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The role of the rail system in the Sydney journey to work – a geospatial analysis

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Abstract

This paper presents a baseline analysis of the relationship between Sydney's rail network, commuter belt journey to work travel patterns and Sydney's urban development from historic, current and future perspectives, and examines how the rail links mooted in the Metropolitan Transport Plan relate to planned development. It reports part of a program of urban planning research that will lead to an understanding of the physical and economic sustainability impact of deferral of public transport infrastructure investment in a growing metropolis. The analysis draws largely on the 2006 Census data and State Government data, using geospatial mapping. It examines patterns of urbanisation in relation to the development of the rail network and the present urban planning paradigm. The paper shows that the rail network continues to be a key factor in Sydney's development despite Sydney's car dependency, but that it is falling further behind as the metropolis grows. Examination of the Metropolitan Transport Plan rail proposals in this framework underlines the disconnect between Sydney's metropolitan growth, development of its transit infrastructure and the claim that its planning integrates the two.

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1. Introduction

Sydney is a city with a global profile and aspirations, but which is faced with the significant problem of accommodating population growth of nearly 40% over the next two and a half decades (NSW Department of Planning, 2010). Like many cities in North America and Australasia, it limited development of its rail transit system for over sixty years in the face of growing automobile use. The transit elements of its transport plans of the past four decades remain largely unimplemented. The current Metropolitan Transport Plan (NSW Transport and Infrastructure, 2010a) provides largely for road-building and for upgrades of the existing rail network and bus fleet. With one exception (the South West Rail Link) this plan defers major new investment in rail infrastructure expansion to the latter part of the plan period and beyond.

This paper examines the role played by the rail system in Sydney's development and trip patterns. It looks at this from historic, current and future perspectives, and examines how the rail links mooted in the Metropolitan Transport Plan relate to planned development. It presents a baseline analysis of the impact of Sydney's rail network on commuter belt journey to work travel patterns and on its urban form.

Following this *Introduction* the paper contains three sections and a *Conclusion*, as follows:

- Some relevant *Background*, notably the historic role of the rail system in Sydney's urbanisation and the essence of the current planning paradigm;
- The *Journey to Work*, which presents a broad outline of the employment characteristics of the Sydney commuter belt at the time of the 2006 Census and examines the work journeys to the major centres; and
- The *Role of the Railway*, which examines how the rail network serves this and how the proposed expansions of the network relate to the growth centre land use plans.

Transit systems play important accessibility roles for a variety of trip purposes. However, the journey to work, along with education journeys, largely drives peak demand and hence road congestion and transit capacity requirements. Many more journey types need to be considered to complete the picture, but the others are outside of the scope of this paper.

The analysis draws largely on the 2006 Census data and State Government data. It is part of a program of urban planning research that will lead to an understanding of the physical and economic sustainability impact of deferral of public transport infrastructure investment in the growing metropolis. The primary hypothesis of this broader research program is that the opportunity cost (benefits lost) of the lack of high quality transit such as that afforded by rail systems is high, and is measurable. Furthermore, the growth pressures are leading to significant changes, notably densification, where the existing road and rail system will need to provide the greater capacity needed and other impacts will need to be managed.

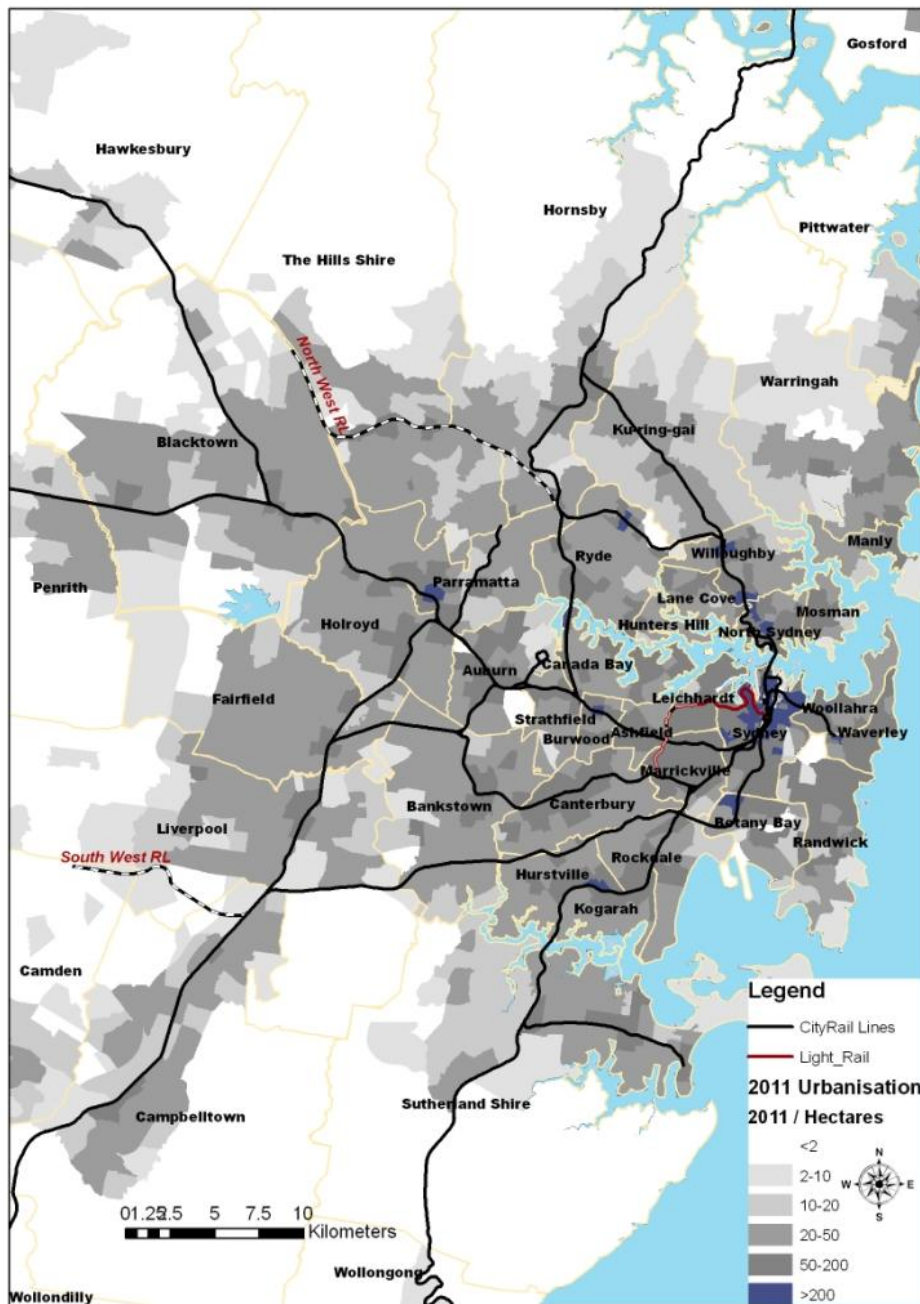
The present research encompasses the travel patterns and the physical impacts on the transport network and its service levels, intended to later translate to the generalised (economic) costs to the potential user population and other stakeholders, and to the non-economic consequences such as loss of amenity and of local environments. It is concerned with the impacts and implications over time, and the question of path dependency (Mahoney, 2000) – the role of the past in developing the future – in the unfolding scenarios in the accommodation of growth.

