



Paper for Special session- Cities, regions and the digital economy: new challenges and opportunities
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Part 1- Introduction

Worldwide the knowledge economy and information communication technology are underpinning economic activity in post industrial economies. ICT and the knowledge economy are characterised by urban proximity and agglomeration, with strong links between ICT, spatial distribution of knowledge workers, urban density and productivity. The knowledge economy requires an increase in the knowledge intensity of capital, labour, products and services. Cities in post industrial economies, it is argued, are characterised and driven by this intensification of knowledge. This paper argues that there are three interrelated factors of knowledge intensification in the modern economy:

- intensification or agglomeration of knowledge economic activity;*
- intensification of knowledge within human capital knowledge ie within individual workers and where those workers work and reside;*
- intensification of knowledge and data within ICT systems and infrastructure.*

However, Australia's post industrial cities are characterised by agglomerative central CBDs and sprawling suburbia raising a number of questions. Is urban sprawl limiting further growth in Australia's knowledge economy? Are metropolitan planning policies addressing the right policy settings for economic sustainability of Australia's metropolitan areas? This paper will examine where the knowledge economy is developing in the metropolitan area of Perth, Western Australia and consider the impact of sprawl on further development of the knowledge economy in Perth.

Part 2 - Nature of problem - Perth, Western Australia: The sprawling city

Perth is one of the most isolated cities in the world. It is the capital of the state of Western Australia. Western Australia has a total land area of 2.5 million km² (Geoscience Australia 2005). Perth's metropolitan area (including the Peel region) had an estimated population of 1.67 million in 2010 (over 75% of the state's population) (ABS 2010). The next largest city in regional Western Australia is Bunbury with only 32,499 people. The Perth metropolitan area is 120 kms long and 40 kms wide (Weller 2009). The population density of Perth was 314.9 people per sq km at June 2010 (ABS 2010). This was lower than the density of Australia's capital cities combined (370 people per sq km) (ABS 2011).

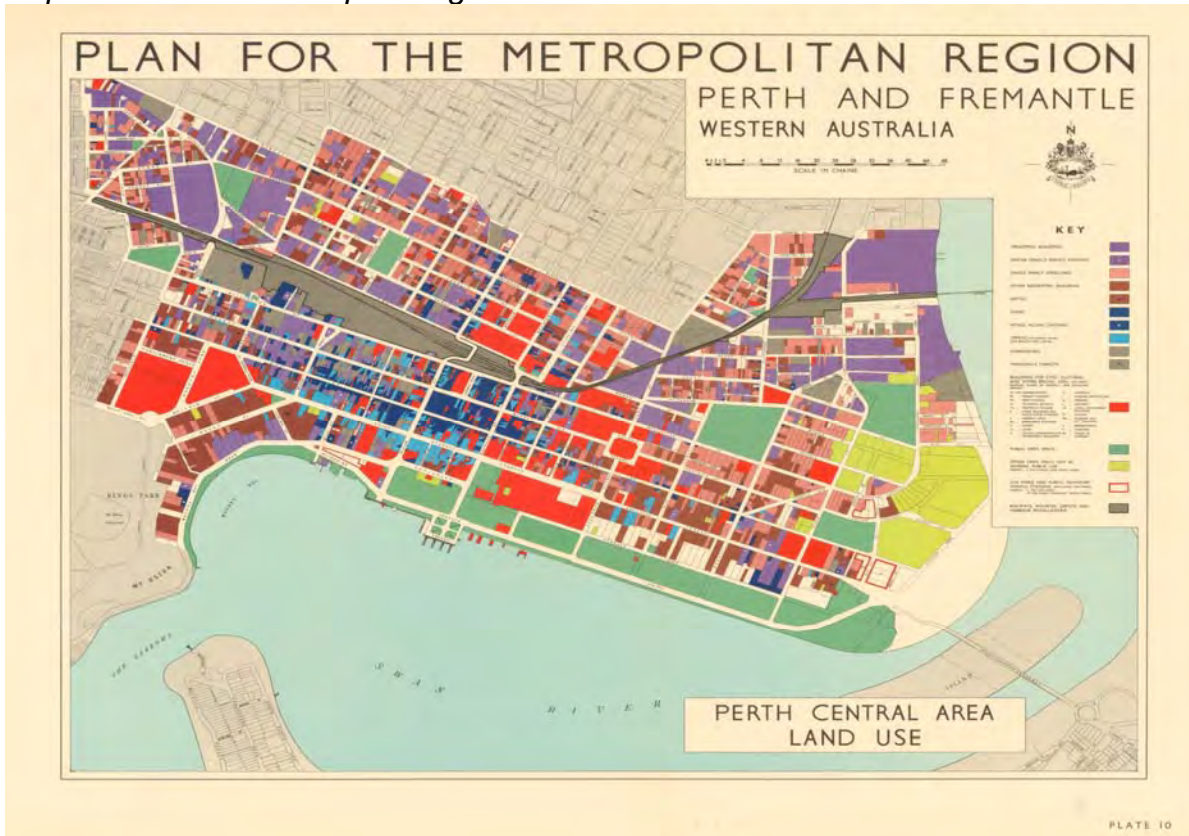
Not surprisingly Perth is one of the most car dependent sprawling cities on the planet with low urban density (Weller 2009). Perth has been described by Weller (2009) as

“a flatland of freestanding suburban homes and their related infrastructure. In a word sprawl... Perth is now one of the most sprawled (or should we say spacious) cities on earth .”

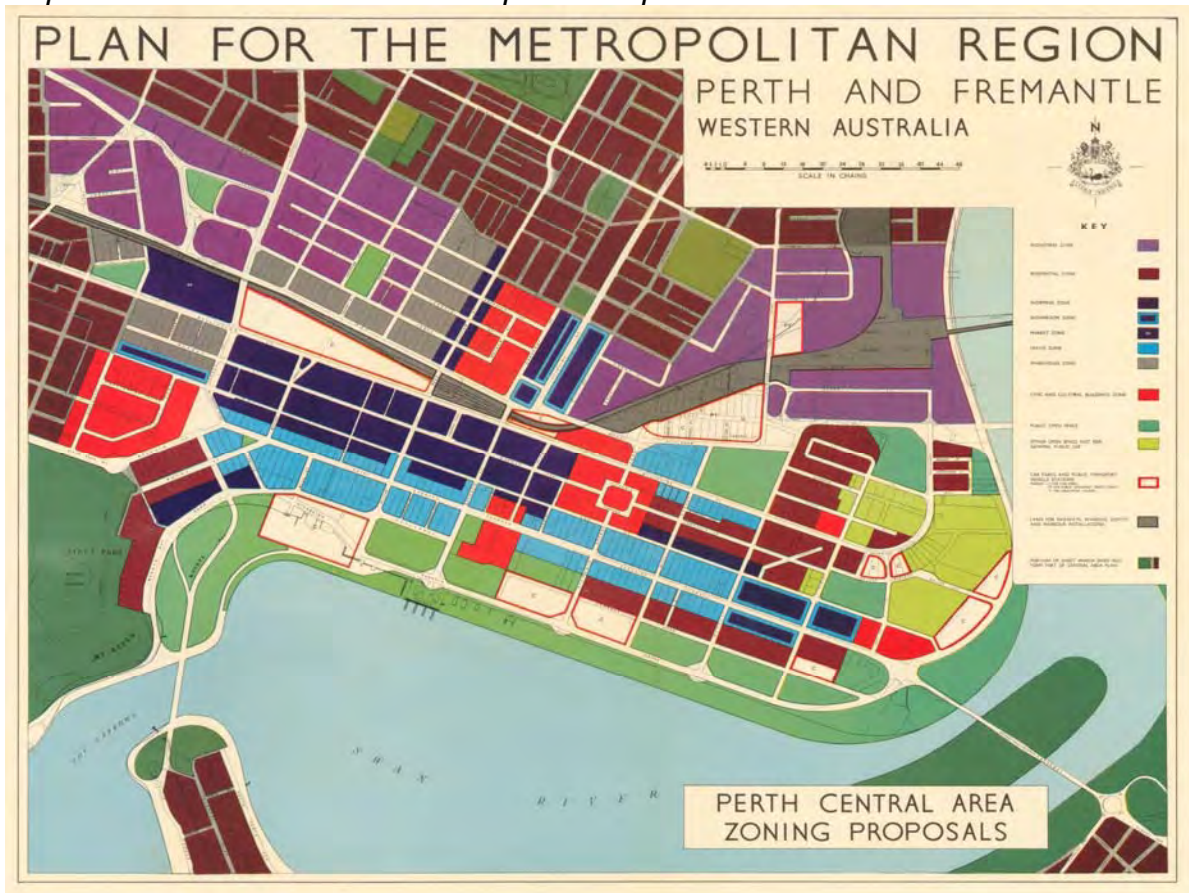
The low density nature of Perth is reflected in its transport systems. The impact of transport infrastructure, particularly road, on the form of urban development and structure of Perth is well established (Edmonds 1998). The structure of modern metropolitan Perth, following the Plan for the Metropolitan Region, Perth and Fremantle, 1955 (Stephenson and Hepburn 1955) was that of a road-based city.

Motor car dominates transport mode share in Perth and hence is a major influence on employment spatial distribution within the metropolitan area. Since 1976, when census data was first collected on travel to work, public transport's share declined in Perth from 13.5% to 9% in 1996 with a recovery to 10.4% starting in 2006. In 1976 Perth was the second most car dominated capital city in Australia (after Canberra) and by 2006 remained the second most car dominated capital city after Adelaide (Mees, Sorupia and Stone 2007). Car use has gone from 79.4% of work trips in 1976 to 82.1 in 2006. Looking beyond work travel the picture is even more car oriented. In a study of 100 cities around the world Perth was ranked in the top ten for both motorised private mode split (at 87%) and passenger car km per capita (at 8,260km) (Kenworthy and Laube, 2001). Perth's characteristic as a car dominated city is a result of the success of the Hepburn Stephenson Plan which originated in the 1950s (Leigh 1989). Figures 1 and 2 demonstrate the impact of planning for the car on land use within the Perth CBD. Figure 1 is pre planning – a fine grain mixed use 19th century walking and rail focused grid. Figure 2 indicates the plan for the Kwinana Highway across Narrows Bridge with a ring road around the southern, eastern and northern boundaries of the CBD. The impact was not just on the CBD. The motor car provided the mechanism for Perth to grow to a large city area wise for its population. By 2001 Perth had the third highest number (77.9%) of separate houses after Brisbane and Hobart, with the third lowest amount of highest density housing also after Brisbane and Hobart (ABS as quoted in the State of Environment Report, Beeton et al 2006).

