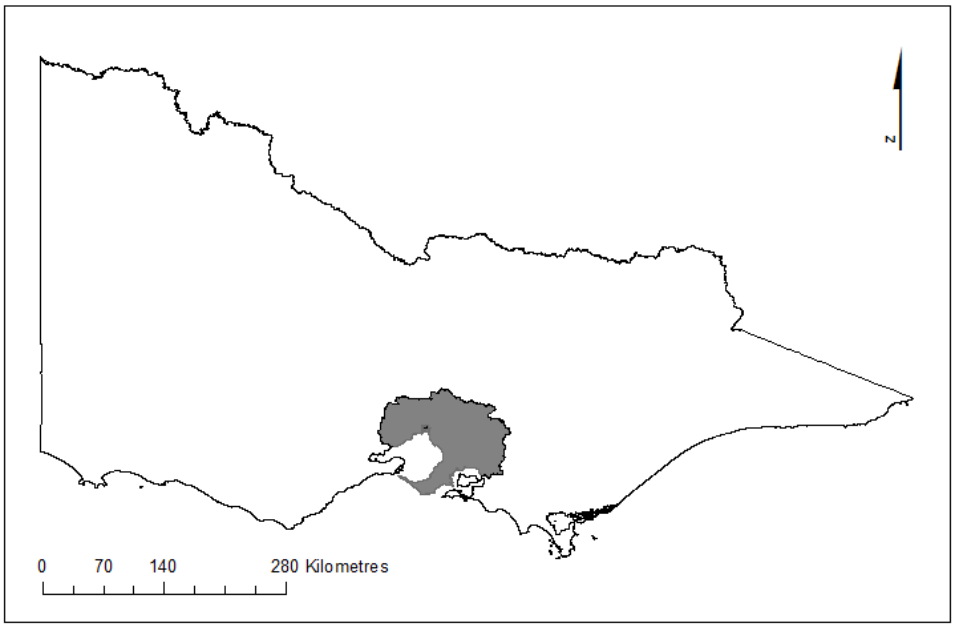

Figure 1: Melbourne Metropolitan Statistical Region
Data Source: ABS, 2006

[1] Defined here using the ABS Metropolitan Statistical Region. It covers an area of around 7,600 square kilometres in an arc around Port Phillip Bay. See Appendix 2 for a description of the comparative analysis of the Knowledge Economy workforce by state.

These intra-metropolitan economic regions bear some resemblance (physically, if not in economic function) to Hoyt's (1939) original sectoral model of city development: with commuting zones mostly radiating out in a wedge shape from the inner urban area. This speaks to the concept of ESC, where most metropolitan residents live and work in a relatively spatially contiguous area.

2.1 Employment Self-Containment

The concept of employment self-containment (ESC) as a measure of local economic health has an extensive research history (e.g. Trendle & Siu, 2007; Yigitcanlar *et al*, 2007; Coombes, 1986). It is also a metric regularly used in economic and other planning work. This includes the larger developers and local or state government using it as a performance indicator for the impact of local employment generation strategies. Being more than a collection of dormitory suburbs is seen as desirable by some local governments, more so if the jobs are white collar. In theory at least, it is also an objective of several Australian state governments, not least for traffic management reasons.

However at the aggregate level to which they are usually applied, ESC targets have limited effectiveness as a planning tool. Statistical analysis of the relationship between ESC and a substantial number of geographical and demographic parameters reveals a high degree of variability with respect to location within the metropolitan area; age; income; occupation; duration of residency; and industry of employment. In previous work I regressed ESC for all SLAs in Australia against geographical data (e.g. location and size of SLA), combined with almost 200 different demographic variables. This highlighted strong correlations and collinearities. Examples of statistically significant positive correlations include length of residency, income, specific educational backgrounds and selected industries of employment. So, for example, owners of small businesses are more likely to live and work locally, as are 15-19 year olds; graduates in architecture (more so than people working as architects); those who live some distance from a train station; and artists.

This analysis only touches the surface of what is a complex set of relationships needing more investigation. Local economic development plans are often based on anecdotal evidence, 'best practice', but inappropriate, replication of ideas or intuition. The way to increase its impact is by having a better understanding of how (and how much) metrics such as ESC can vary in response to a mix of different factors and, in turn, how these factors can interact. This applies no less to the Knowledge Economy workforce than to any other sector of the economy. In fact, it may even be particularly relevant to the Knowledge Economy and increasingly important if this sector continues to grow. In order to make policy interventions more effective, a far more sophisticated understanding of the dynamic nature of the geography of the Knowledge Economy is required.

2.2 Influences on the Location of the Knowledge Economy

The assertion that there are measurable, and potentially manageable, influences on the spatial distribution of the Knowledge Economy has its theoretical roots (or at least the seed) in the research literature on the origins of contemporary gentrification. There are two major schools of thought on the underlying process. Firstly, that inner urban gentrification was the result of consumer-led demand for different housing products (Zukin, 1982). Secondly that it was driven by capital-led reinvestment in under-performing inner urban property (e.g. Smith, 1992). Both perspectives lend tacit support

to the argument that there is no endogenous economic reason for the Knowledge Economy to be tied to the inner urban area. Moreover, apart from a cultural shift towards a preference for living in the inner city, neither has the Knowledge Economy workforce (i.e. the gentrification cohort) any 'need' to live there. It may only have been the imperatives of property investment (from consumers or producers) that have led the Knowledge Economy to many of its locational outcomes.

This is not to say that Knowledge Economy jobs do not need to cluster, just that there is ambiguous evidence that economic functionality dictates that they need to cluster in the inner urban areas. For example, Searle and Pritchard's (2005) study of Sydney's Information Technology and Telecommunications sector concludes that the sector's clustering is as much an effect of the entire city's economic functionality as it is the localisation economies of the sector itself.

By the same token, however, the literature also notes that Knowledge Economy clustering is spatially linked to high amenity and housing, transport and services tailored to the characteristics of the Knowledge Economy workforce (e.g. Baum *et al*, 2007; JVSN, 2001). A visual examination of the concentration of Knowledge Economy jobs and workers (by place of residence) in metropolitan Melbourne appears to confirm this. There is a notably stronger positive correlation between proximity to the central city[1] and the concentration of Knowledge Economy workers (by place of residence) than there is between proximity and the location of Knowledge Economy jobs (Figure 2).

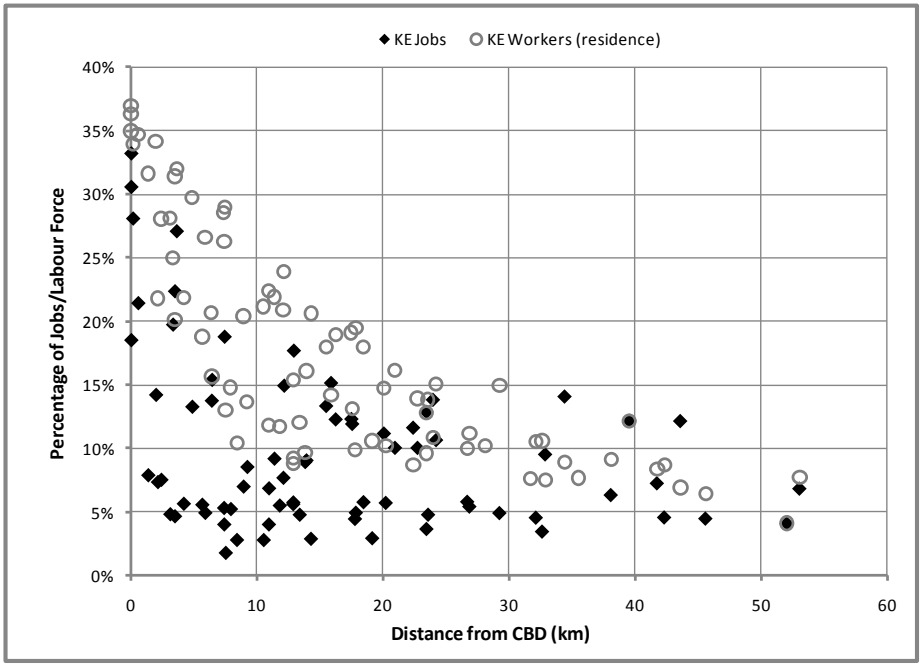

Figure 2: Proximity to CBD and Knowledge Economy Place of Residence and Work
Data Source: ABS, 2006

[1] Measured 'as the crow flies' from the centroids of each SLA to the CBD. See Appendix 3.

This visual confirmation of Baum's (*et al*, 2007) findings suggests it is reasonable to conclude that the Knowledge Economy is not necessarily spatially tied to the inner urban area. Instead, it is more likely associated with a set of conditions (most obviously including the presence of a university campus) conducive to Knowledge Economy workers. These conditions - which most obviously (and often) include the presence of a university campus - are more often than not found in the central city.

With this in mind, economic development strategies that target components of the Knowledge Economy may have substantial scope to attract these jobs to other parts of the city if (a specified selection of) these conditions can be replicated. In fact, we find that there are several small clusters of Knowledge Economy jobs in suburban areas of Melbourne, as will be explored later.

3. The Research Premise

This analysis began with the hypothesis that there would be distinctive geographical (spatial) dimensions to the Knowledge Economy workforce and, moreover, these would vary between subsets of the sector. This first assumption was an extension of previous work that investigated the commuting patterns of creative industry workers. Based on this assumption, the expectations were that:

1. While overall ESC for the Knowledge Economy is likely to be similar to that of the whole workforce (they do, after all, make up a sizeable proportion of Melbourne's jobs), characteristics of it will differ. Descriptive statistics confirm this. By investigating disaggregated components of the workforce (e.g. by subsector of the Knowledge Economy, or by geographical subregion).
2. Given the assumed link between Knowledge Economy jobs and proximity to the CBD, as well as the range of other determining factors, the proportion of jobs in each SLA that are in the Knowledge Economy is not likely to be normally distributed across the 79 SLAs of the metropolitan area[1]. Geographical clustering, as well as some anomalous outliers will result in a more complex distribution. In turn, key factors such as clustering will be a response to various influences including everything from historical precedent to the agglomeration of complementary skills (Johnson *et al*, 2006).
3. For various reasons, Knowledge Economy jobs will cluster in and around the CBD. This clustering will have an impact on self-containment due to the limited availability of housing in these areas. To accurately understand the commuting patterns consideration will need to be given to residents in SLAs that are adjacent to these clusters.
4. At the same time, given the relative affluence of parts of the Knowledge Economy workforce, many people will be willing to commute some distance to these jobs. This assumption is based on job search theory (Trundle & Siu, 2007).
5. IT, telecommunications and media will maintain proximity to the Finance sector (see Table 1).
6. Finance-related jobs will be concentrated in the CBD and, therefore, ESC for them will be lower than other subsectors of the Knowledge Economy due to the relatively low number of residential dwellings in the CBD.

[1] See Appendix 3.

7. Given that they also have a local service role in the metropolitan economy, both Media and Finance jobs will be more widely distributed than R&D/Higher Education, Design and Cultural Industries jobs.
8. R&D/Higher Education jobs are likely to demonstrate a high degree of clustering adjacent to universities and established research/high technology areas. Conversely, job search and human capital theory suggests that these workers will live in a more distributed pattern.
9. Design and Cultural Industries will show sign of clustering together around, but not in, the CBD. Additionally, there should be some difference between the job locations of the design related, commercial industries and the creative arts jobs. Our previous research has also shown that Cultural Industries workers are more likely to live in proximity to their place of work[1].

These claims are based on interpretations of historical and cultural trends, for example, the preference for the cultural industries workers to locate in vacated inner urban industrial areas – a very well documented phenomenon. They are also based on a brief review of Australian national accounts data. This has several notable features including high inter-industry flows between IT/Media and Finance, contrasted with the self-contained nature of the Cultural Industries and R&D/Higher Education (Table 1).