2. Background

This section first describes the relationship between Sydney's growth and its railway system, and then the policy environment that has and is affecting the development of the metropolis and its rail network.

The relationship between Sydney's urbanisation as it is expected to be in 2011 (Transport Data Centre, 2009a, b) and the existing and proposed rail network is shown in Figure 1 below. For current purposes, urbanisation is defined as the sum of residential population and jobs in an area, per hectare. This is a convenient surrogate for the drivers of work trip origins and destinations.

Figure 1: Sydney rail network and 2011 urbanisation



Map by author based on NSW Transport Data Centre population and employment forecasts 2009a, b

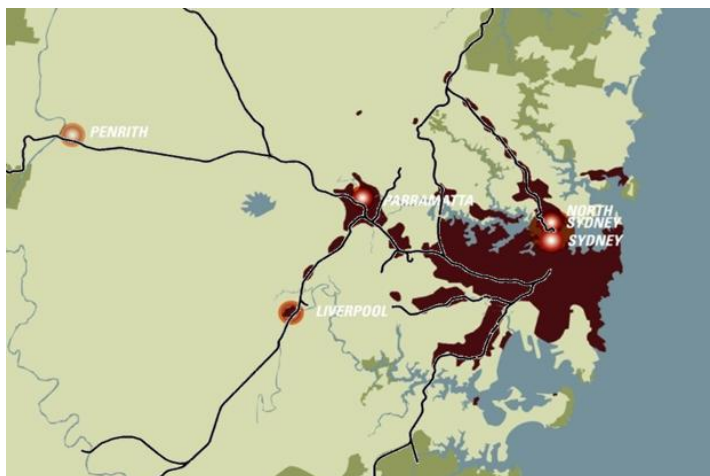
Even at this simple visual level it is evident that there is a strong relationship between the intensity of employment and population density on the one hand and the rail network on the other, notwithstanding Sydney's evident automobile dependence (Newman and Kenworthy, 1989, 1999). Other than along the Northern Beaches (Manly, Warringah, Pittwater) and the Eastern Suburbs (Waverley, Randwick), Sydney's development broadly follows the rail lines, and it anticipates the proposed North West Rail Link.

2.1 The railway network

Sydney has an extensive transit system comprising a network of suburban heavy rail lines (branded 'CityRail'), government-run and government-supported bus services, ferries and a single light rail line. The CityRail network of 1043 route kilometres includes the 328 kilometres electrified 'CityMet' suburban system (RailCorp 2008) that covers a large part of the contiguous urbanised area. Understanding a little of its history is important to understanding its role, and this is best considered in terms of three significant epochs. In the first, the latter half of the nineteenth century, railway development preceded urban development. In the second, the first half of the twentieth century, urban development and that of the railway occurred together. In the third, post World War II, the railway has been allowed to fall behind.

During **Epoch 1** Sydney consolidated its position at the centre of the New South Wales economy, in no small part due to the development of the country railway system which locked in the Port of Sydney's stranglehold on colonial trade. The core of the State rail network and its Sydney lines were largely completed between 1851 and 1880 (Bozier, 2010). Suburban railways were not then a priority due to a very strong rural bias in Parliament (Collins, 1983); but nevertheless by the turn of the century the core of the suburban network had been established. Like the railways of Europe and other countries, it allowed new urban villages to grow in the countryside outside of what had been until then a compact urban area in Sydney's inner west (Brown et al., 1969). These villages included high quality developments, particularly those north of the Harbour (Duffy 2006). The influence of rail transport was clear – by the early 1900s Sydney's development was a mix of streetcar (tram-served) suburbs in the inner areas and the railway villages 'like beads on a string' (Bernick and Cervero, 1996, NSW Department of Planning, 2005a) further out along the railway lines. Figure 2 illustrates the pattern of development that resulted, with the railway network overlaid. The strong relationship with the rail network has been very evident from that time.

Figure 2: Sydney urbanisation 1917 showing rail network



Source: Base map NSW Department of Planning (2005b); rail development Collins 1985, Bozier, 2010

During **Epoch 2** the centrepiece of the suburban railway was completed, defined by the iconic Harbour Bridge and railway scheme ultimately finalised, after many inquiries, in 1926 by Mr (later Dr) JJC Bradfield (Raxworthy, 1989, Moss, 2009). Bradfield built the Bridge and the underground City Railway including the City Circle (albeit with a gap at Circular Quay), which eliminated the mass transfer to trams at the Devonshire Street railway terminus. The suburban network was electrified to the west, south, and to Hornsby via both the North Shore and Strathfield. Sydney's extensive tramway network, throughout the southeast, inner west and lower north shore, reached its maximum extent in this period. The electrified East Hills railway was built then, but the Bradfield railways to the eastern and other suburbs were deferred with the Great Depression and then war. It was in Epoch 2 that the recognition of the importance of the relationship between the railway and development by all stakeholders was most evident.

Epoch 3, post World War II has been an extended period of equivocation and increasing prevarication in respect to rail expansion. Nevertheless the period saw a slow process of extending electrification, including the InterCity lines, and ultimately a number of modest rail network additions. However, a key feature of Epoch 3 was rapidly increasing 'automobilisation' (Mees, 2000) that had begun before the War, and abandonment of the tramways. Epoch 3 has been characterised by protracted breaks in railway construction and lack of recognition of its importance to development. Most notably, at least until recent times, the prime example was the thirty-year stop-start construction of the Eastern Suburbs Railway and its infamous construction 'holes' in the city (Riordan, 1983). The NSW Premier of the time, Jack Renshaw, was reported to have made one comment highly portent to the current, twenty-first century, paradigm:

"Treasury opposed the scheme in 1964, as they did during the 1950s...We were committed to building the thing, matching Askin's promise to fill the holes...He obviously thought money grew on trees" (Riordan, p138)