Map 1 - Perth 1955 Pre-planning



Map 2 The vision for Perth CBD Hepburn Stephenson Plan



By 2003 the WAPC, while recognising the population shift to cities, raised the question that in the 21st century, with the rise of the internet and the increasing ability of service sector businesses to conduct their networking and attain their supporting service infrastructure in cyberspace, it will be problematic to see continuing agglomeration of the service sector in a CBD (WAPC 2003). The WAPC foresaw future job distribution within metropolitan Perth was likely to be more evenly distributed than it has been in the past, with work trip distances and times reduced as jobs move towards the outer regions. It was even foreseen that much of the future long term employment and population growth of metropolitan Perth did not necessarily have to concentrate within metropolitan Perth. Developing new urban alternatives to the city were thought to be a possible better option. The WAPC was foreseeing the end of distance at the metropolitan scale. By the early 2000's Perth's industrial composition reflected these changes in favour of the service industries, with finance and business services, public administration, community services and trade and entertainment growing at the expense of manufacturing, transport and construction and other non-service industries (WAPC 2003). With an increasing sprawling population Perth's employment was shifting away from the inner city to the suburbs. Most notably, the Perth CBD's share of jobs had almost halved over the previous thirty years. Jobs or industries were according to the State Government's Western Australian Planning Commission (WAPC 2003) no longer tied to specific locations, reflecting decentralising population patterns (WAPC 2003). However this was really two intersecting trends happening. As Perth suburbs grew so did retail and other population driven service employment within these suburbs. The other trend was the employment growth in professionals, associate professionals, and managers and administrators all which grew from the mid 1990s (DTWD 2010, ABS 2012). From 1997 through to 2008-09, professionals (46,600 persons), technicians and trades workers (46,000), and managers (42,800), experienced the largest increases in employment growth (DTWD 2010). In the period 2009-10 to 2016-17, these three occupation groupings were expected to continue to experience the strongest increases in employment growth. The Chamber of Commerce and Industry (CCI WA 2007) has noted that the increase in the size of the professional occupational group has been the notable change and by 2006 was the largest occupational grouping with 17.9% of the workforce. The spatial location of professional employees within Perth rather than dispersing like retail and other service occupations have concentrated in and around the CBD. This trend will be examined later within this paper. However this trend and its implications do not seem to have been understood within the planning framework for Perth in that the metropolitan regional plans do not examine the spatial distribution of knowledge economy jobs or associated ICT infrastructure.

The importance of the resource sector to Perth cannot be underestimated¹. The resources sector dominates Western Australia's economic landscape into the 21st century with investments in the mining sector, particularly gas and iron ore production during 2000 to 2006, led to unprecedented growth levels in the city (WAPC 2010 - Directions 2031). Even the State's relatively small (compared with the rest of Australia) manufacturing industry is largely related to the mining industry. Business investment, a major proponent of the State's economy, has been predominantly driven by capital expenditure in the State's resource industry. In contrast to its large share of production, the mining industry employed only 38,500 people in 2003-04, or 4.0% of the workforce. This reflects the highly capital-intensive nature of the resources industry in Western Australia. The income generated by primary industries also supports substantial

employment in the remainder of the economy. What this means is that most people in Perth are not connected in an employment sense to primary industries, but have jobs that provide services to other people in Perth (WAPC 2003). The City of Perth (the local government for the CBD area of metropolitan Perth) has noted in its 2010 economic strategy that Perth is operating in a global economy, competing beyond the domestic market to attract financial capital, skilled workers and business investment (City of Perth 2010). The economic strategy for the City of Perth identifies the growth in the resource industry as the key driver of the Perth CBD's economy¹.

The increasing importance of the resource sector to Perth coincided with the rise in the knowledge based economy in Australia. The structural shift in the Australian economy can be dated back to the 1970s (Productivity Commission 1998). As in other countries, Australia has seen extensive changes in its industry composition and employment since the 1970s. Output and employment in the services sector have expanded considerably with declines in manufacturing output and employment with this transformation have been greater in Australia than in most other OECD countries (Productivity Commission 1998). These changes to the Australian labour market have arisen from developments Lewis (2004) referred to as the 'New' or 'Global Knowledge' Economy, which was contended emerged out of two forces; namely the growth in technology and the subsequent knowledge intensity of economic activities including knowledge intensive goods and services, and the globalisation of economic activity (Lewis 2004). The knowledge economy, it is argued, requires an increase in the "knowledge intensity of capital, labour, products and services, particularly knowledge based services" (Lewis 2004).

Australian cities share similarities with US cities in terms of their low density, spreading urban areas, though with stronger CBD's like European cities (Mees, 2000; Buxton, 2000 in Curtis 2006). However as Scannell (2010) and Weller (2009) have put it Perth is rapidly heading down the path of endless sprawl. Urban sprawl has been said to be an ill-defined term including terms such as 'low density', 'dispersed', 'decentralised', 'suburban', 'polycentric', 'scattered', 'leapfrog development', 'commercial strips' and 'single-use development' (Ewing, 1997 in Curtis 2006). However all of these features are recognisable in the suburbs of Australia's major cities. All of Australia's state capitals metropolitan planning schemes are long term aspirational 'compact city' plans² which recognise the need to move away from sprawl to increase infill development and build up and diversify activity centres outside of their CBDs. In 2005 the WA Government, following extensive public consultation and involvement, released the Network City plan. Network City was based on a network with a hierarchy of centres suited to serving the different needs of the population at different spatial scales (regional, district, neighbourhood), with the centres also providing a key role in integrating and supporting a transport network of different modal layers (Curtis 2006). Curtis (2006) has argued that the main benefit of the a network of activity corridors and transport corridors is in promoting sustainable urban growth through accommodating urban population growth within higher-density activity corridors containing urban sprawl

¹ The City of Perth's Economic Strategy noting that the Western Australia's state's economy nearly doubled in size between 2000 and 2008 with almost 200,000 new jobs created, mostly in the 'booming' resource sector As of January 2010 there was about \$278 billion worth of projects classified as either under construction or committed to start construction soon in Western Australia.

² Perth's plan being Directions 2031- formerly Network City; Melbourne 2030, Sydney - City of Cities and Brisbane's South East Queensland Regional Plan (SEQRP)

and using land more efficiently. Perth's Network City reflected an emerging professional consensus towards a type of multi-centred city form centred on public transport corridors (Curtis 2006). In 2010 Network City was replaced as Perth's principle planning document. Perth's present spatial planning scheme Directions 2031 (2010) continued the support for the need to curb urban sprawl in favour of a connected city with much better public transport. However the previous scheme for Perth, Network City (2004) planned for example to have 60 per cent of the city's growth occur on infill sites: this was changed with Directions 2031(2010) to 47 per cent infill (Day 2010). Scannell (2010) contends that Directions 2031 left a lot to the market at a time when the market is not really ready for change. According to the ABS (2011) low density dwellings still make up two thirds of all building approvals in the Perth metropolitan area with this proportion having barely changed in the last decade despite state government goals for higher urban density.

In some respects the differences between Network City's and Direction 2031's infill target masks the similarities on focusing on a polycentric city structure with connected activity centres, with an increasing role for public transport. Directions 2031 is very much about strategies to meet strong population growth and how the planning system could accommodate a city of 3.5 million people. By 2031, the population of the Perth is forecasted to grow by at least half a million people to 2.2 million residents. The rate of growth may be even faster, with the population potentially reaching 2.88 million by 2031. In order to accommodate 2.2 million people it is estimated that there will need to be another 328,000 houses and 353,000 jobs. The title of the document is adopted from the 2031 census year. In the foreword it is stated that "Underpinning our growing economy is a growing population..... Our challenge is to find room for this new growth." The focus on addressing population growth is not surprising, as the Productivity Commission (2011) noted in examining the nation's planning system, Australia's population is projected by the ABS to grow from over 22 million today to between 30.9 million and 42.5 million in 2056 (ABS 2008).

However, how economic growth could be stimulated or influenced or made sustainable by Directions 2031 is largely unclear as the focus of the strategy is on assumed economic growth. The economic context of the economic growth underpinning Directions 2031 is stated as:

Over the coming decades economic, business and political forecasts indicate that Western Australia will move into a period of sustained population growth and economic development. This is underpinned by our mining and engineering sectors with strong export markets to Asia – particularly India and China. The strength of our economy will depend on our ability to build business confidence, attract foreign investment and create jobs.

Little to no recognition is given to knowledge economy growth or agglomeration and how these would or could be stimulated by spatial planning. Increasing density is seen mainly as a mechanism to create capacity for infill population growth (and in Network City to increase sustainability). Perth's New Directions 2031 (2010) has elevated the outlying centres of Rockingham and Joondalup as primary centres only below the Perth CBD in the hierarchy. While Joondalup (with Edith Cowan University) and Rockingham (Murdoch University Rockingham campus) have tertiary institutions (and major shopping centres) the largest universities in the state are Curtin and University of

Western Australia (UWA) (Universities Australia 2009). Curtin University and UWA, with activity centre including Murdoch University, are in Directions 2031 in the category of specialist centres. The three specialist centres have been elevated to the same status as the seven major activity centres (effectively the major suburban town centres and major shopping centres) with these two categories of centres classed as strategic centres. This means there are 10 strategic centres outside the Perth CBD competing for agglomerating activity.