Table 1: Selected Inter-industry Flows (2005-6)

Industry	Part of...	Highest Inter/Intra-Industry Flow To...
Communication services	IT & Media	Legal, accounting, marketing and business management services
Banking	Finance	Legal, accounting, marketing and business management services
Non-bank finance	Finance	Banking
Insurance	Finance	Legal, accounting, marketing and business management services
Services to finance, investment and insurance	Finance	Services to finance, investment and insurance
Scientific research, technical and computer services	R&D/Higher Education	Scientific research, technical and computer services
Legal, accounting, marketing and business management services	Finance	Legal, accounting, marketing and business management services
Other business services	Finance	Legal, accounting, marketing and business management services
Education	R&D/Higher Education	Education
Motion picture, radio and television services	Cultural Industries	Motion picture, radio and television services
Libraries, museums and the arts	Cultural Industries	Libraries, museums and the arts

Date source: ABS, catalogue no. 5209.0.55.001

3.1 Preliminary Evidence

The first step in the analysis was to organise and evaluate the available data to ensure there was *prima facie* evidence for continuing the investigation. When Census data for employment by place of work and residence is disaggregated to extract Knowledge Economy workers, we find that the assumptions outlined above generally hold, albeit with some caveats. Firstly, there is, in fact, a small difference between *overall* ESC ratios for the Knowledge Economy workforce (18.2%) compared to the rest of the economy (22.6%). This suggests that either more Knowledge Economy workers live further from their place or work and/or Knowledge Economy jobs cluster more in concentrated

[1] Unpublished research for various clients found that, with the exception of farmers, cultural industry workers were more likely to live and work in the same SLA than any other sector of the workforce (Geografia, 2009).

employment nodes with little available housing. Looking further we find that average SLA-level ESC for Knowledge Economy jobs is 45.7%, compared with 31.7% for the rest of the workforce. As it turns out, it is the low ESC of the finance sector working in the CBD that explains the slightly lower overall figure[1].

It is by looking at the ESC ratios for individual SLAs that we see the interesting variations. Analysis of this suggests that Knowledge Economy jobs and the workforce cluster in a statistically significantly different way to the rest of the economy. In fact, as Columns 1 and 2 of Table 2 show, most Knowledge Economy jobs are found in and around the CBD (Melbourne Inner) and the workers live around these jobs, concentrating in the eastern suburbs (e.g. Glen Eira Caulfield). When accounting for relative labour market size, we also see distinctive clusters of jobs by Knowledge Economy subsector (Columns 3 and 4). For example, R&D/Higher Education jobs do, indeed, cluster around (but not in) the CBD and towards the south east around the Australian Synchrotron near the Monash University Campus.

Table 2: Concentration of Knowledge Economy Jobs in Metropolitan Melbourne

Industry of Employment	(1) Most Jobs	(2) Number	(3) Local Concentration	(4) Percentage
Place of Work				
All KE Workers	Melbourne (Inner)	66,378	Melbourne (Inner)	43.0%
IT/Media	Melbourne (Inner)	5,323	Yarra (Richmond)	7.5%
Finance	Melbourne (Inner)	48,119	Melbourne (Inner)	31.4%
R&D/Higher Education	Melbourne (Remainder)	14,267	Monash (South-West)	18.6%
Design Related	Melbourne (Inner)	3,688	Stonnington (Prahran)	5.9%
Cultural Industries	Melbourne (Southbank-Docklands)	1,017	Melbourne (Southbank-Docklands)	2.7%
Place of Residence				
All KE Workers	Glen Eira (Caulfield)	9,484	Melbourne (Inner)	36.9%
IT/Media	Port Phillip (St Kilda)	1,628	Port Phillip (St Kilda)	5.9%
Finance	Manningham (West)	3,616	Melbourne (Southbank-Docklands)	16.0%
R&D/Higher Education	Glen Eira (Caulfield)	2,691	Melbourne (Inner)	10.8%
Design Related	Yarra (North)	984	Yarra (North)	4.2%
Cultural Industries	Yarra (North)	426	Yarra (North)	1.8%

Data Source: ABS, Census 2006

From this first step, it was possible to identify five distinctive geographical clusters: each a collection of contiguous SLAs (Figure 3). In formulating them, consideration was given to both the similarity in workforce profile and physical connectivity. The key

[1] This analysis found several features unique to the finance sector, most probably due to a combination of the job characteristics and demographic features of the workforce. Determining to what extent this sector should be treated separately will be one element in future modelling work.

criterion is that the Knowledge Economy accounts for at least 20% of the local jobs[1]. Anyone familiar with the economic geography of metropolitan Melbourne will not find the existence of these clusters surprising. They also are more-or-less aligned with 7 of the 10 State Government Specialised Activity Centres (Figure 4). The clusters are:

1. 'The Hoddle Grid'. This is the original CBD grid as defined by surveyor Robert Hoddle in the 1830s. Its Knowledge Economy activity is dominated by finance sector workers.
2. 'The Edge'. Surrounding the CBD is a typical mix of former docks and working class suburbs now dominated by Knowledge Economy workers, particularly creative industry workers in places such as Fitzroy, South and North Melbourne. The 'Edge' also incorporates the Parkville Bioscience Precinct - including the University of Melbourne's main campus - and the Alfred Hospital.
3. 'The Knowledge Corner'. To the east of the CBD and inner circle incorporating the suburbs of Prahran, Richmond and Hawthorn is a mix of high (and some low) income households and businesses with a diverse range of Knowledge Economy activities, particularly IT/Media and Design.
4. 'Synchrotronia'. Centred on the Australian Synchrotron and Monash University's Clayton campus is a R&D/Higher Education cluster 20 kilometres to the southeast of the CBD.
5. 'Northern Campus'. La Trobe University's Bundoora campus and several health-related commercial/research precincts are at the centre of a growing R&D/Higher Education cluster around 14 kilometres to the north of the CBD. Although the SLA for this area does not quite meet the '20%' criteria, it was included on the basis that it defines an important emergent R&D hub.

Further analysis of the manner in which these clusters formed could be carried out, taking as a starting point Baum's (*et al*, 2007) categorisation of four spatial forms. For example, 'The Edge' could be associated with Baum's 'Production District'. However, for the purposes of this paper, the basic classifications outlined here are sufficient.

[1] This cut off was selected simply because the Knowledge Economy accounts for around 20% of all employment in the metropolitan area.

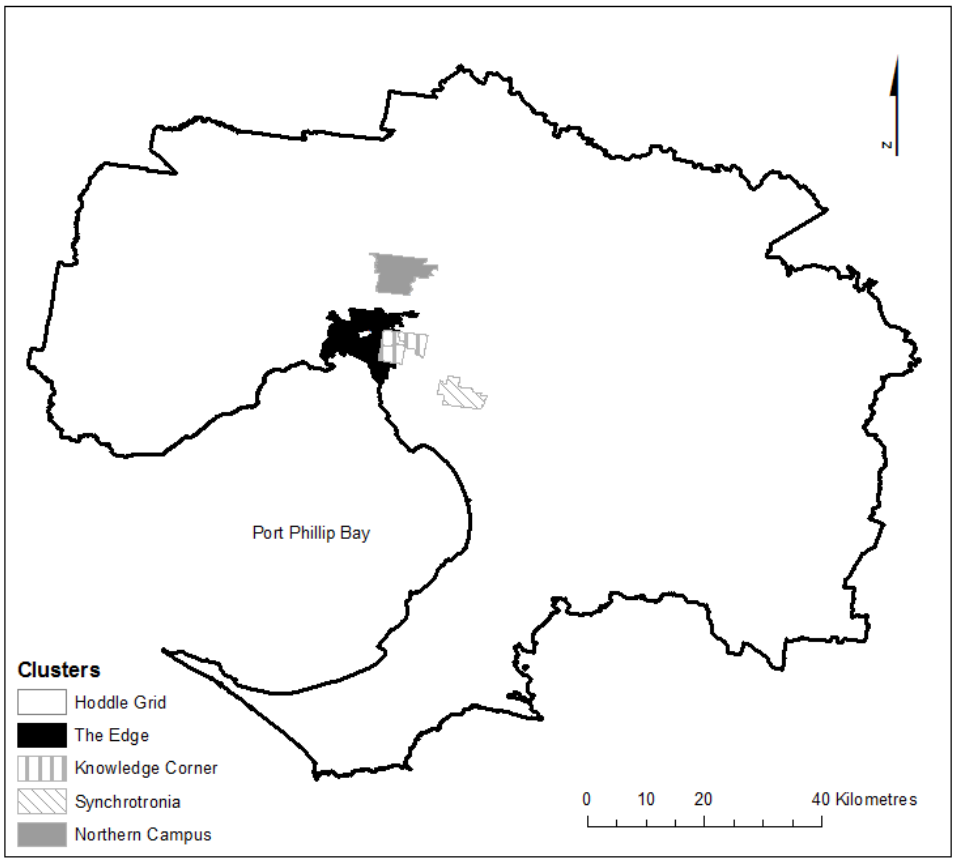

Figure 3: Location of Knowledge Economy Clusters

Data Source: ABS, 2006

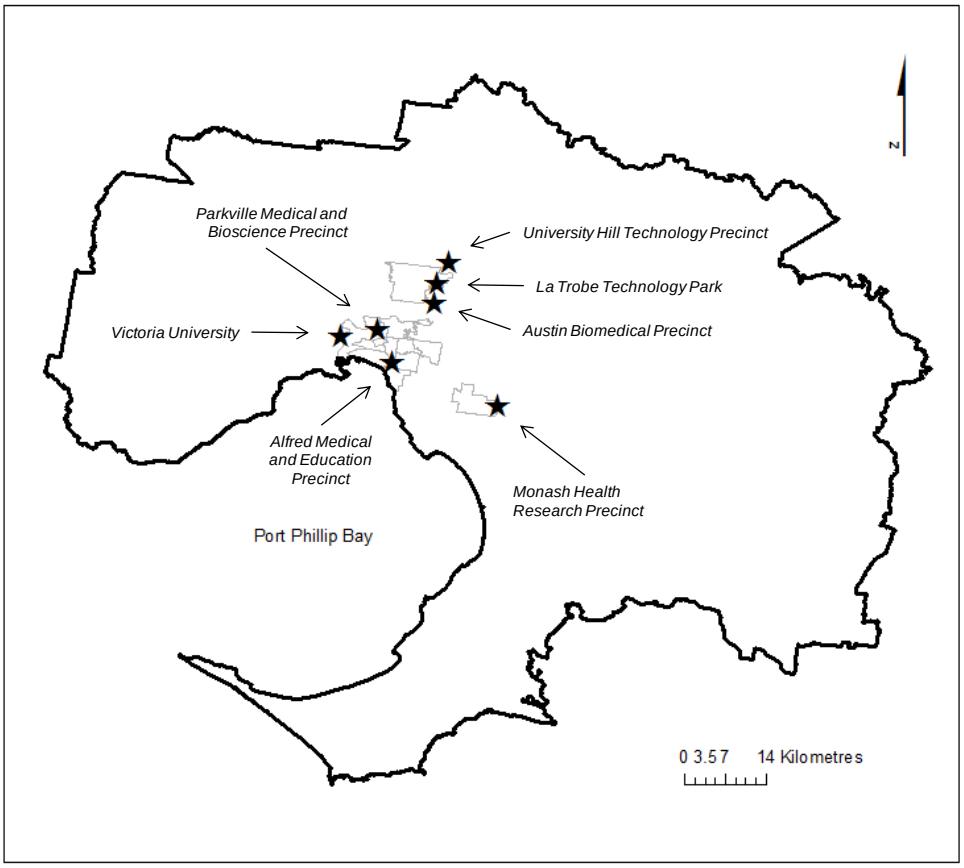

Figure 4: Knowledge Economy Clusters and SACs

Seven of the ten Specialised Activity Centres identified by the State Government as high technology research and commercial precincts are adjacent to the Knowledge Economy clusters used in this analysis. Data Source: ABS, 2006, DPCD, 2010

Combined these clusters account for around 34% of all jobs in the metropolitan area and over two thirds of all Knowledge Economy jobs; all of this in no more than 2% of the total land area of the Melbourne Statistical Region (Table 3).