2.2 The recent Sydney urban and transport policy paradigm

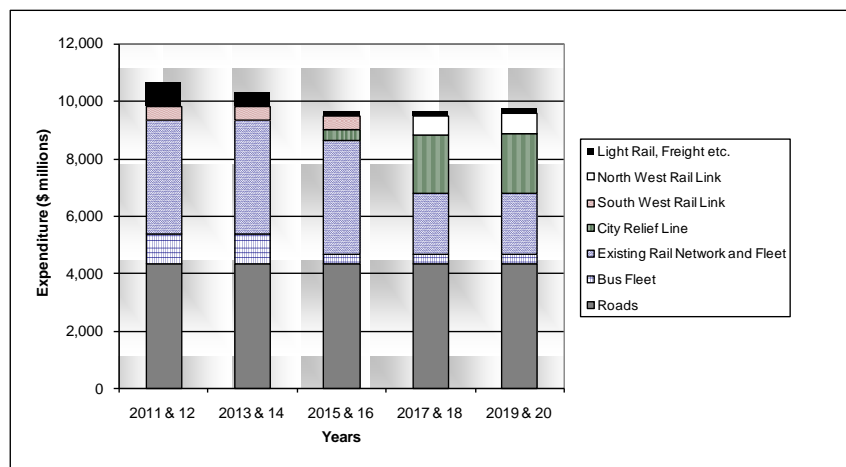
The limitations of a conference paper prevent a detailed discussion of Sydney planning history; however there are several features very relevant to this discussion. The 1968 Sydney Region Outline Plan (State Planning Authority NSW 1968) is particularly important in that it identified land releases in the Hills District, West and South West, and it proposed that Parramatta become the major regional centre (Meyer, 2006, Westacott, 2004). The 1968 Plan was prolific in its rail proposals, which largely radiated from Parramatta. These proposals collapsed after the Whitlam era and withdrawal of Commonwealth money for urban development. The eventual Regional Environmental Plan (Department of Environment and Planning, 1985) recommended that no heavy rail corridor be retained and that either Light Rail or Bus could be accommodated by road widening. The 1998 transport plan *Action for Transport* (NSW Ministry of Transport, 1998) reversed this again and was prolific in 'essential' rail proposals including the North West and Parramatta-Chatswood links.

Action for Transport was succeeded by the current Metropolitan Strategy *City of Cities* produced in 2005 (NSW Department of Planning, 2005a). The Centres Policy, as articulated in the Strategy, sought to focus the 31% growth in employment forecast over the planning period to 2031 in strategic centres and employment lands, and to enhance their housing role. It also envisaged residential and employment growth centres in the North West and South West. The transport centrepiece of *City of Cities* designed to service this was the Metropolitan Rail Expansion Program (MREP). MREP comprised the North West Rail Link from Epping to Rouse Hill, the South West Rail Link from Glenfield to Leppington, and a CBD/Harbour Rail Link from St Leonards through the CBD to Central and Redfern.

There have been several important changes since *City of Cities* was published. Sydney's economy has fallen behind and it moved from having the lowest unemployment among the state capitals in 2005, to the highest in 2009 (Australian Bureau of Statistics 2009). Secondly, the Strategy is being rethought from a centres perspective (NSW Department of Planning 2009, 2010) and from a transit infrastructure perspective as noted below. Third, growth in transit use in other Australian capital cities has outpaced that in Sydney (Mees et al., 2008); in some cases by a very large margin (Glazebrook, 2009).

The events since *City of Cities* to the present have been documented in detail as part of this research, but are precluded by space from description here. They clearly show the dysfunctional nature now evident in Sydney's transport planning. There have been massive swings in the infrastructure plans and little public evidence that decisions have been informed by analysis (Besser, 2009, Clennell et al., 2009), despite the plethora of contractual and engineering documents now in the public domain (NSW Transport and Infrastructure 2010a). The rail plans have been variously accelerated (Premier of NSW, 2006), replaced by various Metro proposals (MetroLink, 2008, Sydney Metro Authority, 2009); and the South West Rail Link reduced to a grade separation and car park, then reinstated in full. A much reduced CBD Metro became a priority for the New South Wales government. However, after an intense twelve months of well-publicised activity the entire Metro proposal was abandoned at a reported cost of \$530 million (West, 2010). The present Metropolitan Transport Plan (NSW Transport and Infrastructure, 2010) defers much of any new infrastructure some 10 years. Figure 3 interprets the 2010 plan as an estimated expenditure timeline.

Figure 3: 2010 Metropolitan Transport Plan: planned expenditure to 2020



Source: Cash flow estimated by author from NSW Transport and Infrastructure 2010b

The Plan essentially continues the status quo, with the bulk of the expenditure going to the existing network. There is a consistent expenditure of \$2.2 billion per annum planned for the state's roads, and \$1.7 billion per annum average for new trains and renewals/upgrades for CityRail and the bus fleet. This is a very significant amount and reflects part of the problem, in that the demands of maintenance and renewal of the existing network are a large demand on the budget, for the time being of the order of that for roads. Of the total \$50.2 billion committed for the next 10 years, only \$7.8 billion (16%) is for new rail projects and much of this is to enhance the existing Western corridor. This lack of real network expansion is very concerning to many observers of urban development (Property Council of Australia, 2010). The North West Rail Link, first proposed as a line from Parramatta in the 1968 *Sydney Region Outline Plan* and in *Action for Transport* for completion to Castle Hill by 2010 has reappeared 'brought forward' (Premier of NSW, 2010) to be completed in 2024.

3. The journey to work

As was noted at the beginning of this paper, the journeys to work and education largely drive peak demand and hence road congestion and transit capacity requirements. This section examines some of the characteristics of the journey to work in Sydney, most notably its orientation to employment destinations that suit transit service, and trips that have high transit share.

At the time of the 2006 Census there were nearly 2.3 million jobs in the Sydney Greater Metropolitan Area, of which around 1.8 million were in the Sydney Statistical Division, which approximates the commuter belt defined for this purpose as within a two hour in-vehicle time range by public transport. This Sydney employment tends to be clustered at the centres, and the distribution of employment has remained relatively consistent over time (Black, 2008, Transport Data Centre, 2008c). The 2006 data are examined in this section in order to create a snapshot of commuter travel patterns in Sydney through a public transport - 'transit' - based lens.

3.1 Employment in Sydney

Table 1 shows the 2006 number of employees in the Sydney commuter belt by industry, broken down into services, distribution and production using TDC data (Transport Data Centre, 2008a). Across this area, more than 70% of industry is of a services nature. In Australia, the services sector accounts for more than 75 per cent of economic activity and 85 per cent of employment (Infrastructure Australia Major Cities Unit, 2010). The services proportion is greater in the broadly defined *City of Cities* 'Global Arc' (principally the LGAs of Sydney, North Sydney, Willoughby, Ryde and Botany Bay). It is likely that much of the distribution and construction activity also reflects the requirements of the services sector, and little more than 10% of the Commuter Belt total (185,000 jobs) now relates to manufacturing. While certain categories do not present a clean fit, Table 1 serves to distinguish between those industries that are, by their nature, inflexible in their location opportunities, and the services sector that is more likely to be suited to centres, mixed development and transit service (Bernick and Cervero 1996).