The main focus with regard to activity centres of Directions 2031, like Australia's various capital city metropolitan planning schemes, is to transform seven traditional shopping centres (or older regional town centres dominated by retail) into mixed use regional activity centres with more than retail and service provisions (see notes to State Planning Policy 4.2 Activity Centres for Perth and Peel, Western Australian Planning Commission ("WAPC") 2010). The focus is on transport sustainability (ie a more energy efficient urban form) and the need to reduce the overall need to travel through support of public and active transport for access to services, facilities and employment. This is seen to require the planned network of activity centres in Directions 2031 to have an evenly distribution of jobs, services and amenities throughout Perth and Peel. In this sense outside of the CBDs the metropolitan spatial plans are mainly focused on centres dominated by consumption rather than production. This is not to say that Direction 2031 or other metropolitan regional schemes do not direct attention at knowledge centres or clustering innovation activity. Directions 2031's Activity Centre policy notes that 'specialised centres focus on regionally significant economic or institutional activities that generate many work and visitor trips, which therefore require a high level of transport accessibility, and that they provide opportunities for the development of complementary activities, particularly knowledge-based businesses. Opportunities for transformation to mixed use residential, cultural and knowledge economic centres driving the metropolitan economy are not part of the vision. Other than Murdoch Activity Centre around the University and the new tertiary Fiona Stanley Hospital, little regard for knowledge economy strategies can be presently ascertained in the priorities for Directions 2031 (WAPC 2011). In many respects it can be said that specialised centres are performing a niche role in the activity centre strategies for Australian cities. This paper will question the extent that the knowledge economy will grow within activity centres structured around consumptive retail and surrounded by low density urban sprawl. In particular it will propose that knowledge intensification that underpins the knowledge economy means that there are limitations as to where the knowledge economic activity will develop in sprawling areas of the Perth metropolitan area.

Part 3 - What is knowledge and how is it created and transferred?

In trying to understand the knowledge economy and its spatial context it is worth addressing the question; 'what is knowledge?' A way of understanding knowledge is to see it being codified or tacit. Codified knowledge is knowledge that is formalised, turned into data through operating manuals, blueprints, or patents. Polanyi (1966) defined codified or explicit knowledge, as he referred to it, as knowledge that is transmitted using orderly formal languages. Tacit knowledge is knowledge that cannot be articulated, with Morgan (2004) arguing that tacit knowledge is personal and context dependent is difficult to communicate other than through personal interaction in a context of shared experience. Similarly Polanyi (1966) saw tacit knowledge as personalised and defined tacit knowledge as knowledge that indwells in a comprehensive cognizance of the human mind and body. Fallah and Ibrahim (2004) similarly see tacit knowledge as embedded in the individual or group of individuals. However Morgan (2004) notes that it is generally accepted that tacit and codified knowledge are really part of a continuum with the real issue being the cost of conversion or codification.

Knowledge transfer

The transfer or spillover of knowledge is one of the key elements in the theory of agglomeration economics. The theory, originally developed by Marshall (1920) provides for advantages arising out of companies and organisations clustering around geographic locations ie cities or regions. Three advantages are provided: access to a relatively large skilled labour pool, economies of scale in terms of access to and availability of resources, and materials and inputs including services. The third is the intensity of knowledge exchange between people, firms and institutions within close geographic proximity (Fallah and Ibrahim 2004). While agglomeration provides economic productivity it is knowledge spillover that has been shown by a range of researchers and economists to provide innovation benefits (Fallah and Ibrahim 2004). Therefore how knowledge transfer occurs and how the transfer can be positively influenced is an important economic issue. As spaces and places are key influences on knowledge transfer spatial planning therefore has a key role in enabling knowledge economy outcomes. This tacit knowledge sharing space can be both a physical space enabling close physical communication or it can be cyber place through electronic means. Nonaka and Takeuchi (1998) argue that because of its personal nature most powerful learning comes from face to face communication and from the use of the body not the mind. Therefore this supports the contention that while information communication technology can be seen as a key technological conduit for information transfer, physical human interaction is seen as being superior for creation and transfer of tacit knowledge. Lawlor (2008) has argued that that the most successful places enable a variety of exchanges – social, cultural, economic. These places include the streets, the block, the district and the city. Successful places and place-making provide knowledge workers with day to day close encounters, and engagements in few, bounded communities of practice (Undheim 2002). This is important as knowledge community and knowledge creating relationships evolve over time.

In this sense tacit knowledge is 'sticky' at the geographical urban scale - supporting clustering of people and organisations (but that is not to say clustering does not happen

with codified knowledge where other benefits of agglomeration other than knowledge spillover occur). Evers et al (2010) argue that knowledge based work needs teamwork and the existence of communities of practice, frequent social interaction and capacity building by direct face to face learning. Storper and Venables (2002) contend that there is a broad advantage to 'stickiness' and relevance of face to face contact with quality contact being a non substitutable means by which potential partners in knowledge or creative projects:

- *overcome coordination problems;*
- *minimise risk;*
- *screen potential partners;*
- *form cooperative groups; and*
- *provide for informal and intensified communication.*

The building of trust through direct face to face relationships expedites organisational learning especially where reciprocity or further relationship activity is expected (Morgan 2004). Evers et al (2010) note that a fair number of relevant studies have provided empirical evidence that proximity and face to face interaction indeed facilitates the transfer of tacit knowledge. Evers et al (2010) argue this is because knowledge production is a social process that requires interaction and while it may take place to a certain extent, in cyberspace, innovation and discovery are also driven by emotions, fun and anger, excitement and frustration, which are projected at persons in direct interaction.

Part 4 – Intensification of the knowledge economy

Intensification of knowledge economy activity

The stickiness of tacit knowledge is supported by examination of the clustering of knowledge economic activity within cities. The agglomeration characteristics with ICT and the knowledge economy are not generalised, with agglomeration occurring in particular regions and in particular parts of cities, usually the city core (Burger et al 2009) including within Australia (Johnson 2010, Hu 2010, SGS 2008 Spiller 2003, 2005). In the United Kingdom the Eddington Transport Study 2006 found that agglomeration economies were substantial for the service sector (D. Graham 2005). In particular, high agglomeration values were found for business services and management consultancy, financial services and public services. The evidence of agglomeration benefits now abounds in the international literature but this understanding has not made their way into cost-benefit analysis and appraisals of Australian infrastructure investments or in any measurable way been introduced into urban planning for Australian centres (Trubka 2009, Rawnsley and Szafraneic 2009). It also been noted that academic work within Australia on urban agglomeration of Australian cities is still very much in its infancy (Trubka 2009, Rawnsley and Szafraneic 2009). This has meant that Australian cities have sprawled without awareness of the inefficiencies and economic costs associated with this spatial organisation (Trubka 2009). Trubka (2009) estimates agglomeration economies in Australian capital cities provide between a 3.5% and 7.4% increase in productivity when an area's employment density is doubled, which remains consistent with findings from international examples. Rawnsley and Szafraneic (2009) also note the link between size of the city and spatial organisation of the city and argue that labour productivity can be achieved by ensuring that agglomeration is maximised within the city's existing structure. In particular it could be affected by providing high density employment space building on existing employment hubs (outside the CBDs) which already experience high agglomeration. Rawnsley and Szafraneic (2009) argue that policies that support over supply of non manufacturing employment land outside the CBD which provide for low density development result in employment sprawling and missed agglomeration and productivity. Instead centres should be encouraged to build upwards as with CBD environments.

There also is an inherent relationship between transport and agglomeration (Eddington 2006, Graham, D 2005) including between spatially concentrated ICT and transport (Moriset 2003, Maeng and Nedovic-Budic 2010, Kane 2010). Maeng and Nedovic-Budic (2010) found that even with continued growth suburbanisation and urban sprawling around Washington DC ICT firms were locating where there was better accessibility, better ICT infrastructure, and higher density. The spatial concentration of any firm is dependent on the nature of transport provision with transportation costs crucial to generating spatial concentration. This is because it is transport that links workers into large city labour markets with their spatially concentrated workplaces (Prud'homme and Lee 1999). Transport infrastructure that leads to urban dispersment will lessen labour and overall economic productivity, whilst transport that provides density (ie public transport and particularly rail) will ultimately deliver agglomeration and

labour productivity (Rawnsley and Szafraneic 2009, Spiller 2012). Congestion in highly urbanised locations diminishes returns to agglomeration in industries with congestion favouring a more dispersed economic geography (Brulhart and Sbergami 2009, Accetturo 2010). However as Prud'homme and Lee (1999) note congestion is not so much an indication of city size but the lack of good city management and transport investment. This is supported by Eddington (2006) and Graham (2005) who argue that the economic benefits of agglomeration can be demonstrated as wider economic benefits of transport investment beyond the benefits accounted for in standard cost benefit appraisals (Graham, 2005). Fujita and Thisse (2002) argue that agglomeration happens provided that transport costs are below some critical threshold. The type of transport investment however could be critical in that it may be logical to argue that more knowledge intensive industries that benefit from densification and agglomeration would also benefit from transports infrastructure that has the greatest impact on intensifying human activity (ie public transport) whereas industries that benefit from disaggregated urban forms would correspondingly benefit from road transport investment. One way this can expressed is by looking at the carrying capacity of rail versus freeway infrastructure. For example the proposed underground Cross Rail project in Brisbane is expected to carry 120,000 in and out of the city during the morning peak; the rail lines two proposed tunnel bored rail tunnels being equivalent to 30 lanes of a motorway (Bligh 2010).

Intensification of human capital

It can be argued that what distinguishes the new knowledge economy is it links with intensification of human knowledge capital through increased education and skill levels. The changes in information technologies as a result are making educated and skilled labour more valuable and unskilled labour less so – effectively labour is becoming more knowledge intense (Fuente and Ciccone 2002, Castells 2005, Smith 2000, Scleicher 2006). Castells (2005) has argued that societies in transition to the new economy find greater divisions between those who use and those who do not use technologies such as the Internet. Utilization of new technologies becomes more of a question of the generation to which one belongs: the younger the generation and higher the education level, the greater the use. Changes in technology, and particularly the advent of information technologies, are making educated and skilled labour more valuable, and unskilled labour less so (Scleicher 2006).