Table 3: Knowledge Economy Clusters

Knowledge Economy Clusters	Total Jobs	KE Jobs	IT/Media	Finance	R&D/Higher Ed	Design	Cultural Industries
The Hoddle Grid	153,395	66,378	5,323	48,119	8,915	3,688	333
The Edge	243,389	68,330	10,147	23,187	24,994	7,272	2,730
The Knowledge Corner	70,511	18,127	3,398	7,401	3,860	3,108	360
Synchrotronia	33,965	7,604	412	601	6,310	239	42
Northern Campus	28,828	4,098	244	827	2,744	220	63
Rest of Metropolitan Area	1,014,970	80,448	11,259	30,398	24,443	12,151	2,197
Total	**1,545,058**	**244,985**	**30,783**	**110,533**	**71,266**	**26,678**	**5,725**

Data Source: ABS, Census 2006

With the clusters identified, the next step was to compare ESC ratios in these five clusters for both Knowledge Economy (KE) jobs and non-KE jobs (Figure 5) and for KE and non-KE residents (Figure 6) [1]. There are several notable patterns in these data, including the concentration of Knowledge Economy workers living and working in the inner urban area.

As noted earlier, across the metropolitan area, the Knowledge Economy has a slightly lower overall ESC ratio. The metropolitan-scale, however, conceals the markedly higher ratios in the key Knowledge Economy clusters. Additionally, correlations between central city proximity and ESC for Knowledge Economy and non-Knowledge Economy are statistically significantly different. Why this may be the case has not been examined, but may be worth further analysis.

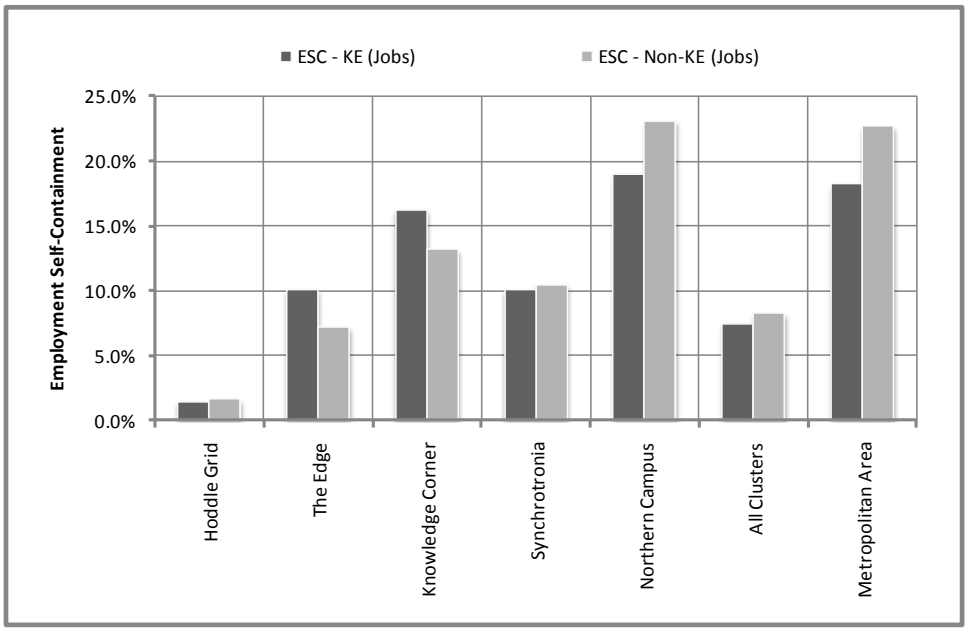

Figure 5: Employment Self-Containment by Cluster - Jobs (2006)

Data Source: ABS, Census 2006

[1] As noted earlier, 'job' employment self-containment refers to the proportion of jobs filled by people living in the same SLA as the job is located. 'Resident' employment self-containment is the proportion of residents working in the same SLA as they live.

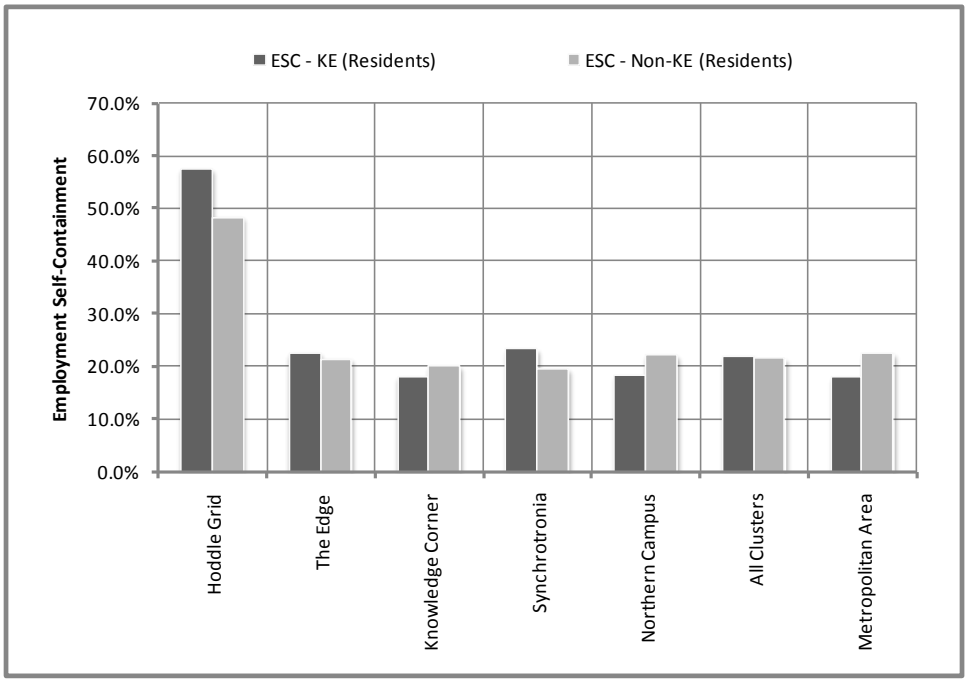

Figure 6: Employment Self-Containment by Cluster - Residents (2006)

Data Source: ABS, Census 2006

4. Commuting Patterns of Knowledge Economy Workers

Figures 7 to 12 show the commuter zones for the five clusters, separately and combined. In this case, 'commuter zone' is used to refer to the place of residence for 80% of the Knowledge Economy workforce.

Again, the key point to note is the overall high concentration of the workforce in the inner urban area, as one would expect. However, Figures 9 to 11 clearly show divergent patterns as the residential commuter zones focus around the respective clusters. Again, though, this is generally what would be expected. That is, on balance, people will tend to live in proximity to where they work (or, alternatively, work close to where they live).

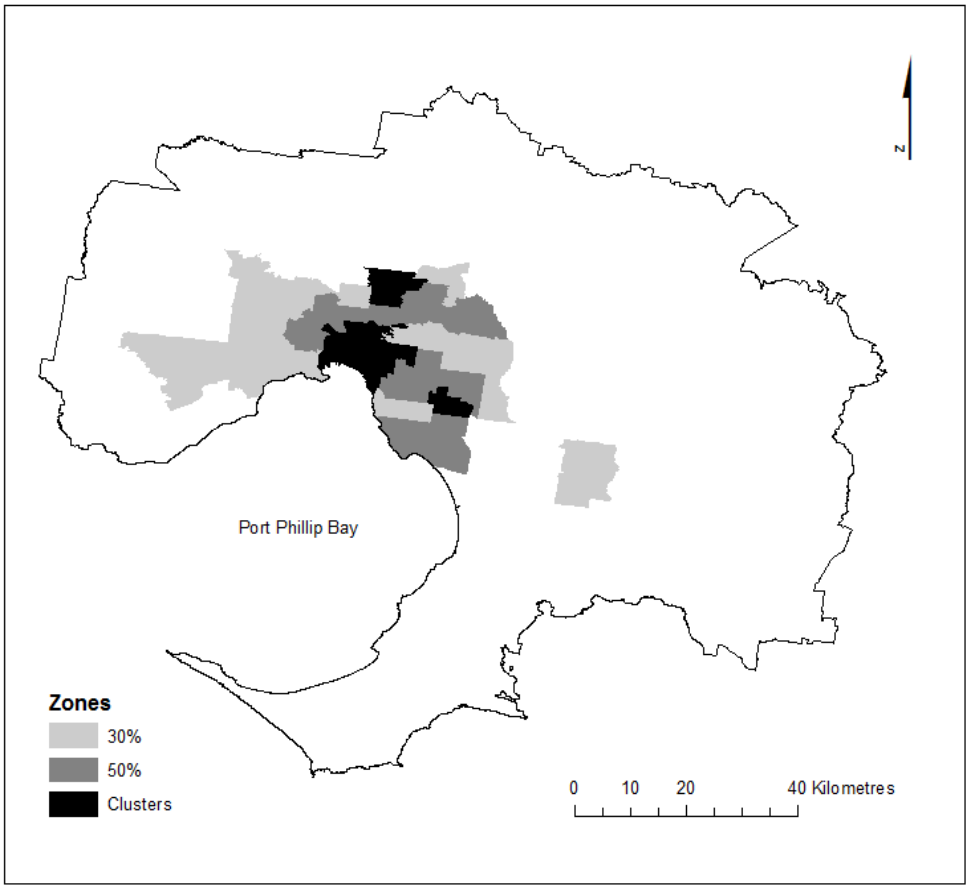

Figure 7: Knowledge Economy Commuter Zones

All five clusters are shaded in black. The grey areas represent the place of residence of 80% of the knowledge economy workforce for these clusters. For all Figures 6 to 11, darker grey represents areas where higher absolute numbers of commuters live (totalling 50% of the Knowledge Economy workforce). Lighter grey accounts for the next 30% of workers. Data Source: ABS, Census 2006