Table 1: Employment by Industry, Sydney Commuter Belt, 2006

Services		Distribution		Production	
Accommodation/ Food	110,887	Electricity etc	15,761	Agriculture	7,339
Administration	56,599	Transport/ Warehousing	94,807	Construction	95,336
Arts / Recreation	26,164	Wholesale	103,286	Manufacturing	185,200
Education	138,932			Mining	4,678
Financial Services	122,105				
Health / Social	187,852				
Hiring/ Real Estate	35,491				
Information	55,008				
Professional	166,098				
Public Administration	106,862				
Retail Trade	197,379				
Other Services	68,636				
Total Services	1,272,013	Total Distribution	213,854	Total Production	292,553
Services %	70.6%	Distribution %	11.9%	Production %	16.2%
				Unknown	22,221
Total Commuter Belt Employment					1,800,641

Source Data: Transport Data Centre, 2008b

Services typically dominate locally across Sydney, but there are some interesting, if obvious, exceptions:

- Botany Bay, which houses the airport and major container seaport, has over 50% of its jobs in the distribution industry category and a relatively modest 30% in services. The Global Arc extends to Botany Bay because of its international connections.

- Blacktown, Auburn, Liverpool, Fairfield and Bankstown in the west are the locations housing strong production and distribution sectors.
- The services sector in Ryde, which includes the Macquarie Park congregation of high-end information and technology firms, showed a relatively modest 67% services in 2006, and only half of the information industry jobs that were recorded in North Sydney in 2006.
- Although the Hills Shire (Baulkham Hills) is generally not regarded as being part of the Global Arc, it has a similar number of services industry (and total) jobs as Willoughby, which is.
- Some of the smaller LGAs have higher proportions of services employment simply because of their scale, which leads to low manufacturing and distribution opportunities.

The distribution of employment in Sydney is mapped from the ABS/TDC data using ESRI ArcGIS® software in Figure 4, which shows total employment and services employment by LGA.

Figure 4: Distribution of Employment in Sydney, 2006



Map: Author; Source Data Transport Data Centre 2008c

This map emphasises both the spread of employment across the Metropolitan area, and the dominance of the City of Sydney in the distribution - a mix of CBD-centric and distributed employment. In effect, one quarter of the employment in the commuter belt is in the City of Sydney, increasing to one third in the 'Global Arc' in its broadest definition, and the remainder is spread throughout the metropolis. The strongest employment zones in this last, distributed, group are the Parramatta (Sydney's 'second CBD') and Blacktown LGAs, which are located roughly at the geographic centroid of the metropolitan area; although Blacktown in particular, with its high level of production and distribution activity has less potential for a compact employment centre.

The Global Arc LGAs, along with Parramatta, represent the top five locations of jobs in the commuter belt. In Parramatta's case, however, managerial and professional jobs represent only 37% of the LGA's total, compared to 48% to nearly 60% in the other cases. Clearly the Global Arc is the centre of the high-end employment activity in Sydney, as it is for services more generally. As will be discussed later in the paper, this has very important implications for rail commuting.

3.2 Commuter catchments and work journeys

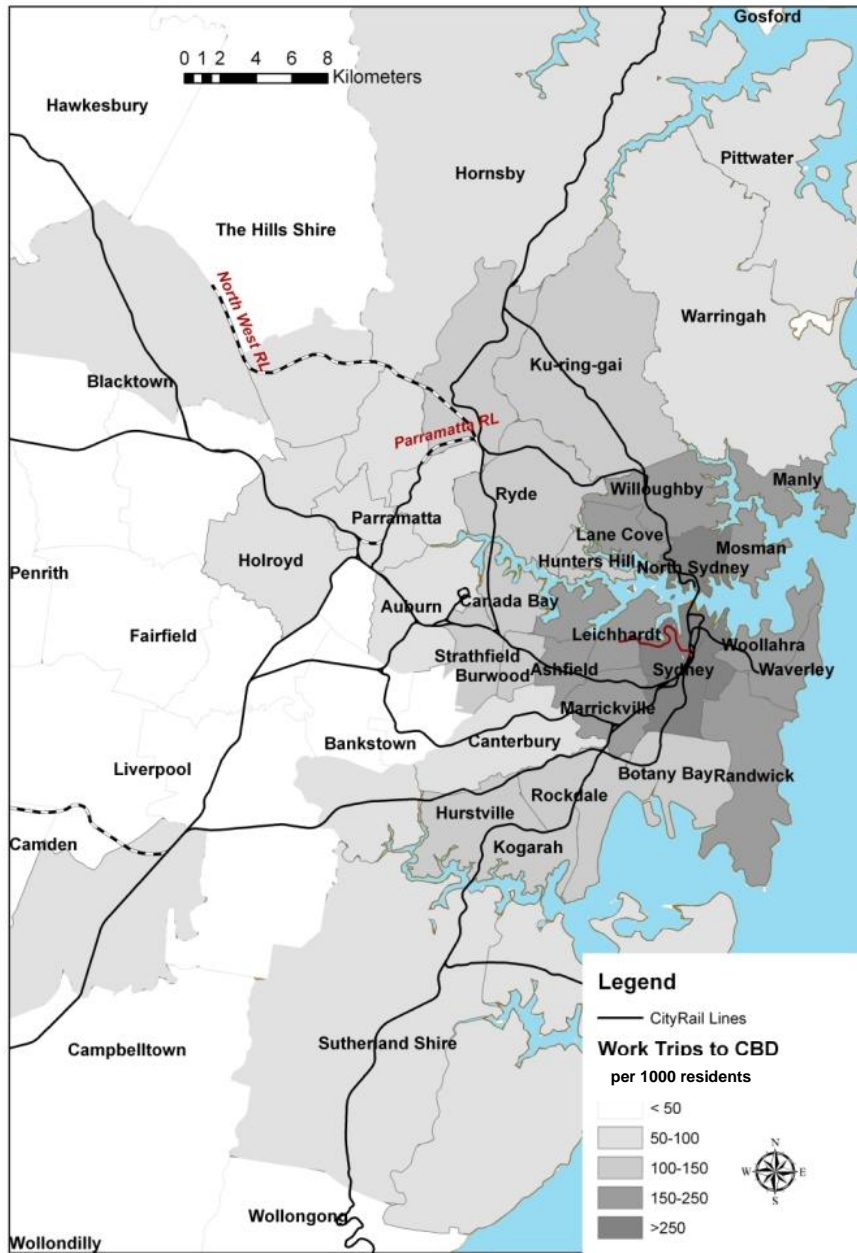
The Sydney Commuter Belt journey to work pattern has been examined to assess the extent of trip attraction. The analysis corresponds to that mapped for 2001 in *City of Cities* (NSW Department of Planning 2005a p105f). In broad terms the patterns are:

- The Harbour Cities of Sydney and North Sydney and the other core Global Arc LGAs attract work trips from Warringah, Hornsby and The Hills Shire (Baulkham Hills) in the North, from Parramatta and Blacktown in the West, and the Sutherland Shire in the South, and of course the inner suburban belt. This represents a catchment some 50 kilometres in radius to the three sides not constrained by the ocean.
- The River Cities of Penrith, Liverpool and Parramatta have catchments that extend west and south west of their respective locations. There is less journey-to-work travel from the eastern side of the Sydney to these locations. Parramatta, as the major centre has a catchment that includes Penrith, Blacktown and the Hills Shire. Liverpool reaches to Fairfield, Campbelltown and Bankstown for its workers, while Penrith attracts people from the Blue Mountains, Hawkesbury and other immediate neighbours. In each case the volumes are much smaller than the Harbour Cities.