The change in the economic nature of Australia's economy in the last few decades has seen an increasing proportion of workers with qualifications. Shah and Burke (2006) note that the number of people employed in Australia increased by 19.7 per cent from 1995 to 2005, however the number with qualifications increased by 44.7 per cent. The reasons for this was skill deepening, more so than new employment growth (Shah and Burke 2006), with skills deepening being the increase in the proportion of people with qualifications over and above that due to employment growth. Shah and Burke's analysis is supported by a broader analysis of the knowledge intensification of occupations within Australian labour market over the last three and a half decades (Sheehan and Esposito 2001, Esposito 2010, Esposito and Abbott 2011). Esposito and Abbott's (2011) analysis while incorporating measures of formal education, used measures of skill and knowledge that have been developed to incorporate a far broader concept of the acquisitions of skills/knowledge. The increase in knowledge and skill of

the workforce has not just involved the acquisition of formal qualifications; indeed, a great deal of knowledge and skill has also been acquired in the workplace.. The proportion of the labour force that was formally qualified rose from around one quarter in 1970/1971 to around two-thirds by 2007/2008. The growth in the number of higher education graduates over the period has been particularly strong. Using graduate numbers to reflect growth in human capital and knowledge intensity appears to show a very substantial increase.

Intensification of knowledge workers within cities

Knowledge workers are, especially noting arguments made by Smith (2000), not exclusively limited to particular industries or employers. However the spatial distribution of knowledge workers within cities is spatially concentrated. Florida (2002a, 20002b, 2002c, 2004), Lorenzen and Andersen (2009) and Boschma and Fritsch (2009) have looked at the spatial distribution of knowledge industry or creative workers across regions. Florida (2002a, 20002b, 2003) is noted for his arguments that a globalised economy in which innovation constitutes competitive advantage. This means creative workers are important for competitive advantage and growth because they are technically, socially, and or artistically creative on the job. According to Boschma and Fritsch (2009) Florida's argument are supported by European research that indicates the creative classes are not evenly distributed across space: not every city or region is equally well endowed with members of the creative class. Similarly Lorenzen and Andersen (2009) found strong empirical evidence that creative workers, similar to Florida's US findings, were unevenly distributed across Europe. While much of the focus of Florida's earlier work (2002a, 20002b, 2002c, 2004), has focused on regional development strategies, later work with others has stressed the importance of knowledge spillover through higher density of creative workers. Knudsen, Florida, Gates and Stolarick (2007) looked the role of (occupational) density and creativity on urban innovation. They hypothesised that high densities of creative individuals promotes and facilitate face to face interactions creating knowledge spillover and innovations. Using the joint and separate effects of population density and creativity on innovation for 240 metropolitan areas in the US it was found that creativity-density was positively and significantly linked to patents. In particular Knudsen et al (2007) concluded that proximity and intellectual human capital work together to power innovation, and as they put it:

It is the geographic concentration of people with expertise, knowledge that powers the exchange and spillover that precede innovation.

Effectively the research supports the premise that both intellectual and spatial intensification of knowledge in the form of creative workers creates spillover and agglomeration benefits. Studies in Australia support the conclusion that knowledge workers are concentrated in cities and in particular urban areas of cities. Hu (2010) using Location Quotient (LQ) analysis measured the employment concentration in Central Sydney in relation to Metropolitan Sydney over the period 1996-2006.³ The findings were that Central Sydney tended to be more and more concentrated on few numbers of industries. The research showed knowledge-based economy concentrating

³ LQ analysis is widely used to identify the concentration of an industrial sector in a local economy relative to a larger reference economy.

in Central Sydney in two broad categories of industry subdivisions: commercial services; cultural and media services. This was despite a decreasing dependence on the central city as a focus of employment other than those employed in the business, finance and information service sector (Forrest 1996). In Melbourne analysis by Johnson (2010) conclusively demonstrates the particular different spatial characteristics of knowledge workers within the Melbourne metropolitan area. Johnson (2010) found that there were distinctive patterns to the relationships between jobs and place of residence for knowledge economy residences in clusters around the Melbourne metropolitan area. Combined these clusters accounted for around 34% of all jobs in the metropolitan area; over two thirds of all Knowledge Economy jobs. All contained in around 2% of the total land area of the Melbourne Statistical Region. Johnson (2010) found that knowledge workers tended to live in and around the central city, more so than there were knowledge economy jobs. Preference for knowledge workers to live in and around the central city was seen as being a driver for inner city clustering of jobs (Johnson 2010), though arguably it could be argued that it was the agglomeration benefits that accrued to BOTH inner city jobs and inner city residents as per Knudsen et al (2007) in that inner city workplaces and residences facilitated face to face interactions creating knowledge spillover and increased human capital.

Intensification of ICT within cities

The evidence of a positive contribution of ICT to the productivity of workers, establishments, and industries is well established (Fuente and Ciccone 2002, Echeverri-Carroll et al 2007). Fuente and Ciccone (2002) in reviewing the literature on the economic return from human capital investment contended that the wider benefit or spillover from increased knowledge and skills through education is because of their complementarity with technology. Studies worldwide of ICT and other high technology industries confirm the strong tendencies to cluster or agglomerate with like industries (Giovannetti, Neuhoff and Spagnolo 2005, Strange et al 2006, Maeng and Nedovic-Budic 2010). The connection between ICT and spatially concentrated knowledge workers suggest that there is likely to be a spatial concentration with ICT infrastructure. Research into internet infrastructure supports the contention that ICT has a strong spatial context.

The concentration of firms means that not surprisingly data flows and infrastructure are also concentrated. Research (by Gorman et al 2003, Gorman and Malecki 2000) from the turn of the century on the internet shows that in the USA the internet backbone network traffic disproportionately agglomerates in the largest metropolitan areas. The result is a ICT spatial hierarchy of the United States with the coasts being more connected to each other than they are to the interior of the country – the coasts are the core and the interior is the periphery (Gorman and Malecki 2000). Gorman and Kulkarni (2004) have argued that while information networks allow direct global connections between distant places at speeds and volumes not possible before, geography and distance are still important factors particularly with the location of super connected nodes having important economic, business and security implications. This uneven spatial distribution of the knowledge economy has effectively seen an uneven distribution of ICT. The modern knowledge economy as it is enabled by ICT is dependent on the physical fibre optic and other hardware such as data centres, servers, bridges and hubs, routers, personal computers, all of which have a physical location

and structure (Gorman and Kulkarni 2004). The physical reality is that telecommunications networks consist of large and complex series of hardware (Gorman et al 2003). The physical elements of the internet the paper will consider are fibre optic networks, data centres, and internet exchanges. The physical long haul fibre enters cities and most often surfaces at a co-location facility, network access points or a metropolitan area network or internet exchange (Gorman and Kulkarni (2004). Access to newer communication technologies has characterised a hierarchical diffusion pattern: starting first in large cities, where the largest markets are found, and then subsequently to smaller places (Gorman et al 2003, Malecki 1999), though not always to regional areas in Australia (ACMA 2008 and IE Aust 2010(1) and (2)). This ensures early starter advantage in a competitive economic environment. The economics of rolling out fixed network infrastructure to Australia's regional areas (prior to the start of the rollout of the fibre optic National Broadband Network NBN⁴) was influenced by demand characteristics and the distances involved (ACMA 2008, IEAust 2010(1)). This meant infrastructure costs were generally significantly more expensive than comparable network infrastructure in Australia's major capital cities. The internet is in this sense not removed from previous layers of communication technologies and their spatial characteristics. Even with the roll out of the NBN key internet exchanges, tier 1 fibre internet backbones, and private fibre optic networks will ensure a CBD ICT advantage.

⁴ NBN's intention is to connect 93% of homes, schools and workplaces with optical fibre (fibre to the premises or "FTTP"), providing superfast broadband services to Australians in urban and regional towns. The remaining 7% will be connected to next generation fixed wireless and satellite, subject to final design. <http://www.nbnco.com.au/about-us/our-purpose.html?icid=pub:about::men:our-purp>

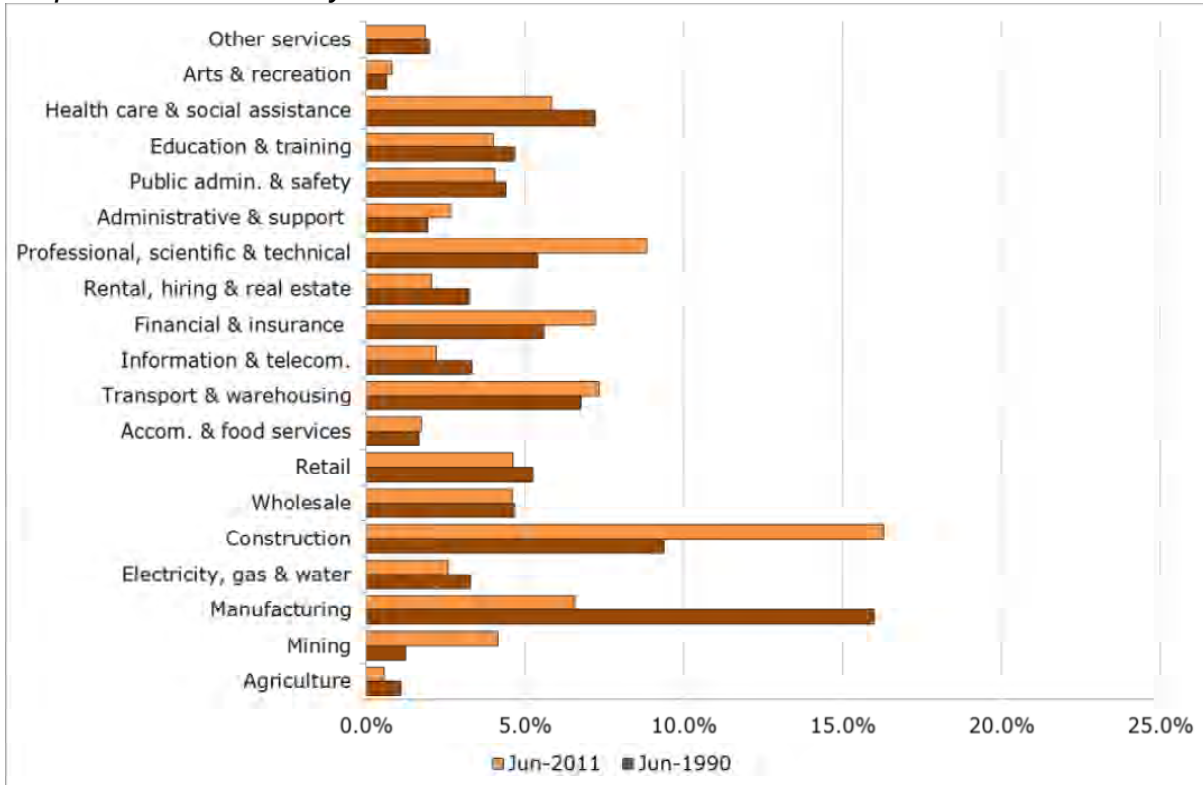
Part 5 - Where is Perth's knowledge economy? An analysis of the knowledge economy, human capital and ICT intensification in Perth