Figure 8: Hoddle Grid Commuters

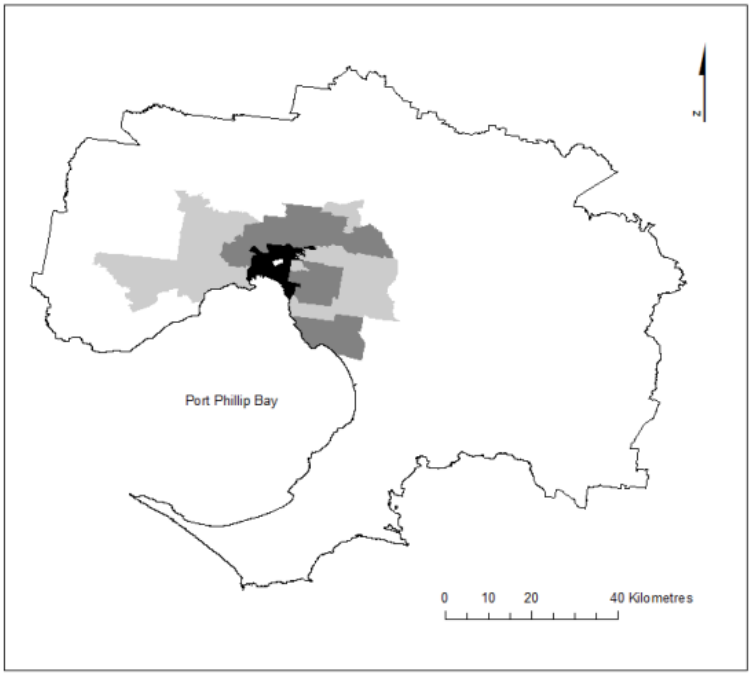

Figure 9: The Edge Commuters

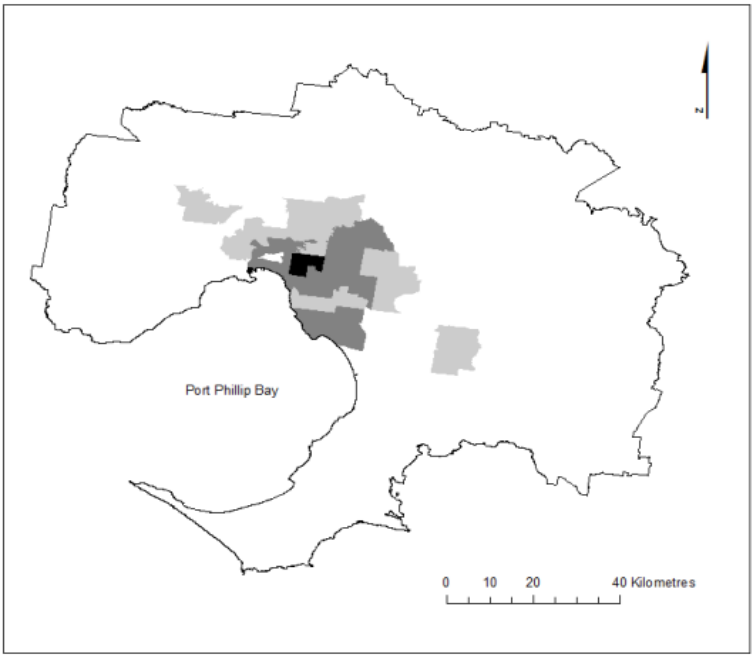

Figure 10: Knowledge Corner Commuters

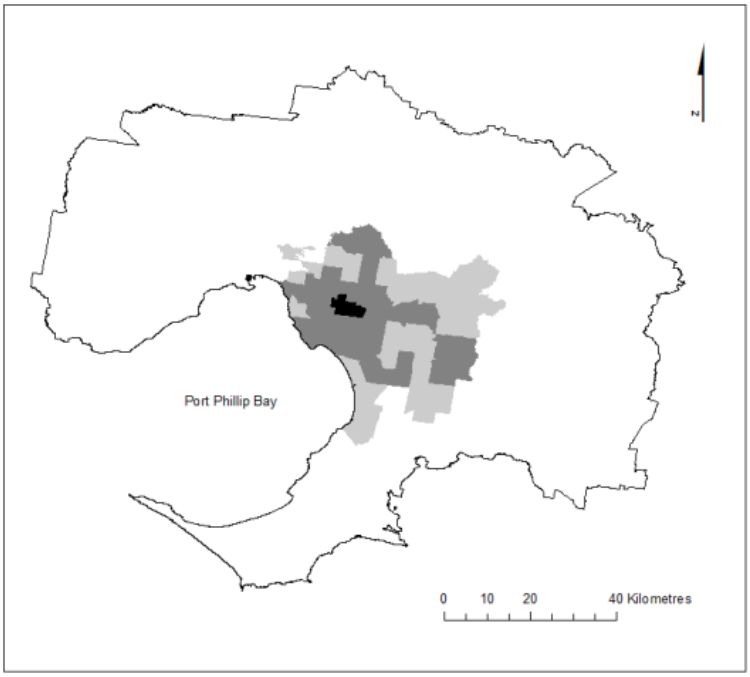

Figure 11: Synchrotronia Commuters

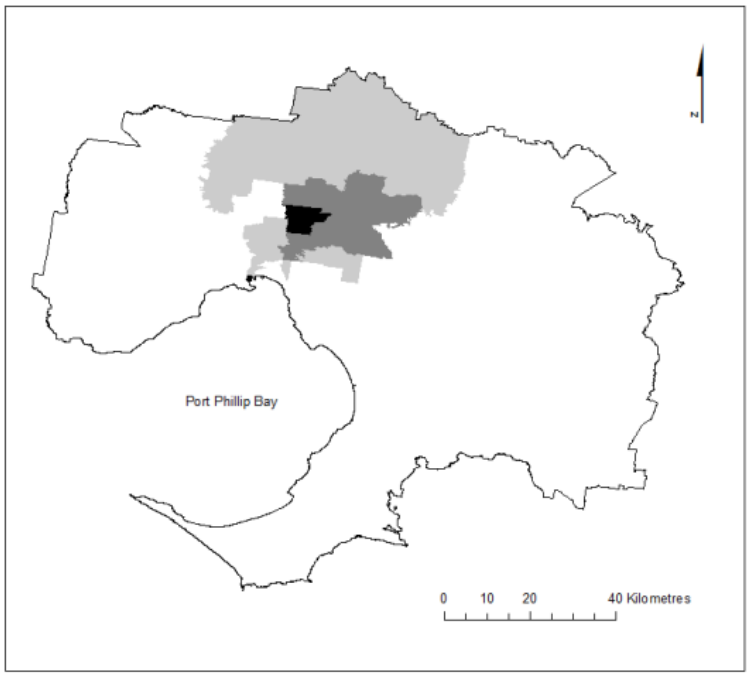

Figure 12: Northern Campus Commuters

4.1 The Knowledge Economy Clusters, CADs and Melbourne's Polycentric Urban Form

Analysis of the manner in which people live in proximity to their place of work goes back some years. Most usefully, O'Connor and Healy's (2002) efforts described the regional nature of metropolitan Melbourne's commuting patterns. Rather than a single, amorphous metropolitan area, Melbourne can be viewed as a group of several 'sub-regional' economies within which most commuting occurs. More recent Australia-wide analysis by Mitchell and Watts (2010) showed that this is a nationally consistent pattern and, for the most part, all Australian metropolitan areas can be broken up into 'Functional Economic Regions'. An interesting study of commute patterns in the UK also confirmed the anecdotal assumption that London is a *"polycentric structure composed of simple flow patterns organised around a limited number of activity centres arranged in a hierarchical way."* (Roth *et al*, 2010: 1).

The body of evidence on this is such that it is fair to say that Melbourne is a system of inter-connected, but relatively self-contained, employment zones. These zones can be defined by, *amongst other things*, commuting patterns and employment self-containment. Obviously the dominance of the CBD as an employment node must be factored in this, as should the concentration of certain industries in purpose built locations (e.g. industrial parks), historical antecedents and existing transport networks. In fact, a large number of parameters influence this structure, which points to the need for a systems-based model to understand it.

Reconfiguring the metropolitan form in this manner can be a useful underpinning for strategic planning initiatives such as the Victorian Government's Activity Centres policy. This specifies six Central Activities Districts (CADs) in metropolitan Melbourne, along with 20 'Principal Activity Centres' and almost 100 'Major Activity Centres. This is a hierarchical classification of nodes of employment and other activity and is a feature of the Network City urban planning model. As noted earlier, the hierarchy also includes 'Specialised Activity Centres' that align with the Knowledge Economy clusters used in this research (DPCD, 2010). Figure 13 overlays the location of the CADs on O'Connor and Healy's customised regions. It suggests how the metropolitan area could evolve into a polycentric, relatively self-contained form.

While there are traces of a polycentric structure to the metropolitan economy, there are still enormous challenges to successfully developing these CADs into self-sustaining mixed-use nodes. This is particularly obvious when one considers the disconnect between where the high-income, high skilled, Knowledge Economy jobs and workers are and where the CADs are.

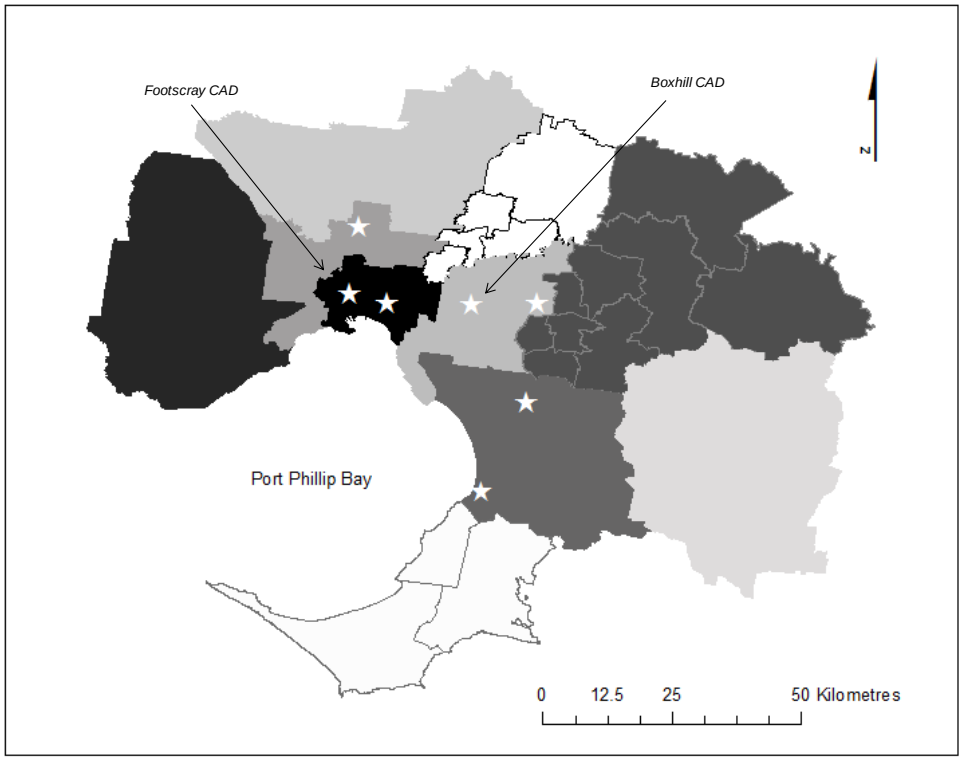

Figure 13: Melbourne's Employment Regions and CADs

O'Connor and Healy's (2002) 10 sub-regions of metropolitan Melbourne (different shaded areas) are overlaid with the location of the seven Central Activities Districts (indicated by stars). These make up part of the network of concentrated development nodes in the State Government's Activity Centres policy (DPCD, 2010). While some of the inner CADs are roughly contiguous with Knowledge Economy clusters (e.g. CBD, Box Hill and Footscray), the majority are some distance away.

This analysis is the first part of an effort to better understand how a City's metropolitan form evolves and, on the basis that it is a desirable outcome the aim is to make a contribution to the emergence of viable CADs: if not in the current arrangement, then in some form that encourages the polycentric urban form. The goal is to build a dynamic model based on a more detailed examination of financial, employment, land use and demographic data. This will factor in the self-reinforcing and countervailing relationships and decision-making processes that lead to locational outcomes for Knowledge Economy jobs and its workforce. There is certainly sufficient information - such as economic signals – to do this. It is merely a case of first building a conceptual model and then formalising it. This, though, is a topic for another occasion.

For now, it is clear that the sub-regional nature of metropolitan areas also applies to the Knowledge Economy. What remains to be seen is whether there are significant differences between the subsectors of the Knowledge Economy. This is what we will turn to next.

4.2 Employment Self-Containment, Commuting Zones and Knowledge Economy Subsectors

Breaking down the Knowledge Economy into the five subsectors described in the Introduction allows us to explore the differences in the commuting and ESC ratios. The data are provided in full in Tables 4 to 11 (Note: Table 9 is an aggregation of all five clusters and Tables 10 and 11 summarise key elements of the preceding tables).

Disaggregating the data in this way disentangles the overwhelming effect of location on ESC and shows how the ratios change according to industry of employment. From this we can eventually make some comment on the merit of industry-specific planning policy designed to encourage ESC.