Figure 5 (overleaf) presents trip data at the Local Area (SLA) level expressed as trip rates (work trips per 1000 residents) for Harbour City employment.

The catchment of the Harbour Cities CBD is shown very clearly in this format. Trip rates to the Harbour Cities from west of a line drawn through Parramatta are very low – less than 50 work trips per 1000 residents. By and large the CBD does not attract work trips from the west and south west of the commuter belt. Moderate rates are evident north, north-west and south. Trip rates to the Harbour Cities are heaviest in the inner suburbs, ranging from 130 up to 400 trips per 1000 residents. There are clear socio-economic and geographic reasons for this divergence; however from purely a market perspective this pattern has significant implications for the public transport system.

Figure 5: Harbour cities commuting: trip rates to the CBD by local area origin



Source: Transport Data Centre, 2008d, e

4 The role of the railway

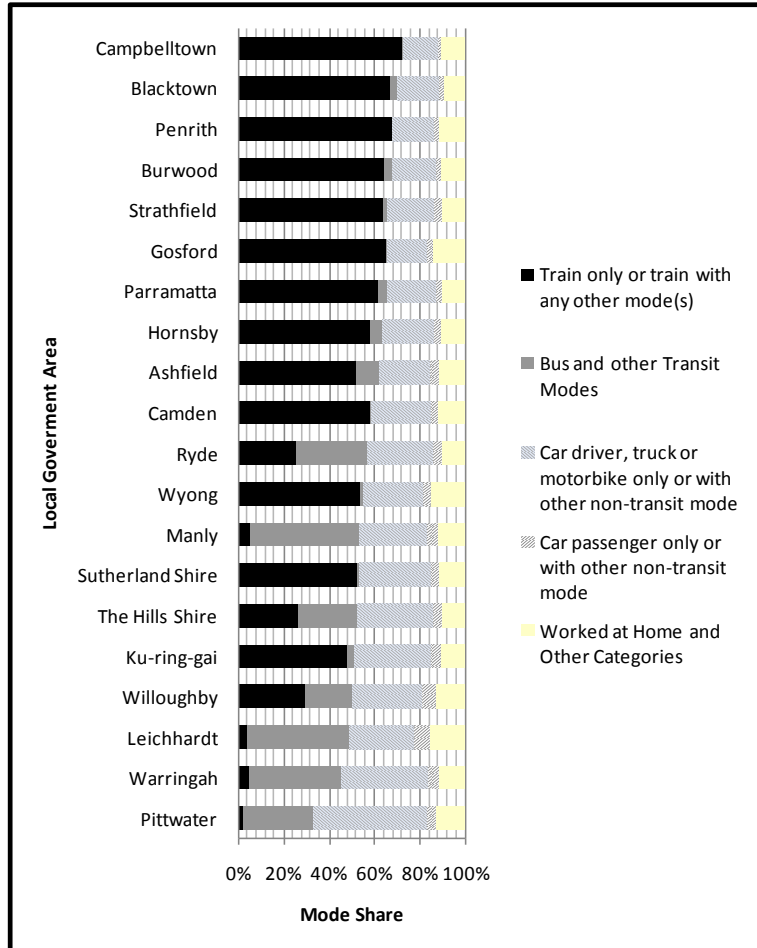
The discussion now turns to the means by which the rail network interacts with these patterns. There is clear evidence that the rail network plays a key role; however it is highly focussed on the Harbour Cities and the Global Arc, and those LGAs that are most oriented to them.

4.1 Mode share

Figure 6 overleaf shows the transit mode share from Commuter Belt LGAs, selected for their relevance, to Sydney and North Sydney, arranged in order of transit mode share. A high transit share in this presentation does not necessarily correspond to a high trip rate; indeed some of the highest rail shares are from LGAs such as

Campbelltown, with trip rates to the CBD that are quite low. This graph presents the transit share in terms of the Priority Mode concept used by the NSW Transport Data Centre (Transport Data Centre 2008b) which, where multiple modes are used, orders the modes in terms of the longest part of the journey. This places 'Train' as the highest, followed by 'Bus', with the lowest as 'Walked Only'. This may favour Train slightly, however not to the extent where it is of concern.

Figure 6: Mode Share: Selected LGAs to the Harbour Cities, by origin, 2006



Source Data: Transport Data Centre 2008d, e, reproduced from Norley and Peters (2010)

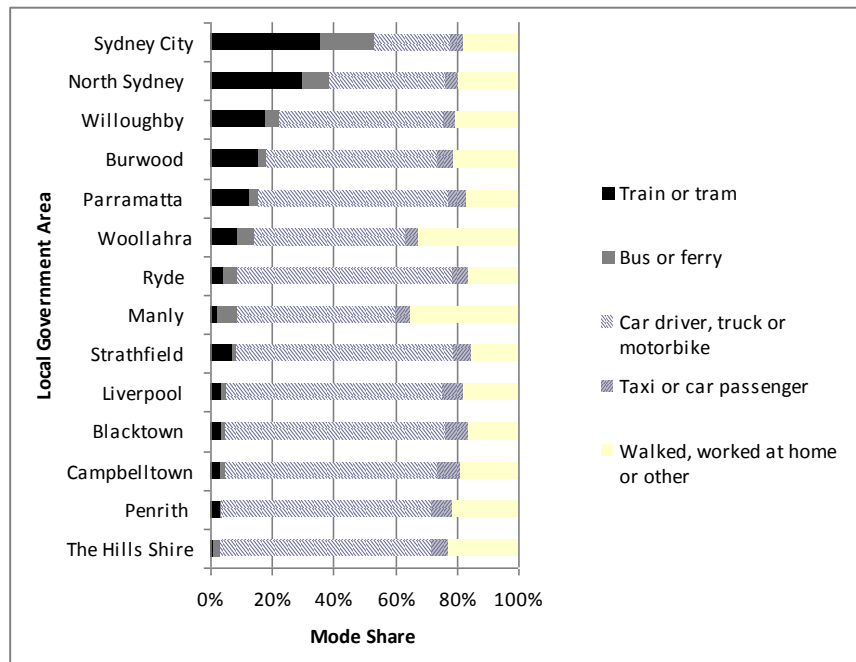
The data show that the Harbour City work trip to be strongly transit oriented. More than half of the work trips to these LGAs (51%) used public transport – mostly train or bus – and a further 17% either used other active modes or worked from home. Only 31% travelled by motor vehicle as a driver or passenger. The highest share comes from Campbelltown, on the Main South railway, 40 kilometres south of the city, albeit with the relatively low trip-making from that source. Other very high mode shares (of the order of 65% or more) are clustered around middle and outer LGAs that follow the Main West railway line through Burwood, Strathfield, Parramatta, Blacktown and Penrith to the Blue Mountains. Generally all of the very high shares follow the main rail corridors from the west and south, key rail centres such as Hornsby and the CityRail Intercity corridors from the Central Coast (Wyong), Illawarra and the Mountains. Camden, which has no rail line of its own, shows a high transit share, almost all of which is Train, presumably via Campbelltown. Campbelltown and Glenfield, the latter being the junction for the proposed South West Rail Link, have among the highest car access rates in the CityRail area (RailCorp 2008). It should be noted that the LGA level is a fairly coarse scale, and most LGAs extend beyond the

centre that may share their name. Once again the importance of the railway is emphasised by these data.