Intensification of knowledge economic activity in Perth

Perth's employment is concentrated in the inner and middle suburbs, while population is concentrated in the outer suburbs. The outer regions of the Perth metropolitan area have 51 per cent of employed residents, but only 30 per cent of jobs (Major Cities Unit 2010). An examination of Perth's employment spatial distribution using education and occupation profiles again demonstrates the relatively higher concentration of high-skilled 'knowledge workers' in professional and intermediate clerical occupations who work in the Perth CBD and immediate surrounds compared to the capital city CBDs (ABS 2006, DEEWR 2006). Perth's professional workforce is also heavily focused on servicing the commodities goods based mining sector with estimates of 40% of people in the professional, scientific and technical services industry engaged in mining related or support activities (ABS 2008). In this sense Perth and in particular the CBD acts as the knowledge economy centre for the Western Australian mining and resource sector.

An examination of economic activity within the last decade strongly supports an increased intensification of knowledge economy activity within central Perth. There has been considerable GDP growth in Perth in this period driven by the mining and resources sector particularly with professional, property, financial and insurance services – see Graph 1 (SGS 2011, Department of Planning 2009). What is notable about this growth has been the strength of knowledge intensive industries that are known to be advantaged by agglomeration. The financial and insurance service industry is now a larger part of the Perth economy than manufacturing. The other growth industry sectors have been mining and particularly construction however SGS (2010) have noted caution with construction with the large fly in fly out workforces leaving Perth for work in regional mining and resources construction projects.

Graph 1 - Perth Industry Structure ⁵

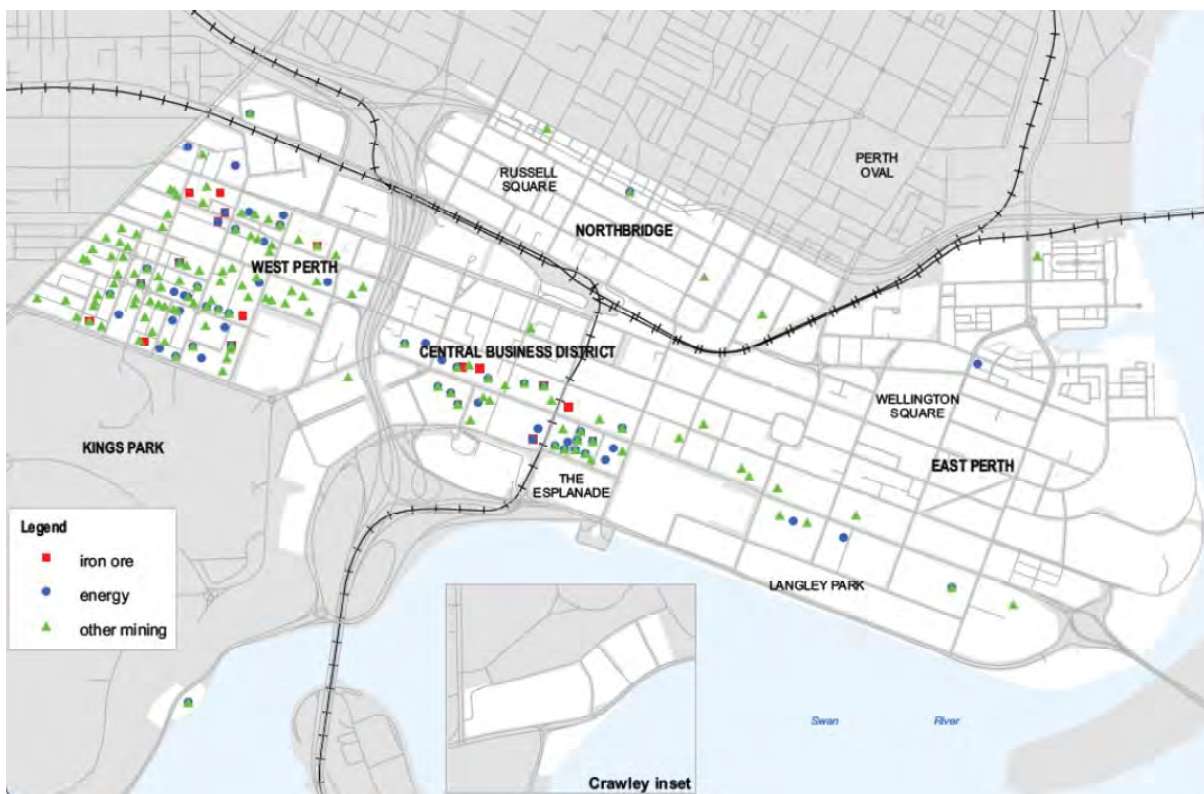


Source: SGS Economics and Planning 2011

The growth in knowledge services has been particularly strong in the CBD and has driven a huge demand for commercial office space (Department of Planning et al 2009, Property Council 2012). This has been accompanied by a considerable growth in office/business land use, implying a further shift towards a knowledge based economy (Department of Planning et al 2009). The number of persons employed in the CBD declined in the early 1990s but since has steadily increased (Department of Planning et al 2009). Employment in the surrounding areas of West Perth, Northbridge and East Perth within commercial offices has also increased considerably. Within the CBD and surrounding areas there are noticeable industry clusters particularly in the mining (see Map 3) and resources, medical, legal and fashion industries. This strongly suggests knowledge spillover and tacit knowledge exchange. Computing and information services were not notably clustered within the CBD however as will be noted later in this paper internet exchange dependent organisations at a Perth metropolitan scale are notably clustered in and around the CBD.

⁵ As measured by industry gross value added share of total industry value added (excluding Ownership of dwellings).

Map 3 - Mining and resource establishments in central Perth



Source Department of Planning, WAPC and City of Perth 2009

A major shift within the CBD and surrounding areas has been the increase in knowledge rich creative industries and professions. For a resource focused city not surprisingly engineering and computing services have the most establishments and employees within the creative and professional industries. Notably increases in employment are identifiable within engineering services, and from a lower base, computing communication services and internet related businesses (Department of Planning 2009) (A part of this industry is further explored with a study of the spatial location of participants in the WA Internet Exchange WAIX later in this paper). Computing services generally however saw a reduction in employment numbers. Another notable change within the CBD from 1990 was the increase in small business establishments particularly since 2001 (Department of Planning et al 2009). The CBD and inner city business areas are developing into multi-purpose mixed use hubs of commercial, economic and social activity, with increases in drinking and dining establishments (Department of Planning 2009). This is consistent with the increased role of the city centre as the location for agglomerative tacit knowledge spillover activity. Outside the CBD and its surrounding inner city areas (West Perth, Northbridge and East Perth) suburban office precincts are generally notably smaller in floorspace with much higher vacancies and much lower rents. To a degree the exceptions to this are Subiaco and Herdsman on the periphery of the inner city (Property Council 2012).

The increasing intensification of the knowledge economy in central Perth has been accompanied by a transport reconfiguration over a three decade period. The likelihood of workers using public transport in Perth is related to employment density (Martinovich