Table 4: Hoddle Grid and Surrounds Employment Self Containment (2006)

The Hoddle Grid	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	57.6%	1.3%	35.1%	13.8%
IT/Media	50.3%	1.5%	22.5%	15.6%
Finance	72.9%	1.0%	58.3%	13.1%
R&D/Higher Education	44.6%	2.6%	16.9%	14.1%
Design Related	46.9%	2.3%	22.6%	18.9%
Cultural Industries	50.0%	6.3%	8.0%	24.9%

Data Source: ABS, Census 2006

Table 5: The Edge and Surrounds Employment Self Containment (2006)

The Edge	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	22.7%	10.1%	35.6%	24.8%
IT/Media	22.2%	10.2%	42.6%	29.8%
Finance	14.3%	7.5%	24.6%	21.1%
R&D/Higher Education	27.6%	9.6%	45.0%	24.5%
Design Related	31.0%	15.3%	36.7%	26.7%
Cultural Industries	46.7%	22.1%	53.9%	35.5%

Data Source: ABS, Census 2006

Table 6: Knowledge Corner and Surrounds Employment Self Containment (2006)

Knowledge Corner	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	18.2%	16.2%	8.2%	24.4%
IT/Media	19.0%	13.1%	13.5%	28.0%
Finance	13.9%	14.0%	6.9%	21.2%
R&D/Higher Education	17.1%	17.5%	6.2%	25.4%
Design Related	31.5%	18.9%	13.4%	26.8%
Cultural Industries	39.2%	52.5%	5.1%	24.4%

Data Source: ABS, Census 2006

Table 7: Synchrotronia and Surrounds Employment Self Containment (2006)

Synchrotronia	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	23.4%	10.0%	5.4%	20.5%
IT/Media	13.0%	10.9%	2.3%	18.2%
Finance	8.0%	16.5%	0.8%	16.1%
R&D/Higher Education	40.9%	8.6%	14.7%	21.4%
Design Related	18.4%	23.0%	1.0%	13.0%
Cultural Industries	52.8%	45.2%	1.0%	14.3%

Data Source: ABS, Census 2006

Table 8: Northern Campus and Surrounds Employment Self Containment (2006)

Northern Campus	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	18.5%	19.0%	5.6%	39.3%
IT/Media	14.9%	32.0%	1.8%	25.4%
Finance	10.1%	23.2%	2.6%	38.5%
R&D/Higher Education	29.1%	14.2%	12.4%	42.5%
Design Related	22.6%	36.4%	2.1%	27.3%
Cultural Industries	38.4%	60.3%	0.7%	9.5%

Data Source: ABS, Census 2006

Table 9: All Clusters and Surrounds Employment Self Containment (2006)

All Clusters	ESC Residents (Core SLAs)	ESC Local Jobs (Core SLAs)	ESC Residents (Adjacent SLAs)	ESC Local Jobs (Adjacent SLAs)
Total K Economy	22.1%	7.4%	26.8%	20.5%
IT/Media	20.9%	8.6%	30.2%	25.3%
Finance	15.2%	4.4%	24.1%	16.4%
R&D/Higher Education	26.8%	9.0%	29.1%	23.2%
Design Related	30.5%	13.2%	26.1%	24.5%
Cultural Industries	44.6%	24.6%	30.5%	32.7%

Data Source: ABS, Census 2006

Table 10: Employment Self-Containment - Core and Adjacent Residents (2006)

Industry	The Hoddle Grid	The Edge	Knowledge Corner	Synchrotronia	Northern Campus	All Clusters
Total K Economy	36.4%	30.6%	10.5%	7.2%	7.2%	19.1%
IT/Media	23.6%	34.5%	14.8%	3.3%	3.5%	20.3%
Finance	59.2%	20.7%	8.6%	1.4%	3.6%	16.4%
R&D/Higher Education	18.6%	38.2%	8.4%	18.0%	14.4%	21.2%
Design Related	23.9%	34.4%	17.6%	2.6%	4.3%	20.5%
Cultural Industries	9.6%	50.9%	12.5%	4.0%	4.8%	25.6%

Data Source: ABS, Census 2006

Table 11: Employment Self-Containment - Core and Adjacent Local Jobs (2006)

Industry	The Hoddle Grid	The Edge	Knowledge Corner	Synchrotronia	Northern Campus	All Clusters
Total K Economy	15.1%	34.8%	40.6%	30.5%	58.3%	27.9%
IT/Media	17.1%	40.0%	41.1%	29.1%	57.4%	33.9%
Finance	14.1%	28.5%	35.3%	32.6%	61.7%	20.8%
R&D/Higher Education	16.7%	34.0%	42.8%	30.0%	56.7%	32.2%
Design Related	21.2%	42.1%	45.7%	36.0%	63.6%	37.8%
Cultural Industries	31.2%	57.6%	76.9%	59.5%	69.8%	57.3%

Data Source: ABS, Census 2006

Some general observations to make are:

Cluster Employment Profiles

1. Three of the five clusters have very clear Knowledge Economy characteristics:
    a. The Hoddle Grid is predominantly Finance.
    b. Synchrotronia has a R&D/Higher Education focus.
    c. Although not a major employer, the Northern Campus is also a R&D/Higher Education Cluster.
2. As would be expected in inner urban areas, the Edge and the Knowledge Corner have a mix of Knowledge Economy employment by industry subsector. If we control for actual industry size, however, we can see that the Edge is the dominant Cultural Industries cluster and the Knowledge Corner is the dominant IT/Media and Design-related cluster.

Core Area Employment Self-Containment

3. All five clusters have an overall (residential) ESC ratio of around 19% for the Knowledge Economy workforce (Figure 14).
4. As is to be expected, residents in the Hoddle Grid (the CBD) are more than twice as likely to be working in the same SLA as those living and working in the other four clusters.
5. By the same token, the Hoddle Grid residents make up a far smaller proportion of total Knowledge Economy jobs found in the cluster. By this measure, the Northern Campus cluster has the highest proportion of jobs filled by locals.
6. Partial correlations of place of residence and work (controlling for distance from the central city and local labour market size) confirm that the R&D/Higher Education workforce is the most likely to live and work in the same SLA.

Core and/or Adjacent Area Employment Self-Containment

7. The Edge has the highest proportion of workers commuting in from adjacent SLAs.
8. By merging the commuter zone to include the core SLA and all adjacent ones[1], we find that the Edge and the Hoddle Grid have the greatest degree of (residential) ESC for the Knowledge Economy. Again, though, a much smaller proportion of available jobs are taken up by local residents (Figure 15).

[1] This is done on the basis that, in many cases, SLA boundaries do not create a useful or consistently comparable area of analysis.

9. By contrast, a far higher proportion of Knowledge Economy jobs are filled by locals in the clusters further afield. However, this contrasts with the fact that most people living adjacent to Synchrotronia and Northern Campus do not work in these sectors.
10. As a rule of thumb it is reasonable to conclude that Design-related or Cultural Industries workers will either live and work in the *same SLA*, or commute some distance in to work (i.e. not from adjacent SLAs). For R&D/Higher Education workers, a similar picture emerges: they will live and work quite locally, or commute from elsewhere in the City.

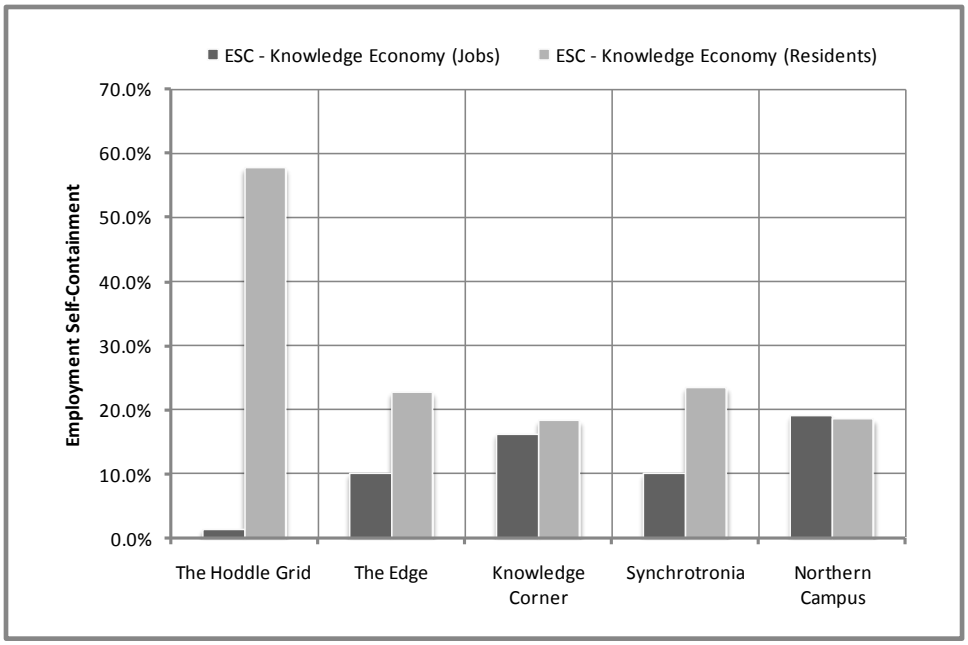

Figure 14: Employment Self-Containment by Cluster - Core SLA Only (2006)

Data Source: ABS, Census 2006

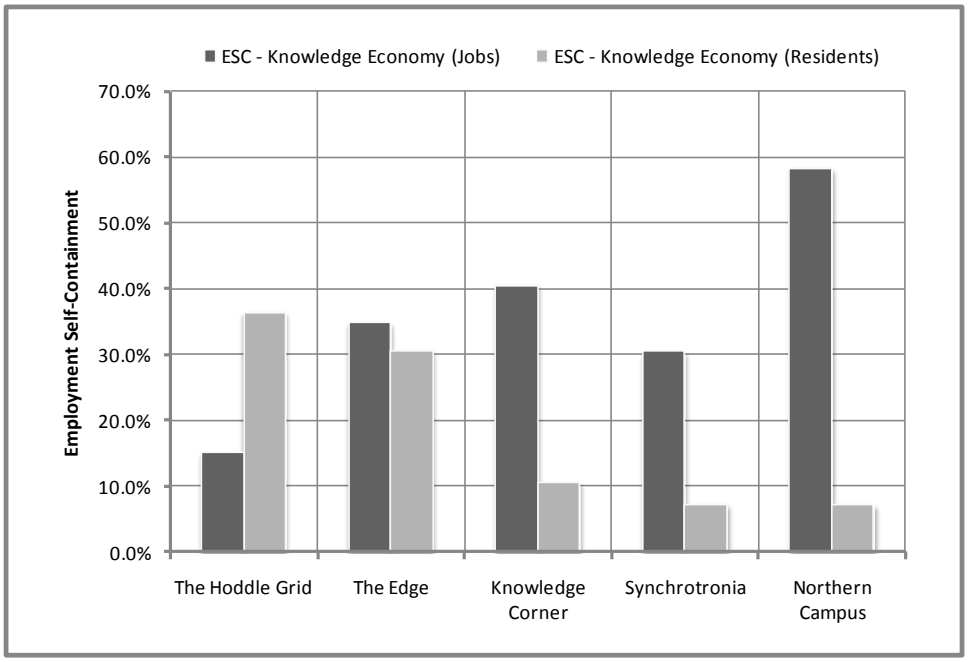

Figure 15: Employment Self-Containment by Cluster - Core and Adjacent SLAs (2006)

Data Source: ABS, Census 2006

4.3 The Relationship between Industry of Employment and Self-Containment

The next step in the analysis was to look more closely at whether there was any discernible relationship between industry subsector and its ESC ratio. Figure 16 shows average ESC by industry subsector for the five clusters combined. The striking feature is the high proportion of Cultural Industries and Design-related jobs that are taken up by local residents, contrasted with the relatively consistent ratio of local residents working locally. This pattern is the same for all five clusters (Figure 17), and strongest within the core SLAs of the clusters. That is, Design-related and Cultural Industry workers are highly likely to live in the same SLA as they work, but much less likely to live in adjoining SLAs. This is in contrast to the other three subsectors, where the reverse is generally the case.

Job search theory would suggest that these differences will be due to the lower income levels in Design and Cultural Industries resulting in reduced willingness to commute (Trundle & Siu, 2007), as well as reduced capacity to secure housing in neighbouring SLAs (these jobs are, after all, concentrated near some of the more expensive residential real estate in Melbourne). That said, previous research has also shown that after controlling for income, we still find these subsectors with higher levels of ESC (Geografia, 2009).

As a word of caution, it should be noted that in analysing the Cultural Industries we are dealing with relatively small numbers of jobs and these conclusions should be treated

as exploratory. When we take into account adjacent SLAs, it is R&D/Higher Education workers who are more likely to live and work locally. Given that they make up almost one third of the Knowledge Economy workforce (compared with 2% and 13% for Cultural Industries and Design respectively), or over 71,000 jobs, they can have a substantial impact on commuting.