The Bus mode is evidently less attractive, and transit shares from the bus-served LGAs tend to be 55% or lower. Ryde is an exception, and its transit share is split between Bus and Train. The western part of Ryde is well served by Train, notably from the then express-served West Ryde station. These figures predate the Epping Chatswood Rail Link, which serves part of the Ryde area. A number of the inner suburbs (perhaps surprisingly), the North Shore, the upper part of which (Ku-ring-gai and, in part, Willoughby) is rail-served and the Northern Beaches (Warringah and Pittwater) exhibit modest transit shares. The Northern Beaches share is likely to reflect lifestyle choices, income and the lack of rail service. The contrast is notable between, on the one hand, the attractiveness of the Harbour Cities and moderately high transit share shown by the Sutherland Shire and, on the other, the lower trip volumes and transit share from Warringah, given that the two have similar local employment bases. The only high transit share from the Northern Beaches is that from Manly, with its Ferry service. The Hills Shire is notable for the fact that its transit market share is evenly split between Train and Bus, despite the fact that it has no rail service to speak of. Pennant Hills, which is the one of the closer stations to the Hills Shire, like Campbelltown noted above, has one of the highest car access rates (RailCorp 2008). Sydney and North Sydney stand out for their high shares of non-vehicular travel and working from home (Sydney 51% and North Sydney 33%).

The share by destination, again a sub-set selected by their relevance, is shown in Figure 7. This illustrates the marked difference between the Harbour Cities (Sydney and North Sydney) and other LGAs, notably the River Cities (Parramatta, Liverpool and Penrith) that represent the next tier of centres in Sydney.

Figure 7: Mode Share: By Destination, Selected LGAs, 2006



Source Data: Transport Data Centre 2008d, e

The River Cities of Parramatta, Liverpool and Penrith are considered in *City of Cities* as the strategically more important regional centres that are to offer the major business services to the catchments that they serve. However in these cases the use of transit is much lower. For example transit share from the major origin LGAs for work journeys into the Liverpool LGA averages only 5.5%. Work journeys to

Liverpool were, in 2006, made by motor vehicle as a driver or passenger 83% of the time. This is despite Liverpool being serviced by the South, Inner West, Bankstown and Cumberland CityRail lines, and the Liverpool to Parramatta Bus Transitway (T-Way) opened in 2003. While served by fewer rail lines the position for Penrith parallels that for Liverpool.

The position for Parramatta is more favourable to transit, but is still well down on the Sydney/North Sydney situation. The average transit use for the 2006 population was 15.5%, and very few origins showed more than 30%. 68% of trips were motor vehicle based. Bus access overall was little more than 3%, and generally confined to local trips from LGAs such as Fairfield (5.8%), Holroyd (8.5%), Ryde (8.1%), Liverpool (4.9%) and Parramatta itself (4.8%). Non-vehicular travel and working from home represent 36% of Parramatta's work access. The Hills Shire, which contributes over 9,200 workers to Parramatta's workforce, but which lacks rail access, had a transit share to Parramatta of just 5.9%, or 543 travellers. This may be compared to the Hills' Harbour Cities' workforce of over 10,000, transit share of 53% and 5,300 transit travellers.

The low levels of transit use in the River Cities is potentially related to a combination of the distribution of the jobs in these LGAs and access from the transit nodes (a question of permeability and distance) and the relative ease of motor vehicle access and parking. The Harbour Cities on the other hand offer their jobs in a very compact area, have multiple rail stations for distribution, and car access and parking is both difficult and expensive. The TDC Household survey lists 'avoids parking problems' as the primary factor in using public transport for work and 'arrives closer to destination' as the least important (Corpuz 2007).

4.2 Means of access

The data also reveal the patterns of access to rail stations. These patterns apparent from the two maps on the following page (Figures 8 and 9) reinforce the urbanisation patterns and the strong walk-in base that surrounds the railway stations. Figure 8 shows the walk-in catchments for the rail network, and Figure 9 the 'motorised' (bus and car) catchments, based on ABS 2006 Collection District (CD) data. The maps, drawn with similar shading, illustrate the strength of the walk-in access relative to the drive-in pattern. These patterns suggest that the railway is more important where walk access is feasible, but that the catchment is capable of being extended by motorised access. However the shares from locations not directly served are not as strong, as would be expected.

The data support the commonly accepted norm of an 800m catchment for rail stations. While there is considerable scatter in the data, CDs where the mode share to rail is greater than 20% are clustered within 1 kilometre of the nearest station. The data suggest a logarithmic curve:

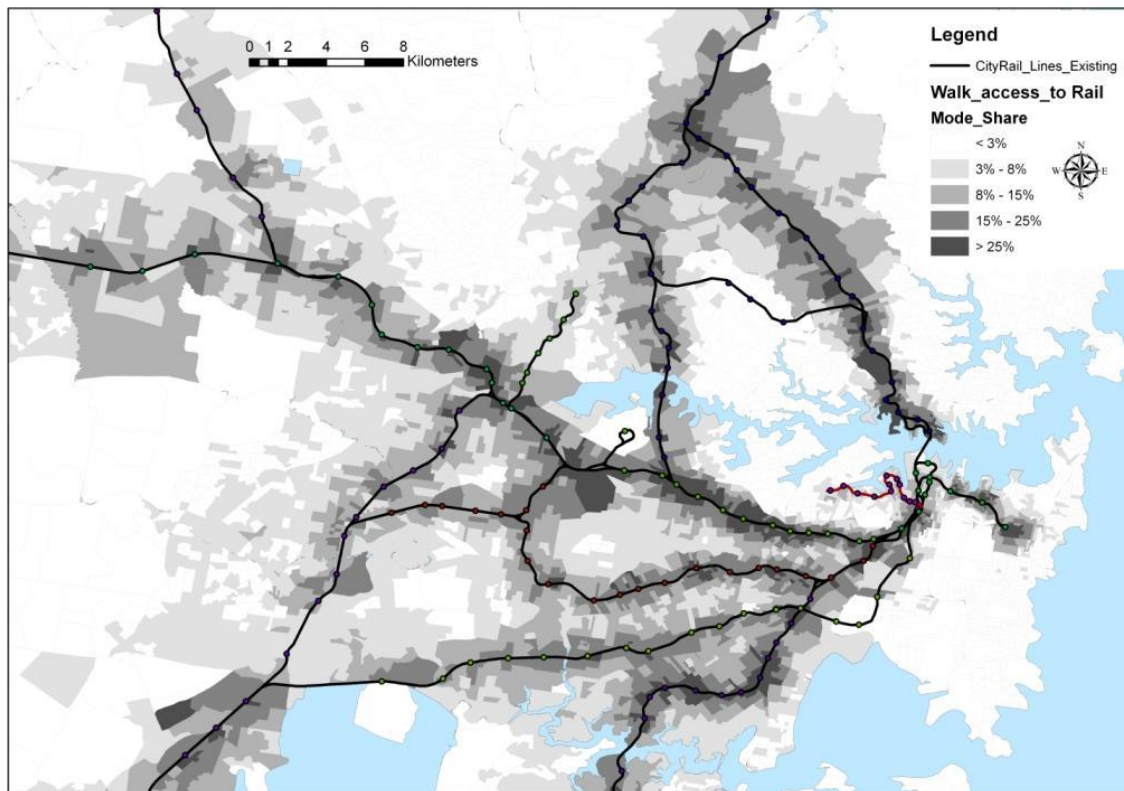
$$S_n = -0.085 \ln(X_n) + 0.7007 \quad R^2 = 0.56$$

where S_n = mode share for CD_n

X_n = distance in metres from centroid of CD_n to the nearest station.

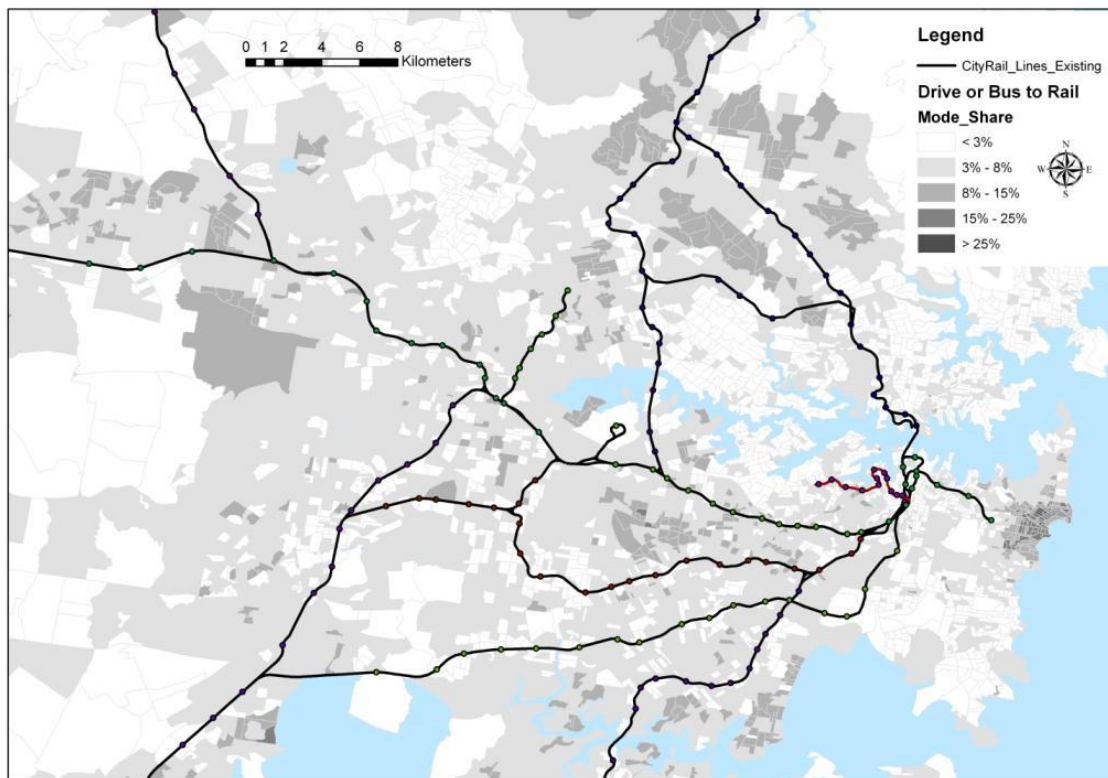
The data show a long tail where some people appear to be walking long distances (several kilometres) to access rail. These latter areas overlap the motorised catchment shown in Figure 8. In the motorised case there is a less defined relationship but it is noticeable that the areas with the greater mode share in this group tend to be around 2-3 kilometres from rail. Where there is no competing rail line this increases to up to about 5 kilometres. A strong bus-rail mode share is noticeable where there is a well-coordinated feeder bus arrangement, such as Bondi to Bondi Junction.

Figure 8: Sydney Rail Network Walk-in Catchment, 2006



Map: Author; Data Source ABS 2008

Figure 9: Sydney Rail Network Drive/Bus-in Catchment, 2006



Map: Author; Data Source ABS 2008

4.3 The growth centre rail links

As noted earlier, a new Metropolitan Transport Plan (NSW Transport and Infrastructure, 2010a) has been released, deferring completion of new rail lines other than the South West Rail Link beyond the next ten years. The proposed North West Rail Link is now not to be completed until 2024.

The North West and South West links are shown in Figure 10 overleaf, which also shows the 2021 forecast urbanised area, the 800 metre walk-in catchment of the proposed new stations and a notional 3 kilometre 'drive' catchment. These distances are common standards used for planning purposes, although the catchments may be larger in certain circumstances as noted before. The North West Rail Link is approximately 23 km in length, mostly underground, from Epping to Rouse Hill in the North West Growth Centre. The patronage estimated for the North West Rail Link (GHD Pty Ltd for TIDC, 2006) ranges from 50,000 to 80,000 passengers per day, which would require 6-8 trains in the peak hour. The South West Rail Link is a less complex project, 12 km of above-ground railway from Glenfield on the Main Southern line to new stations at Edmonson Park and Leppington (Parsons Brinckerhoff Australia Pty Limited for TIDC, 2006). The patronage of the South West Link, estimated at 21,000 passengers per day in 2021 in the 2006 Environmental Assessment, is significantly less than that expected for the North West.