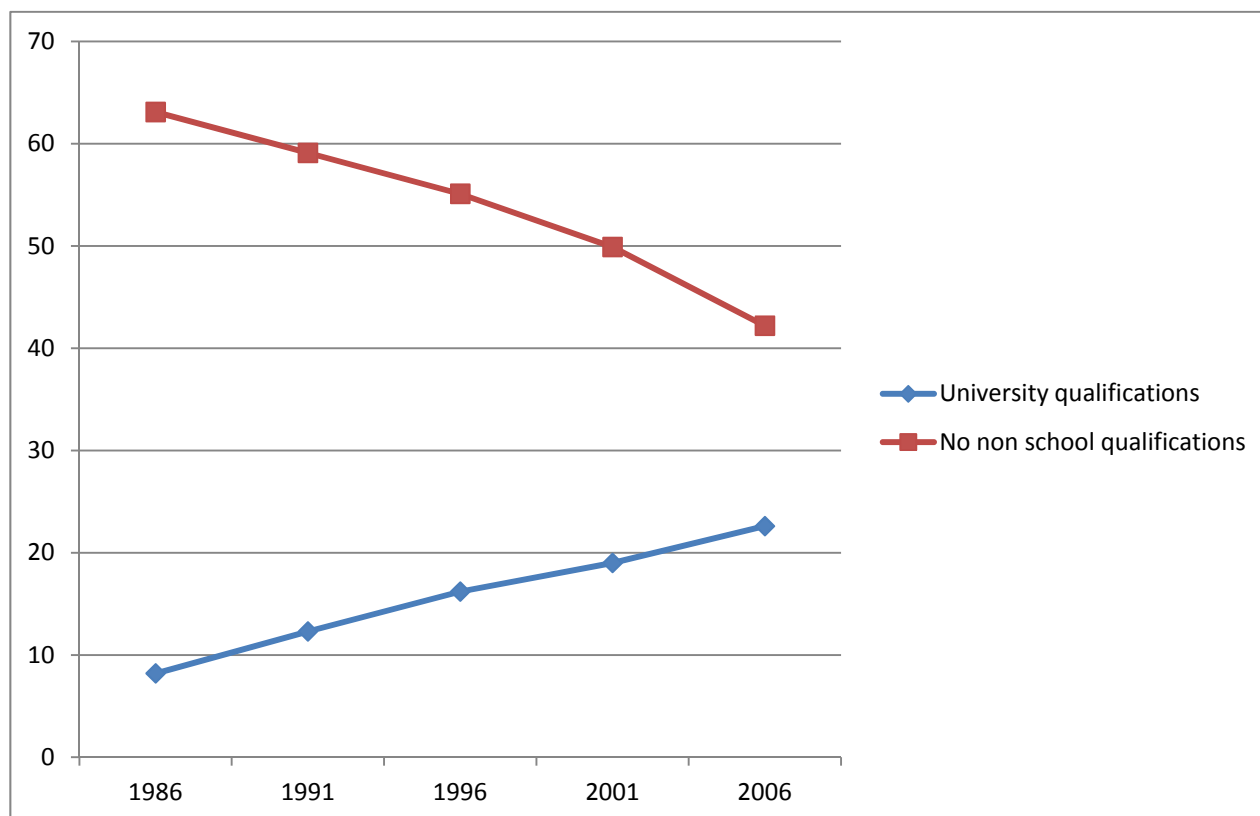
2008), with the Perth CBD being the main destination focus of public transport system. In 2006 (relatively) high concentrations of people who travelled to work by public transport were found (ABS 2006) were those suburbs with easy access to rail, bus or ferry transport, and in areas near the city centre, along the, major arterial roads and railway lines out of the city. The transformation of the CBD in particular has followed a number of state government actions (Muhammad, Low and Glover 2006) supporting high capacity rail over the period since the 1980's with the Fremantle to Perth line reopening in 1983, the establishing of the Perth Parking Policy (limiting parking within the city and subsidising free public transport within the CBD on all buses and trains), the opening of the Joondalup rail line in 1991, and the opening of the Perth to Mandurah rail line in 2007. This facilitated a downgrading of the CBD freeway feeder road network (and the reversal of one way road systems within the CBD). The return of two way streets has been accompanied by strategies to increase and support pedestrian movement and activation within the CBD (City of Perth 2010, Gehl 2009, Department of Planning et al 2009).

Trubka (2009) in one of the first analysis of agglomeration in Australian cities found that outside the Perth CBD agglomeration benefits were low and there was little relationship to urban density. It was contemplated that this may be that the SLAs of Perth may not have industries that are most impacted by agglomeration economies. Trubka (2009) proposed that automobile dependent cities take on a somewhat polycentric economic formation where most of the high quality employment resides in the CBD. The surrounding centres, because of poor planning for economic development and the tendency to sprawl, means the benefits of densification may be lost. Arguably the metropolitan planning policies for Perth focusing on a dispersed number of retail focused metropolitan regional centres are flawed. Arguments over the role of centres anchored by shopping centres, while important for the economic efficiency and sustainability of Australian cities, do not address how Australian cities are going to successfully compete in the knowledge economy in the future digital age. The corporate shopping centres in outer Melbourne, according to Goodman (2005), by their nature both economically and culturally, provided the blandest representation of a monoculture and add very little to sense of place. It would be difficult to assume shopping centres in Perth would be any different.

Intensification of human capital and knowledge within Perth Western Australia

The human knowledge in the Perth labour market has been intensifying consistently since the 1980s and this can be seen by examining the two ends of the labour market; university qualified members of the workforce and those with out post school qualifications. The 2006 Census, found that 42.2% of the total labour force for Perth-Mandurah labour force as having no non-school qualifications, down from 63.1% in 1987 and while university qualifications rose from 8.2% in 1986 to 22.6% in 2006 (See Graph 2) .

Graph 2 - Knowledge intensification of Perth – per centage of labour force with university qualification versus no non school qualifications (ABS Perth Social Atlas 2006, 2001, 1996, 1991, 1986 Census)



Graph 2 demonstrates that the knowledge intensification is happening at both the low and high knowledge end of the Perth labour market. In Perth, educational attainment is closely related to the level of access to jobs. The proportion of people with no post-school qualifications is comparatively low in areas with good access to jobs (Major Cities Unit 2010). The census data demonstrates the spatial separation of education and wealth by inner and outer suburbs (ABS 2006). People with university qualifications have traditionally been concentrated in the western suburbs of Perth, with some areas having more than 50% of the labour having university qualifications and this has not changed since 1996 (ABS 1996, 2006, ABS 2001). These areas also had high proportions of high income households and dwellings with broadband Internet access. Outlying suburbs to the north and south of Perth city, as well as suburbs in the Rockingham-Mandurah region, had low proportions of the labour force with university qualifications (ABS 1986 and 2006).

While the high socio-economic western suburban councils have always had high levels of professional and managerial workers and educational attainment levels Perth has been seeing an intensification of knowledge economy workers within the inner ring suburbs. This is reinforcing the role of the CBD as the knowledge economy centre of

Perth. For LGAs of Subiaco and Vincent the turnaround in population decline to growth was around the early 1980s when the decline in manufacturing and industrial activity began to be replaced with service sector employment (State Planning Commission 1988). Subiaco and Vincent now have highest urban densities in Perth (2,700 person pr km) with a corresponding change to relatively high percentages of professional and managerial workers (ABS 2006, Data Analysis Australia 2008). From 1996 onwards the intensification has been most noticeable in the inner and middle ring LGAs such as Belmont, Victoria Park, City of Stirling and Fremantle (see Table 1).

Table 1 Time series percentage of professional and managerial occupation by selected LGA residential location

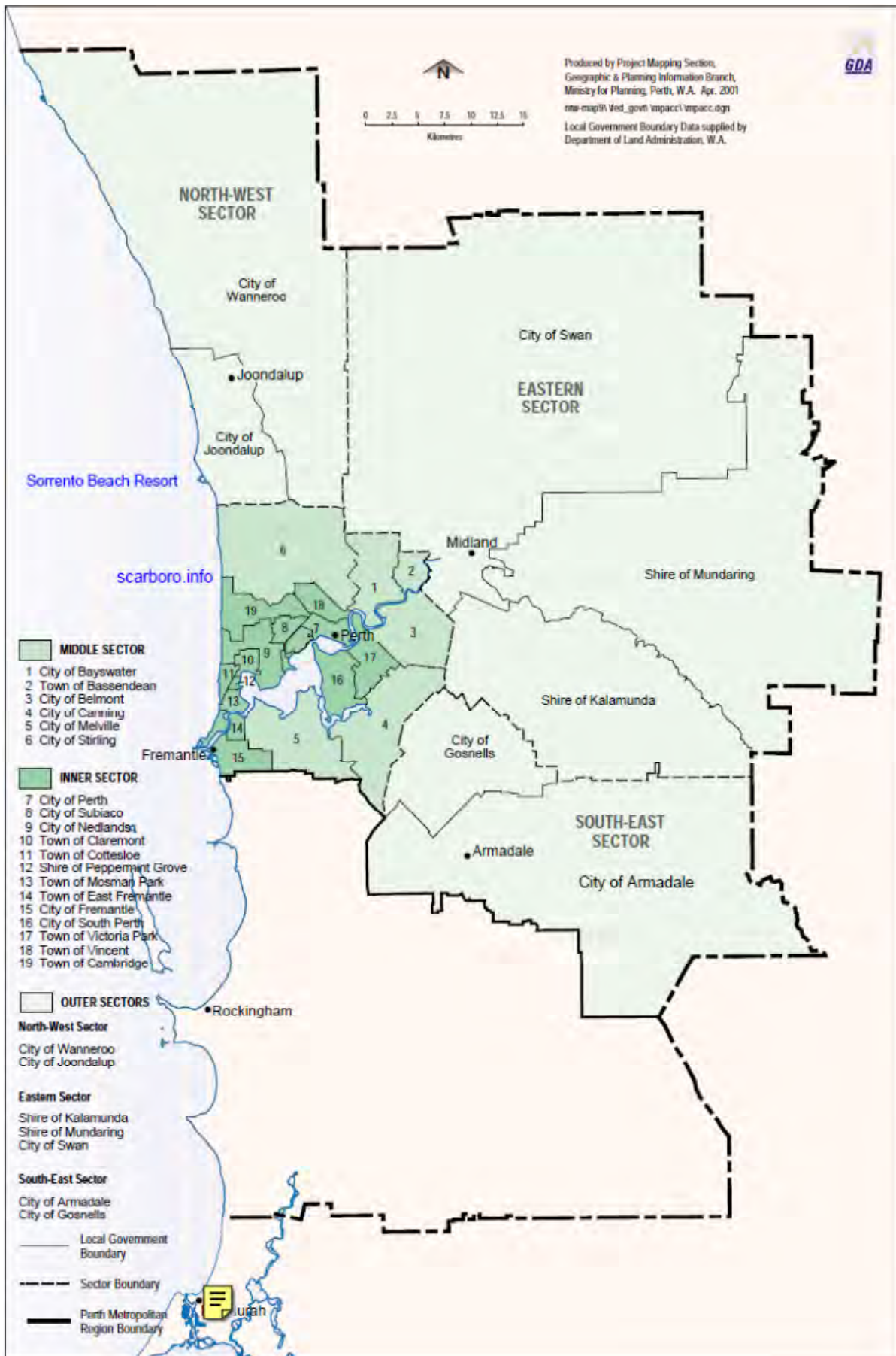
	Victoria Park	Stirling	Belmont	Fremantle	Joondalup	South West Group	Canning	WESROC	East Metro	Perth metro
1996	26.9	26.5	15.1	32.7	24.2	24.7	24.3	50.3	20.7	25.2
2001	29.7	28.2	17.6	35.8	24.7	25.5	24.9	51.5	21.2	25.9
2006	32.9	30.9	20.8	39.4	26.4	26.2	26.2	52	22.3	28.1
% Increase	6	4.4	5.7	6.7	2.2	1.5	1.9	2.7	1.5	2.9

Increase

Source: ABS 1996, 2001, 2006, Profile id <http://home.id.com.au/index.php?nodeId=45>

What is particularly notable is that regardless of their LGA ranking by percentage of residents in professionals and managers occupations, Belmont, Victoria Park, City of Stirling and Fremantle; all are growing faster in terms of increases in professional and managerial occupations than the Perth metro average; faster than the lower ranked outer suburbs (represented by Joondalup, South West group, East metro and Canning); and faster than the higher ranked WESROC (western suburb councils) who have traditionally always had high levels of residences in professional and managerial occupations. What marks the Belmont, Victoria Park, City of Stirling and Fremantle LGAs is their closeness or access to the city centre (see Map 2). What this is evidence of is the knowledge intensification of human capital since the mid 1990s being spatially concentrated in those suburbs most connected to the CBD.