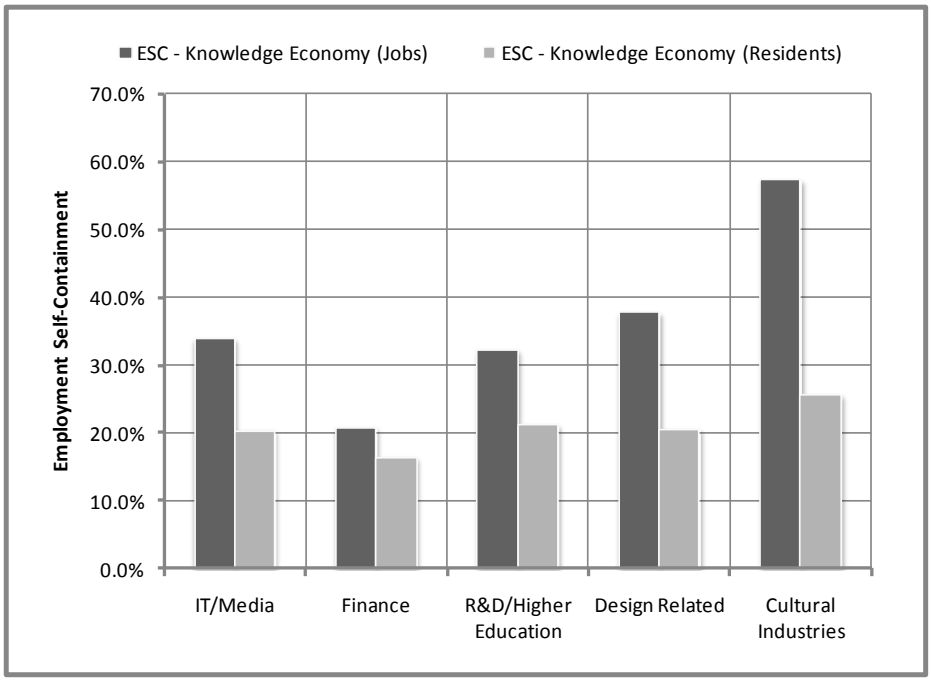

Figure 16: Employment Self-Containment by Industry Subsector (2006)

Data Source: ABS, Census 2006

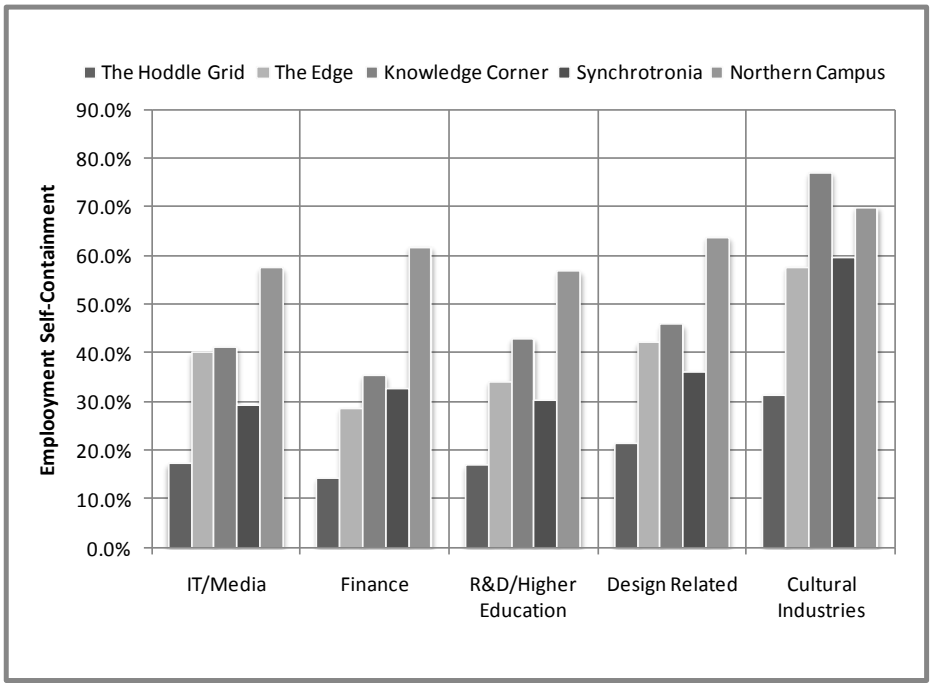

Figure 17: Employment Self-Containment by Subsector and Cluster (2006)

Data Source: ABS, Census 2006

Looking at the data in this format also shows that most locally resident Knowledge Economy workers will work in the locally specific subsector, but still account for a fairly low proportion of the jobs available. For example, the Hoddle Grid has a very high proportion of residents who work in the local Finance sector (73%, which is 42 times the job-related ESC). Equally, Synchrotronia's residents who work in the Knowledge Economy, mostly do so in R&D/Higher Education (41%, which is almost 5 times the job-related ESC).

Figures 18 and 19 illustrate this point for the Knowledge Corner (a Design-related cluster) and Synchrotronia (R&D/Higher Education). They show the difference between how many residents work in the primary Knowledge Economy subsector and how many jobs they account for. All this is saying is that the economic characteristics of a job cluster attract people to live in the area accordingly. However, it also indicates that there is capacity to increase this, given how few of these jobs are taken up by local residents.

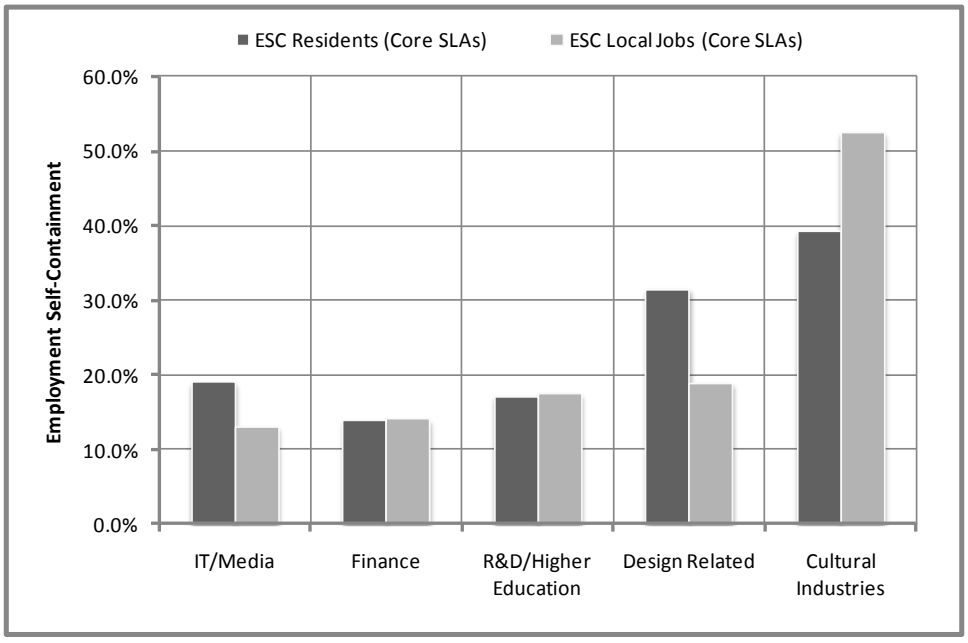

Figure 18: Knowledge Corner Employment Self-Containment Residents and Jobs (2006)

Data Source: ABS, Census 2006

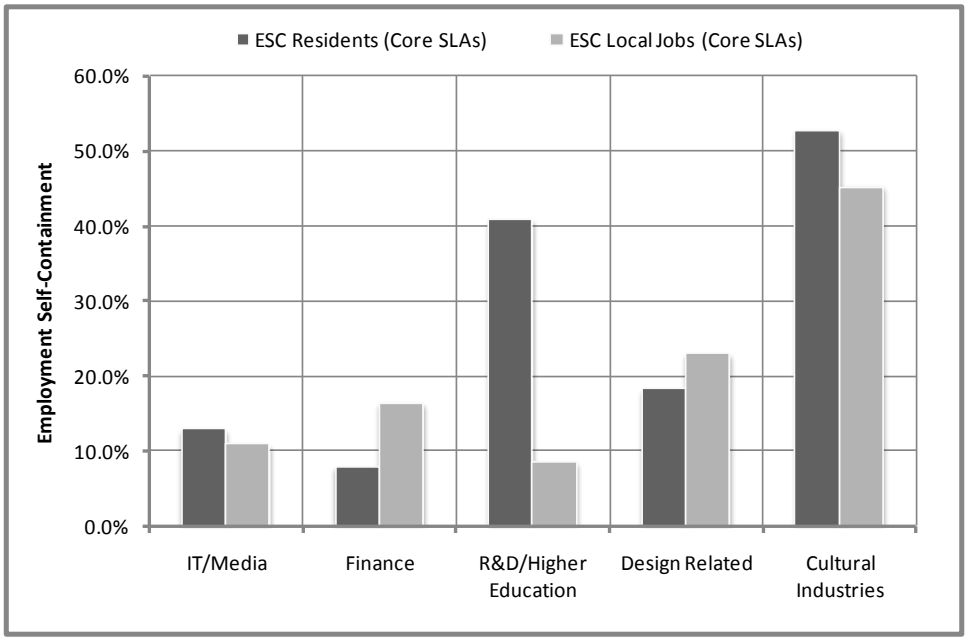

Figure 19: Synchrotronia Employment Self-Containment Residents and Jobs (2006)

Data Source: ABS, Census 2006

4.4 How do they Commute?

This research is just a descriptive first step and there are many ways in which the data can be organised and investigated. For example, one subgroup of the people living and working locally comprises those who work from home. This is of particular relevance to the Knowledge Economy given the presumed ease with which many can work out of home offices or studios, or run mobile businesses. We undergraduates of the early 90s were told that the proportion of people working from home, or telecommuters, would increase significantly in the years to come. In fact, between the last two Censuses, the proportion declined (ABS, 2001; ABS, 2006)[1]. However, in the Knowledge Economy, working from home is understandably more common, for example as a first step in establishing a small Knowledge Economy business that will eventually set up an office in commercial premises. Consequently, where they live and what sector of the economy they work in has important implications for local area planning.

A brief examination of this data show that, again Cultural Industries and Design-related workers stand out from the rest of the Knowledge Economy, with significantly higher proportions of people working from home (Table 12). This partly explains the high proportion of these workers living and working in the same SLA (e.g. Table 5); and is understandable given the high proportion who are likely to be self-employed.

Table 12: Working from Home by Knowledge Economy Subsector (2006)

Industry	Total Number	Working from Home
IT/Media	2,249	6.8%
Finance	6,226	5.4%
R&D/Higher Education	5,961	7.9%
Design Related	3,605	12.9%
Cultural Industries	1,567	23.3%
Other Industries	42,027	2.9%
All Industries	61,635	3.7%

Data Source: ABS, Census 2006

In terms of location, it is true that the highest work from home rates (even for Knowledge Economy workers) is in the outer suburbs. For example, 35% of the resident Knowledge Economy workforce in Lilydale - 40 kilometres to the east of the CBD - works from home. As stressed earlier, though, the numbers we are dealing with here are quite small (usually fewer than 100 people). When only looking at those suburbs with more than 100 Knowledge Economy workers, we find that working from home is most evident in the middle ring suburbs. This matches the concentration of Knowledge Economy workers by place of residence and is particularly high where there are concentrations of Design-related and Cultural Industries workers (Figure 20).

[1] Plausible reasons for this are another, interesting story and likely related to the changing nature of females workforce participation.

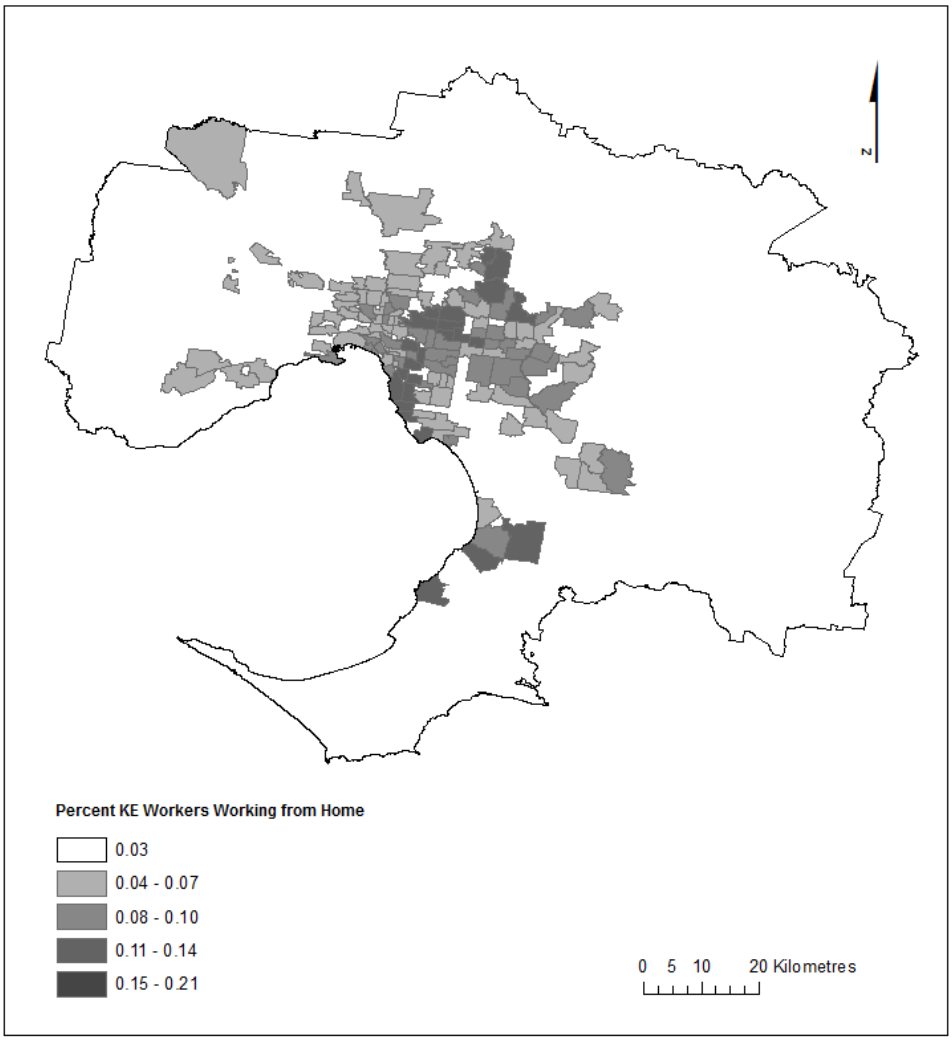

Figure 20: Knowledge Economy Working from Home (2006)

The shading in Figure 20 highlights suburbs in metropolitan Melbourne in which the proportion of Knowledge Economy workers working from home is higher than the metropolitan average for non-Knowledge Economy workers (2.97%). Note that only those SLAs with more than 100 Knowledge Economy workers are included. Data Source: ABS, Census 2006

In general Knowledge Economy workers in metropolitan Melbourne are at least twice as likely to work from home as other workers, reducing *commuter* traffic (although not necessarily private vehicle use) by around 12,000 people a day. Although the overall numbers of people working from home may have declined in Australia, there are groups in the workforce who will embrace this work practice. This will present an opportunity for local economic development planning, particularly in mixed use commercial-residential zones. It is also worth noting where the concentrations of self-employed and/or work-from-home small Knowledge Economy businesses are.

4.5 Summary

From this exploratory analysis we can conclude that, firstly, there are some distinctive patterns to the spatial relationships between jobs and the place of residence of Knowledge Economy workers in clusters around the metropolitan area. Secondly, within the Knowledge Economy these patterns vary both according to location and the subsector of workforce. From a planning perspective, the most significant patterns are:

1. Overall Knowledge Economy commuter patterns in metropolitan Melbourne reflect the same 'sub-regionalised' pattern we see for the entire workforce. We can take from this that there is merit in building a model of the decision-making processes that lead to the Knowledge Economy locational outcomes. It would help to develop better-targeted policies that stimulate Knowledge Economy activity in Melbourne's CADs - or similar suburban nodes – in order to encourage the development of a polycentric urban form.
2. Knowledge Economy jobs cluster in a pattern that defines specific locations by subsectors of the workforce. The exception to this is in the SLAs immediately adjacent to the CBD where there is a more diverse mix of jobs.
3. As the inter-industry flow data suggest, IT/Media and Finance do tend to group, in this case, in the inner city clusters. R&D/Higher Education and Cultural Industries are more self-contained: either through distinctive clustering or higher levels of ESC irrespective of whether the SLA is part of an identified cluster.
4. Knowledge Economy workers' preference to live closer to the central city may be a stronger driver of the geography of the Knowledge Economy than the economic necessity for Knowledge Economy jobs to be located there.
5. In the two outlying clusters, a high proportion of available Knowledge Economy jobs are taken up by people living in (and to a lesser extent around) the relevant SLAs. However, the sum of these local jobs is significantly less than the locally resident Knowledge Economy workforce. That is, Knowledge Economy workers living adjacent to these clusters are travelling elsewhere for work (primarily to the inner urban area). The converse is true for the three inner urban clusters. This is perhaps the most interesting finding if one is considering the goal of developing a polycentric urban form to Melbourne.
6. Following on from this, we can say that Design-related, Cultural or R&D/Higher Education workers live and work in the *same* SLA more so than other Knowledge Economy workers. However, they are also more likely not to live in *adjacent* SLAs to their place of work than the other two industry subsectors.
7. Finally, after examining one element of the commuting patterns in a little more detail, it was found that Knowledge Economy workers are more than twice as likely to work from home as other workers. When looking only at Design-related or Cultural Industries, this disparity increases ten-fold: a sizeable portion of the population who take living and working locally seriously.

5 Conclusion

At the outset, several assumptions were made about the geographical distribution of Knowledge Economy jobs and workers. For the most part these assumptions have been

borne out. That is, the Knowledge Economy workforce reflects the overall sub-regional structure of the metropolitan economy. Additionally, within the Knowledge Economy there are, indeed, distinctive distribution and commuting patterns. This includes the concentration of Finance workers in the CBD; the proximity of IT/Media and Finance jobs; the limited geographical association between R&D/Higher Education jobs and other Knowledge Economy jobs; and the high ESC ratios (at the SLA-level) of Design-related and Cultural Industries.

These different patterns suggest that off-the-shelf local economic development plans with a blanket ESC target and associated transport objectives are unlikely to succeed unless thought is given to the location and the type of work. The effort must work towards a better understanding of the myriad of influences on locational outcomes, particularly those drivers with indirect, but potentially substantial effects. An approach that is based on a conventional analysis of the factors involved in locational outcomes will not provide a sufficiently robust model upon which to develop policy. This undoubtedly applies to the rest of the workforce, as much as the Knowledge Economy.

Nonetheless, any analysis must start with some basics, as is the case here, which revealed some interesting features. For example, people in the Design-related and Cultural Industries often live in closer proximity to their place of work than other Knowledge Economy workers. This is largely irrespective of where the jobs are located in the metropolitan area. That makes them a modest, but potentially efficient contributor to ESC targets, as well as regular users of local transport networks. R&D/Higher Education workers also reveal a preference for living in the same SLA as their place of work. However, they appear less inclined to do so in adjacent SLAs. This finding holds even when decomposing the clusters into their constituent SLAs (e.g. the Edge Cluster, which is made up of five SLAs, one of which encompasses the Parkville Medical and Bioscience Specialised Activity Centre).

While the sector has clearly attracted *some* R&D/Higher Education workers to live locally, these residents take up a relatively small proportion of the jobs that are available in the local area. Meantime, the majority of R&D/Higher Education workers living in adjacent SLAs are commuting elsewhere for work. Why this is the case deserves further examination, particularly with respect to the two outer clusters (Synchrotronia and Northern Campus), where attracting Knowledge Economy workers to both live and work in the area would be an ideal outcome. Understanding what is driving the current situation may lead to a substantial improvement in the effectiveness of employment generation strategies.

Finally, the preference for Knowledge Economy workers to live in and around the central city area appears to be a stronger driver of the locational outcomes of Knowledge Economy activities than the economic needs of the sector itself. Earlier research appears to confirm this (e.g. Searle and Pritchard, 2005); as does the relative concentrations of workers by job location and place of residence as shown in Figure 2. Again, this points to a topic for further research, as well as a potential opportunity to influence commuting patterns.

As noted at the outset, this is just an exploratory examination. There are numerous ways in which the data can be organised: different scales; alternative industry subsets; and occupation breakdowns: and this is just the first step. In order to understand the dynamic interaction of these elements and of the planning policies designed to influence them, it needs to be explored through far more sophisticated modelling techniques than the static, linear statistical analysis used here. This is something that already commenced in relation to the *functionality* of the Knowledge Economy (e.g. Etzkowitz and Leydesdorff, 2000). We have also commenced some investigation into the demographic and economic influences on the *geography* of the sector. At the least this will contribute to the general body of research on the Knowledge Economy. The real aim, however, is to develop a truly systemic understanding of the factors that influence work, residential and commuting decisions. Moreover, by being able to reliably model the impact of proposed planning and policy interventions, it is hoped that more effective strategies, including local economic development and transport plans, will be identified. The ultimate goal is to contribute to the evolution of a metropolis that can be more efficient, more equitable and more sustainable.

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Appendix 1: Defining the Knowledge Economy

Table A1: Knowledge Economy Industries of Employment

Industry Subsector	Industry of Employment
IT/Media	Information Media and Telecommunications, nfd
	Publishing (except Internet and Music Publishing), nfd
	Newspaper, Periodical, Book and Directory Publishing, nfd
	Newspaper Publishing
	Magazine and Other Periodical Publishing
	Book Publishing
	Directory and Mailing List Publishing
	Other Publishing (except Software, Music and Internet)
	Software Publishing
	Motion Picture and Sound Recording Activities, nfd
	Motion Picture and Video Activities, nfd
	Motion Picture and Video Production
	Post-production Services and Other Motion Picture and Video Activities
	Sound Recording and Music Publishing, nfd
	Music Publishing
	Music and Other Sound Recording Activities
	Broadcasting (except Internet), nfd
	Radio Broadcasting
	Television Broadcasting, nfd
	Free-to-Air Television Broadcasting
	Cable and Other Subscription Broadcasting
	Internet Publishing and Broadcasting
	Telecommunications Services, nfd
	Internet Service Providers, Web Search Portals and Data Processing Services, nfd
	Internet Service Providers and Web Search Portals
	Data Processing, Web Hosting and Electronic Information Storage Services, nfd
	Data Processing and Web Hosting Services
	Electronic Information Storage Services
	Library and Other Information Services, nfd
	Libraries and Archives
	Other Information Services
	Advertising Services
Finance	Financial and Insurance Services, nfd
	Finance, nfd
	Central Banking
	Depository Financial Intermediation, nfd
	Banking
	Other Depository Financial Intermediation
	Non-Depository Financing
	Financial Asset Investing
	Insurance and Superannuation Funds, nfd
	Life Insurance
	Health and General Insurance, nfd
	Health Insurance
	General Insurance
	Superannuation Funds
	Auxiliary Finance and Insurance Services, nfd
	Auxiliary Finance and Investment Services, nfd
	Financial Asset Broking Services
	Other Auxiliary Finance and Investment Services
	Auxiliary Insurance Services
	Professional, Scientific and Technical Services, nfd
	Professional, Scientific and Technical Services (except Computer System Design and Related Services), nfd
	Scientific Research Services
	Legal Services
	Management and Related Consulting Services, nfd
	Corporate Head Office Management Services
	Management Advice and Related Consulting Services

Industry Subsector	Industry of Employment
R&D/Higher Education	Scientific Testing and Analysis Services
	Market Research and Statistical Services
	Other Professional, Scientific and Technical Services, nfd
	Other Professional, Scientific and Technical Services, nec
	Computer System Design and Related Services
	Higher Education
	Adult, Community and Other Education, nfd
	Adult, Community and Other Education, nfd
	Arts Education
Design-Related	Architectural, Engineering and Technical Services, nfd
	Architectural Services
	Surveying and Mapping Services
	Engineering Design and Engineering Consulting Services
	Other Specialised Design Services
	Professional Photographic Services
Cultural Industries	Heritage Activities, nfd
	Museum Operation
	Creative and Performing Arts Activities, nfd
	Performing Arts Operation
	Creative Artists, Musicians, Writers and Performers
	Performing Arts Venue Operation

Appendix 2: Knowledge Economy by State

The long-term intention of this work is to develop a dynamic model of job locations and commute patterns that can be used across Australia. Obviously the first step in this is to test for any large-scale differences at the state level. A multiple comparison test (Kruskal-Wallis) was undertaken and revealed some significant differences between the proportions of Knowledge Economy workers and the ratios between place of residence and place of work within SLAs at the 5% level. For the most part this was in the comparisons between the ACT and the rest of Australia (Table A2).