Map 4 - Local Government Areas (LGAs) of the Perth metropolitan area



Intensification of ICT and Internet infrastructure in Perth

An examination of ICT infrastructure in Perth supports the argument that the location of ICT infrastructure is heavily influenced by past economic and technological infrastructure patterns. Institution of Engineers Australia (IE Aust) WA Infrastructure Report Card (IE Aust 2010(2)) on ICT has identified the internet infrastructure characteristics for Western Australia. The existing dominant infrastructure, the public switched telephone network while of a good standard for telephony has major limitations in providing data services with significant broadband blackspots in metropolitan Perth, and very limited availability in non-metropolitan areas. Since 2007 IE Aust (2010(2)) indicates there has been a decline in telecommunication quality due to increased congestion. The IE Aust Report further highlights the urban nodal nature of broadband backhaul infrastructure in Australia with backhaul providing the connection of “telecommunication aggregation points to major nodes in capital cities or regional centres” and providing “high capacity links between capital cities, or from regional centres to capital cities. Backhaul refers to the long distance optical fibre and microwave transmission networks that connect local exchanges, main internet exchanges or main Points of Presence (POPs) and ultimately end users.

In this period pre NBN, Telstra and Optus operate a substantial backhaul transmission networks with a range of other providers, including Nextgen, PIPE Networks, Powertel, Silk Telecom and Soul (IE Aust 2010(2)). While some routes are served by three or more operators, the majority are served by Telstra alone (ACMA 2008). There are four interstate backhaul fibre cables connecting WA to the rest of Australia – two owned by Telstra, and one each by Optus and NextGen (Leighton Contractors), all following the interstate rail to Perth (IE Aust 2010(1) and (2), Govt of WA 2008). All of these backhaul terminate in Perth with only the NextGen cable having an access point outside of Perth (in Kalgoorlie). Within the Perth the CBD dominates with a number of companies offering CBD fibre optic backhaul capacity in a competitive environment (IE Aust 2010). Some companies – Silk (Bright), Amcom and Telstra - have fibre rings or tails into key urban areas and thus competition exists in these areas (Govt of WA 2008). Some of the outer metropolitan areas rely on the less effective microwave backhaul due to affordability issues with areas on major infrastructure corridors (along transport and energy corridors) being serviced by fibre (IE Aust 2010(2) Govt of WA 2008). Regional WA backhaul is dominated by the Telstra monopoly with cost constraints limiting investment (IE Aust 2010(2)).

In terms of internet exchange points (being the key physical infrastructure for the exchange by autonomous networks of internet activity) there are three internet exchanges within WA, all three based in Perth CBD. The Perth internet exchanges include the cooperative WA Internet Exchange (WAIX), operated by the Western Australian Internet Association Inc which backhaul transmission networks Nextgen, PIPE, Silk, Soul and Optus connect into. The Telstra internet exchanges are also in the CBD; in Wellington Street 600 metres from the Perth Internet Exchange and Pier Street, 1 km further east (Telstra Wholesale 2011). The CBD location of the internet exchanges in Perth demonstrates that little has changed over the last few centuries. From the 19th century (and the first telegraph exchanges in Perth) to the 21st century the exchange centres of digital communication have remained within a kilometre radius. This supports

the contention that despite the technological leaps forward, ICT has been developed on the spatial 'bones' of older technology.

Spatial distribution of WA Internet Exchange (WAIX) companies in Perth

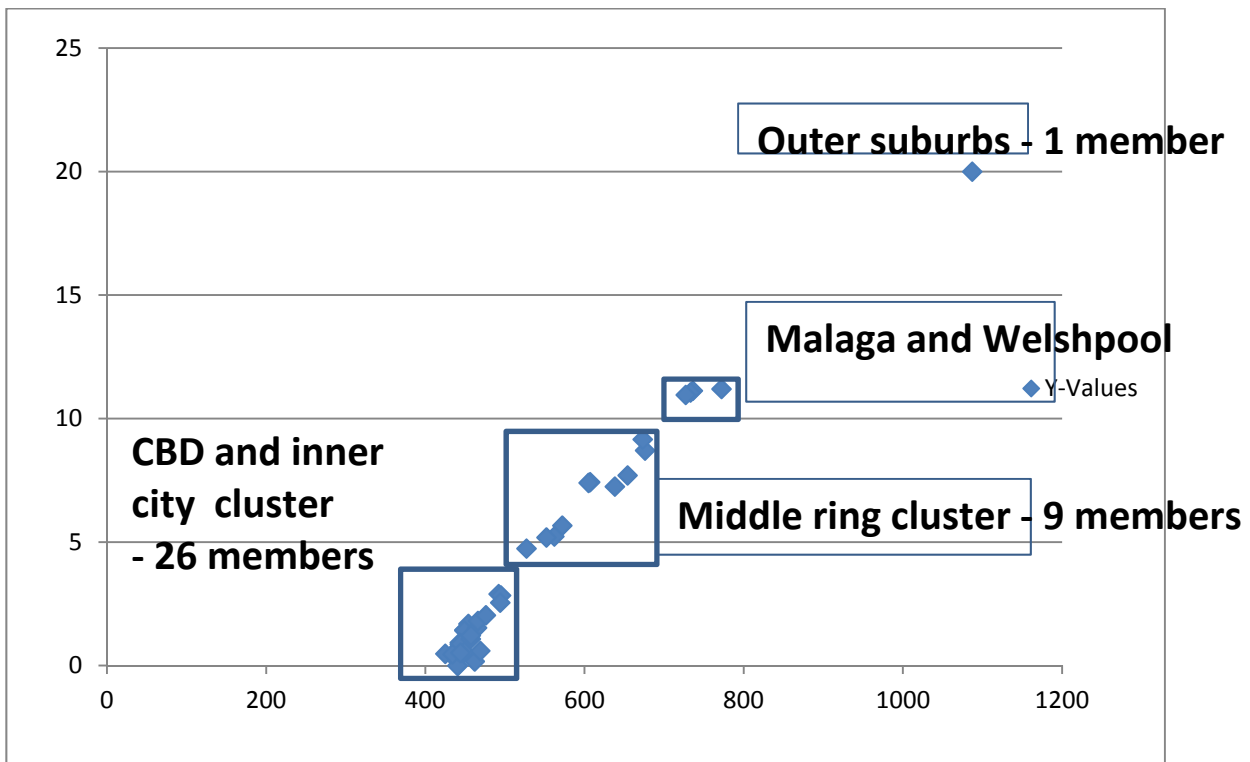
An examination of participants (see Appendix A) in the WAIX as operated by the Western Australian Internet Association (Inc.) (WAIA 2011) and the spatial location of participants and their spatial proximity to other participants in the WAIX allows a consideration of the extent of clustering in new internet dependent companies Perth. The majority of the WAIX participants are within the information media and telecommunications industry, the smallest employing industry in the state and in this sense WAIX participant are not indicative of companies within the Western Australian economy generally. However they are more likely to be ICT and internet dependent companies by nature and therefore should demonstrate whether the internet is likely to cluster or disperse economic activity⁶. The WAIA is an incorporated organisation that was formed in 1995 to represent the Internet community in Western Australia. The WAIA started in 1997 as an industry association for internet based companies and organisations to allow members the ability to inter-connect using an independent internet exchange facility (WAIA 2011). The internet exchange facility allows members to multi-laterally peer their networks at a considerably reduced rate (WAIA 2011). The WAIA operates under a Code of Conduct which provides for a degree of industry self regulation (WAIA 2011).

As Graph 3 demonstrates WAIX members have strong clustering characteristics.⁷

⁶Division J of ANZSIC - in 2009-10 the WA information media and telecommunications industry employed 14,000 persons or 1.2 per cent of the WA workforce (DTWD 2010).

⁷ The list of WAIX participants (and links to their websites and locations) was obtained from the WAIA website in November 2010. Participants' spatial locations were mapped by using street addresses with Google Earth. The relative proximity of participants to each other the actual direct distance between each participant was recorded using Google earth distance calculator. This was then averaged against total number of participants. For graph X the distance of each participant to the WAIX was plotted against the vertical axis and the average relative proximity of participants to each other was plotted against the horizontal axis.

Graph 3 Participants average distances to WAIX and other members – the vertical axis is the distance from the internet exchange, while horizontal axis is the average distance from each of the other WAIX members, (this average distance being a proxy for relative potential physical interactivity with other WAIX members).



Graph 3 of WAIX participants has the hallmarks of a small world graph characterised by strong spatial bias with significant clustering at the local level with local clustering forming “small words” (Gorman and Kulkarni 2004). Various nodes or clusters are apparent in graph y: a Perth CBD and inner city cluster with 26 members, a middle ring Perth suburban with 9 members, four members immediately beyond the ring roads of Leach and Reid Highways, and 1 outer suburbs member. While there are two regional WA members (one each in Bunbury and Kalgoorlie) this is exceeded by clusters in Sydney (11 members) and to lesser extent Melbourne (3 members), with one member each in Adelaide and Brisbane. Internationally there are four members in the USA (exceeding regional WA) and a single member in the UK (Bath) and one and only member in a non English speaking nation – in Gothenburg, Sweden.

The greater concentration of participants outside Perth being in Sydney (11) and Melbourne (3) and across major cities in the north east and west of the USA (5) rather than regional Western Australia (2) is consistent with literature that sees city to city digital city networking (Devriendt et al 2008) with urban concentration at the international ‘technopoles’ of growth (Banister and Hickman 2006). It is also consistent with the knowledge economy agglomerating in particular regions and in particular parts of cities, usually the city core (Burger et al., 2009; SGS, 2008; Spiller, 2003, 2005). This analysis does not answer what the key drivers were for the locational decisions of WAIX internet exchange participants in terms of whether or not locational decisions were determined by infrastructure or by other economic locational issues (closeness to labour, suppliers, clients other industry players). What is clear from the literature and

what would appear to be evidenced by this spatial study is that the combination of ICT infrastructure, and central location for closeness to labour, suppliers, clients other industry players strongly favour a CBD and surrounds. It is also evidence that knowledge economy ICT dependent industries are unlikely to be dispersed into low density suburbia in a city such as Perth that is inherently sprawling.

Conclusion

This paper has found strong evidence that knowledge economy activity, human knowledge capital and ICT infrastructure in Perth is characterised, and increasingly so, by urban concentration and intensification. The development of ICT infrastructure and internet technology has been shown not to be removed from the advantages of proximity, economic agglomeration and from the traditional economic, social and political inequities. The dispersment of economic activity driven by the motor vehicle prior to the turn of the 21st century is now being countered by agglomeration of knowledge economic activity supported by ICT internet infrastructure. The CBD of Perth has been undergoing a renaissance supported by series of state and city councils. Perth CBD has and is addressing the requirements for a successful agglomerative knowledge economy with the focus on high capacity rail public transport at the expense of road based private transport, access to fibre optic networks including tier I backbone networks and internet exchanges, and the addressing of urban amenity necessary for tacit knowledge spillover. Bertaud (2002) has argued that classing cities as purely non-centric or poly-centric can be misleading as most cities operate in a mixed mode with a city is mono centric or poly-centric by degree only. In this sense in terms the knowledge economy and high quality employment Perth can be described as mono-centric. However outside the central city and shoulder, there are dispersed employment patterns characterised by economically vulnerable and disconnected outer suburbs.

The question could be put - where is the knowledge economy most likely to grow naturally strong in Australian cities? Should it be focused in and around the city centres and around knowledge rich activity centres such universities or health precincts? Alternatively can it be dispersed around a larger number of activity centres including those underpinned by large regional metropolitan shopping centres as per the metropolitan regional plans? While strong arguments can be made to recreate activity centres anchored by retail into mixed use centres, these types of centres will be limited by their origins. In this sense shopping centres do not provide environments for innovation or development of the knowledge economy. The underpinning thinking behind Directions 2031 and its predecessor plan, Network City, was focused on increasing the role of activity centres dispersed across the metropolitan area with an intention of reducing the transport task of the city. However this prioritising of strategic centres is to deny the opportunity for most fertile places for agglomeration and the growth in the knowledge economy within a regional city dominated by a mono centric centre. In many ways the lack of research and understanding of urban agglomeration is negatively impacting on Australia's metropolitan regional planning.

The conclusion from this paper is regardless of planning policies the knowledge economy will grow in areas of cities that are capable of agglomeration and of attracting the knowledge intensification of human capital, ICT and economic activity. The urban designs and the transport infrastructure that facilitates density and knowledge intensification and spillover are crucial to the successful redevelopment of any activity

centre. Transport infrastructure (freeways) that leads to urban dispersement will lessen agglomeration and therefore knowledge economic productivity, whilst transport that provides density (ie public transport and particularly rail) will ultimately deliver agglomeration and knowledge labour productivity. The role of private vehicle, so dominant in Australia and North America, has limitations as a mover of human knowledge in urban settings, particularly into denser urban centres. The limitations of the capacity of the private vehicle as against public transport (in terms of road space limiting urban amenity and tacit knowledge exchange, parking space requirements and limited carrying capacity) are well understood. Public transport is a means of intensifying human knowledge and knowledge economic activity within centres. While modern ICT, with the shift from copper to optic fibre, intensifies codified and virtual tacit knowledge; public transport intensifies human carried knowledge through displacing low volume private vehicle travel with high capacity public transport. Public transport has traditionally been planned in response to urban growth, to connect areas of sprawl to the city centre. However it is argued that public transport needs to also be seen as a catalyst for economic agglomeration transformation of centres outside of the CBDs through facilitation of knowledge intensification.

Appendix A WAIX participants as per WAIA website September 2010

Member Name	Location	Web address
HostAway Pty Ltd	Unit 1, 8 Midas Road Malaga WA 6090	www.hostaway.net.au
AAPT		http://aapt.com.au
AARnet	AARNet Pty Ltd POD 3 20 Dick Perry Avenue Kensington WA 6151	Aarnet.edu.au
Accord Crox acquired by Hostech t/a anitel 2010	3/75 Erindale Rd Balcatta WA 6914	accord.com.au
Amcom Pty Ltd	Level 2 44 St Georges terrace Perth WA 6000	amcom.com.au
Australian Nursing Federation	260 Pier St Perth WA 6000	anfiuwp.org.au
AS112 Servers	WAIX Perth 6000	
AsiaNetcom Acquired by Pacnet 2008	Melbourne	
Bekkers IT	Suite 5. 884 Beaufort St Inglewood WA 6052	Bekkers.com.au
B.E.S./E-Wire	17 Millrose Drive Malaga WA 6090	e-wire.net.au
BG&E Pty Ltd	484 Murray Street Perth WA 6000	bgeeng.com
Bitgravity	Burlingame California USA	bitgravity.com
Brennan IT	Sydney Australia	brennanit.com.au
Silk Telecom	Suite 4B, 200 Wellington Street East Perth WA	Silk.com
BroadbandNet Pty Ltd	48 Fairbrother Street, Belmont WA 6104	bbnet.com.au
CacheFly	Chicago USA	cachefly.com
Central Data Systems	88 Havelock Street West Perth WA 6005	central-data.net
CipherTel	Unit 3, 9 Bourke Street Bunbury 6230	ciphertel.com
Commerce Australia	Level 2 8 Parliament Place West Perth 6005	ca.com.au
Community DNS	Bath UK	communitydns.eu
cynergic	Subiaco 6008	cynergic.net
DALnet	USA	
DC West	Level 1 234 Pier St Perth WA 6000	dcwest.net.au
DiversIT	28 John St, Northbridge WA 6003	diversit.com.au
eftel	QV1 250 St Georges terrace WA 6000	eftel.com.au
Emerge Technologies Pty Ltd	3/72 Brockman Street Kalgoorlie WA 6430	emerge.net.au

EON Technologies Acquired by Highway 1 July 2010	Level 5 Williams Street Perth 6000	eon.net.au
e-vision	Huntingdale Victoria Australia	e-vision.net.au
Fast.hit Web hosting	Level 3, 80 Barrack Street Perth WA 6000	fasthit.net.au
Foxgold Pty Ltd	Unit 5 88 Walters Drive Herdsman Lake WA 6017	foxgold.net.au
Global Dial	278 Stirling Highway Claremont 6010	globaldial.com
Highway 1	Level 5, 10 William St Perth 6000	highway1.com.au
Hutchinson	North Sydney, Australia	hutchinson.com.au
iinet	Level 1, 502 Hay Street Subiaco 6008	iinet.net.au
Intelligent IP	48 Fairbrother Street Belmont 6104	ipc.com.au
Internode	Adelaide SA	internet.on.net
i-root	Stockholm, Sweden	netnod.se
ITC Global	Level 3, 28 Kings Park Road, West Perth WA 6005	itcglobal.net.au
JDV Acquired by IWL Limited 2005, acquired by CBA 2007	Level 7, 141 St Georges Terrace, Perth 6000	jdvd.com
Nearmap	66 Kings Park Road West Perth 6005	nearmap.com
Nextgen	Level 2, 18-32 Parliament Place West Perth 6005	nextgennetworks.com.au
Ocean Broadband	Suite 7, 295 Rokeby Rd Subiaco 6008	oceanbroadband.net.au
Orion	Level 2, 231 Adelaide Terrace, Perth WA 6000	orionsat.com.au
Pacnet	Sydney, Australia, Hong Kong and Singapore	pacnet.com
Packet Clearing House	San Francisco	pch.net/contact/index.php
People Telecom Acquired by M2 Telecommunications in 2009	North Sydney (M2 -South Melbourne)	peopletelecom.com.au
PerthIX		Perthix.com
PIPE Network	Brisbane	Pipenetwork.net.au
PowerTel AAPT company	Sydney	powertel.com.au
iprimus	Melbourne	Iprimus.com.au
R-NAS	Bentley Technology Park Bentley 6102	r-group.com.au
ServiceNet	ServiceNet Department of Treasury Finance Cannington WA 6987	servicenet.wa.gov.au
Select Communications	Welshpool, WA 6106	selectcorp.com.au

Service Elements	45 Ventnor Ave West Perth 6005	selements.com.au
Soul	Sydney	soulaustralia.com.au
Symbio Networks	Surrey Hills	symbionetwork.cim
Syra	Adelaide Terrace Perth	Syra.com.au
TPGi	North Ryde NSW	tpg.com.au
Vivid Wireless	Sydney	vividwireless.com.au
Vocus	North Sydney	
West Australian Networks	Hillarys WA 6923	westnet.net.au
WAnet Acquired by inet	Inglewood 6052	wanet.com.au
Webinabox	Leederville 6903	webinabox.com.au
Westnet	Level 7 152 St Georges Terrace Perth 6000	www.westnet.com.au
Xenion Communications	Stirling 6021	xenion.com.au

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