Table A2: Differences in Proportion of KE-Non-KE Workers

	ACT	NSW	NT	Qld	SA	TAS	VIC	WA	NT
ACT	0	1	1	1	1	1	1	1	1
NSW		0						1	
NT			0	1			1		
Qld				0	1			1	
SA					0				
TAS						0			
VIC							0	1	
WA								0	
NT									0

Appendix 3: Location of the Knowledge Economy

Basic statistical tests were carried out to confirm the fundamental assumptions in this study. While not strictly necessary (the body of research in this field has confirmed these conclusions), it was done merely as a precautionary step. The first test was to confirm that there was non-normal distribution of Knowledge Economy jobs across the 79 metropolitan SLAs. This was done using the Kolmogorov-Smirnov Test.

There are likely to be many variables that will have direct and indirect impacts on the distribution and concentration of Knowledge Economy workers and the development of a probabilistic dynamic systems model that can simulate this is a long-term research objective. In the meantime, one of the more obvious parameters to measure is relationship between proximity to the CBD with the locational concentrations of Knowledge Economy workers (by place of residence). Splitting the 79 SLAs into those less than 3km from the Hoddle Grid (an arbitrarily chosen distance for the sake of this test) and those greater than 3km revealed differences in the means and sample distributions (of proportion of Knowledge Economy jobs).

Moreover, the relationship between increasing distance from the CBD and proportion of Knowledge Economy jobs has a high degree of statistically significant negative correlation (-0.775). When controlling for the concentration of jobs, as well as the high proportion of Knowledge Economy jobs, partial correlations are modestly lower (Table A3).

Table A3: Partial Correlations Knowledge Economy Place of Residence

Control Variables			Distance_ Hoddle	PercentPOR_ KE	Local_Jobs	PercentPOW_ KE
-none-[a]	Distance_Hoddle	Correlation	1.000	-.775	-.393	-.553
		Significance (2-tailed)	.	.000	.000	.000
		df	0	77	77	77
	PercentPOR_KE	Correlation	-.775	1.000	.456	.864
		Significance (2-tailed)	.000	.	.000	.000
		df	77	0	77	77
	Local_Jobs	Correlation	-.393	.456	1.000	.557
		Significance (2-tailed)	.000	.000	.	.000
		df	77	77	0	77
	PercentPOW_KE	Correlation	-.553	.864	.557	1.000
		Significance (2-tailed)	.000	.000	.000	.
		df	77	77	77	0
Local_Jobs & PercentPOW_KE	Distance_Hoddle	Correlation	1.000	-.720		
		Significance (2-tailed)	.	.000		
		df	0	75		
	PercentPOR_KE	Correlation	-.720	1.000		
		Significance (2-tailed)	.000	.		
		df	75	0		

By contrast, the correlation between Knowledge Economy *job location* and proximity to the CBD is lower and varies significantly (changing sign) when controlling for total job concentration (Table A4). The hypothesis that can be drawn from this (which, at the least, needs more analysis), is that Knowledge Economy workers are choosing to live closer to the central city for reasons other than proximity to the concentration of relevant jobs. Conversely, Knowledge Economy jobs appear less spatially tied.

Table A4: Partial Correlations Knowledge Economy Place of Work

Control Variables			Distance_ Hoddle	PercentPOW_ KE	Local_Jobs	PercentPOR_ KE
-none-[a]	Distance_Hoddle	Correlation	1.000	-.553	-.393	-.775
		Significance (2-tailed)	.	.000	.000	.000
		df	0	77	77	77
	PercentPOW_KE	Correlation	-.553	1.000	.557	.864
		Significance (2-tailed)	.000	.	.000	.000
		df	77	0	77	77
	Local_Jobs	Correlation	-.393	.557	1.000	.456
		Significance (2-tailed)	.000	.000	.	.000
		df	77	77	0	77
	PercentPOR_KE	Correlation	-.775	.864	.456	1.000
		Significance (2-tailed)	.000	.000	.000	.
		df	77	77	77	0
Local_Jobs & PercentPOR_KE	Distance_Hoddle	Correlation	1.000	.417		
		Significance (2-tailed)	.	.000		
		df	0	75		
	PercentPOW_KE	Correlation	.417	1.000		
		Significance (2-tailed)	.000	.		
		df	75	0		

Appendix 4: Clustering of the Knowledge Economy

To ensure there were differences across the workforce, SLA-level ESC ratios for the Knowledge Economy and the rest of the labour market were compared. Figure A1 shows some divergence between the two, in some cases over 50% variation across outer, middle and inner suburban areas; numbers that clearly require further examination. As Table A5 shows, the data are non-normally distributed. Data were either transformed for analysis, or non-parametric tests were used.

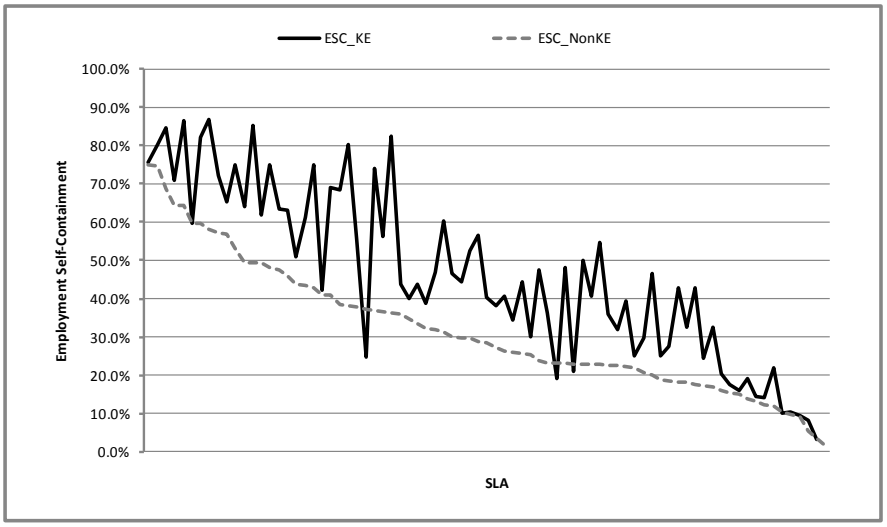

Figure A1: Comparative Employment Self-Containment for all SLAs (2006)

Note that SLAs are ordered from highest to lowest employment self-containment figures. Data Source: ABS, Census 2006

Table A5: Summary Statistics Employment Self-Containment Knowledge Economy and Rest of Workforce

		ESC_Non_KE	ESC_Knowledge_Economy
N	Valid	79	79
	Missing	0	0
Mean		.3173	.4567
Median		.2800	.4400
Mode		.23	.44
Std. Deviation		.17040	.22845
Variance		.029	.052
Skewness		.658	.055
Std. Error of Skewness		.271	.271
Kurtosis		-.123	-.896
Std. Error of Kurtosis		.535	.535
Percentiles	25	.1900	.2700
	50	.2800	.4400
	75	.4300	.6300

Data Source: ABS, Census 2006

An overview of the two datasets shows some variation in the spread of ESC ratios. Due to the nature of the data distributions, a non-parametric test was used (rather than a paired sample T-Test) to compare ESC by SLA for the Knowledge Economy (KE) and non-KE sectors (Table A6). The results indicate the variation is unlikely to be due to chance. After normalising the data paired sample T-Tests were used to reveal high correlations between the different ratios. Low significance values indicate the variation is statistically significant when considering individual SLAs (Tables A7 and A8).

Table A6: Wilcoxon Signed Ranks Test Knowledge Economy and Rest of Workforce

	ESC_KE - ESC_nonKE
Z	-7.355[a]
Asymp. Sig. (2-tailed)	.000

Data Source: ABS, Census 2006

Table A7: Paired Sample Correlations of Normalised ESC Data

		N	Correlation	Sig.
Pair 1	NormalisedESCKE & NormalisedESCnonKE	79	.932	.000

Data Source: ABS, Census 2006

Table A8: Paired Sample T-Test of Normalised ESC Data

		Paired Differences					t	df	Sig. (2-tailed)
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	ESC_Non_KE - ESC_Knowledge_ Economy	-.13937	.11583	.01303	-.16531	-.11342	-10.694	78	.000

Data Source: ABS, Census 2006

Finally, some basic maps were generated to confirm both the concentration of Knowledge Economy jobs (Figure A4) and the existence of self-contained Knowledge Economy clusters outside of the CBD (Figure A5). This provided the evidence for the assertion that Knowledge Economy jobs had distinctively different location and commuter patterns to the rest of the economy.

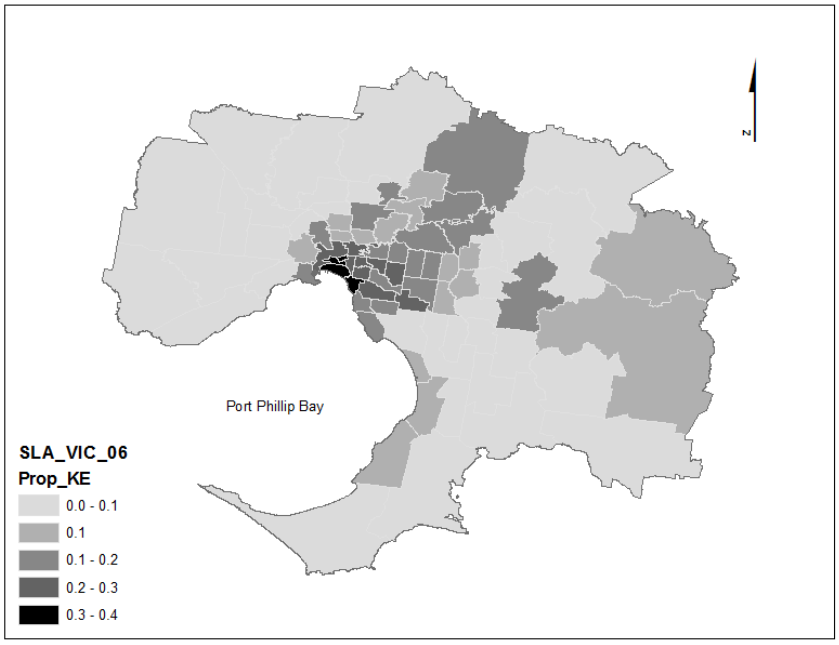

Figure A4: Proportion of Knowledge Economy Jobs by SLA (2006)

Data Source: ABS, Census 2006

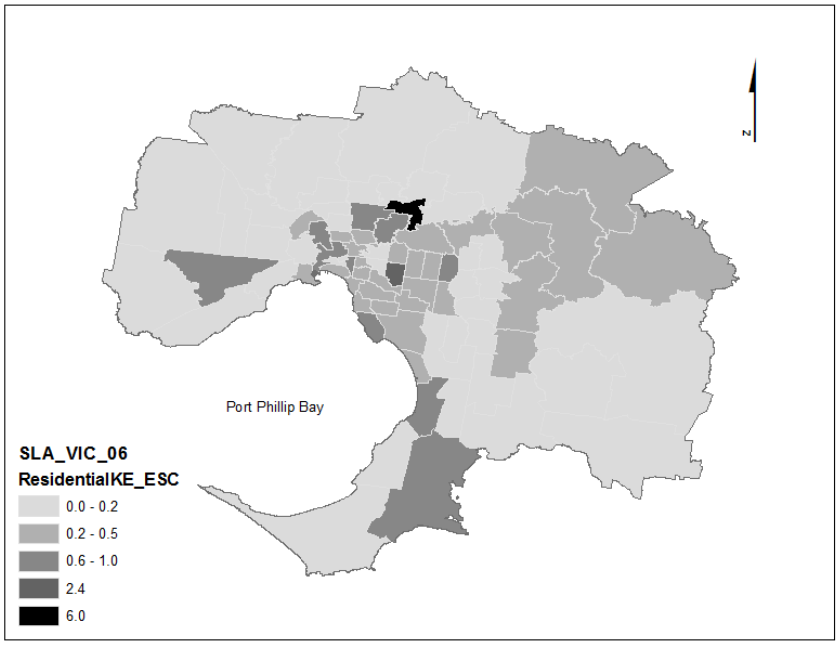

Figure A5: Knowledge Economy Employment Self-Containment by SLA (2006)

Data Source: ABS, Census 2006