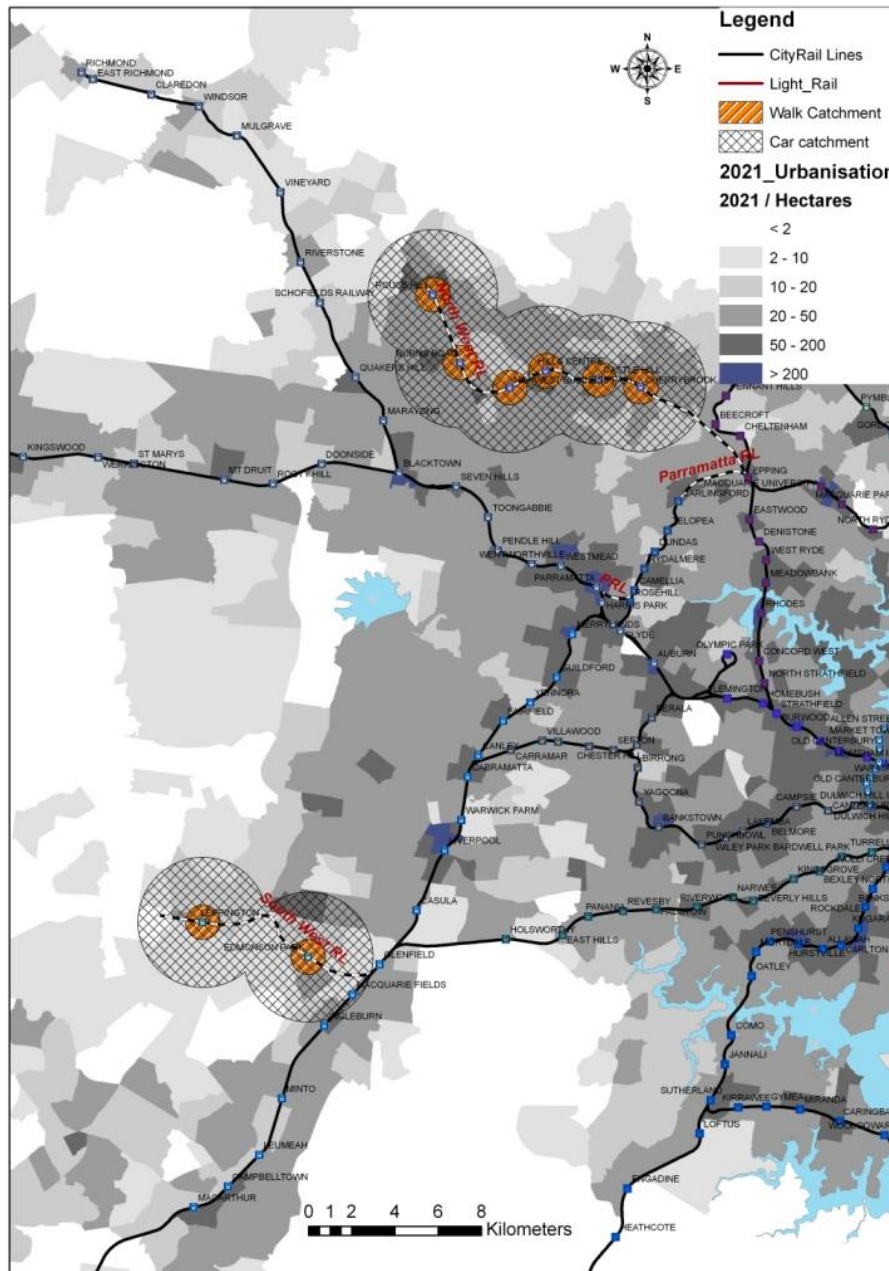
Figure 9 shows how the proposed rail links will relate to development in their catchment areas. This utilises the TDC Rebased Travel Zone figures (Transport Data Centre, 2009a, b) and the buffer and intersect tools of the ArcGIS® software to calculate estimated population/jobs in the catchments. Despite similar descriptors and branding, there is a fundamental difference between these areas apparent from the development forecasts. The map shows the North West catchment to be well established, with population density by then already exceeding the average density of cities such as Perth and Adelaide (Mees, 2010). The planned residential targets for the 'drive' catchment will have been reached by 2021, with densities that approximate the current average density of urbanised Sydney – a little more than 20 persons (population) per hectare. Densities are expected to continue to increase over the planning period. Employment is also well established within walking distance of the North West stations. In all, the North West Rail Link catchment, an area of nearly 10,000 hectares, will increase in urbanisation over the planning period by 50 percent from 180,000 people to 244,000.

In contrast, the South West Rail Link is being built largely through undeveloped land. The South West catchment had a population within walking distance of the stations of about 150 people at the time of the 2006 Census. There were 450 people working in this area at that time. The 2010 Environmental Assessment (Parsons Brinckerhoff Australia Pty Limited 2010) shows a walk-in share of no more than 5% for Leppington station, even in 2036.

The North West Rail Link catchment is an area that is well advanced in its development, both in terms of population and employment. This proposed link services areas that in some cases have been established for some twenty years, and it traverses one of the fastest growing LGAs in Sydney (Australian Bureau of Statistics (ABS), 2009b). It is an area that currently has a strong orientation to CBD and Global Arc employment. While provision of transport infrastructure ahead of development as is the case with the South West is a sound objective, the difference between the two markets is dramatic. By 2021, the South West catchment will have begun to be developed, but that in the North West will be fully built up. The level of development and its orientation to jobs in the Global Arc would have assured the North West Link's utilisation; that in the South West raises some doubt. The South West Rail Link potentially will assist CityRail operations on the East Hills and

Liverpool lines, by providing additional stabling of trains. Rail use from the South West Link itself will be less important as a measure of success for many years.

Figure 10: Growth centre rail link catchments, 2021



Source: TDC 2009a, b; Map updated from Norley 2010a

As a minimum, effective utilisation of the South West Rail Link will require a closely integrated bus network and car parking to optimise its reach into the Growth Centre, and attention to the nature of the development planned such that transit-orientation is maximised. Unfortunately this in itself is problematic, in that the car access and parking is contrary to the principles of Transit-oriented Development. The South West Growth Centre extends well beyond the effective catchment of its Rail Link, and is oriented at right angles to it; parallel in fact to the Main South Railway. This adds further to the difficulties of designing an effective feeder network. Moreover it does not serve parts of the South West such as Camden that exhibit stronger growth and CBD orientation.

5. Conclusions

The rail network has served to focus Sydney's development around it for over one hundred years. It has done this despite increasing car-dependency over much of this time. Patterns that were evident after completion of the core of the suburban railway in the early part of the twentieth century persist today. However the rail network has not kept pace with the urbanisation that has taken place over the last several decades. There is little in the present planning paradigm to suggest that this will change, and the current Metropolitan Transport Plan is heavily focussed on the status quo. There are significant areas that warrant rail service (notably in the North West), but which are unlikely to see it in the next decade. These areas will continue to rely on road-based transit that is constrained by congestion (notably in the city) and offers poor service quality, and which arguably imposes unacceptable social and economic costs.

Sydney's service-based employment and the pattern of centres are such that transit is a real option for many work journeys. The market for the railway network, at least in respect to work journeys, is heavily oriented to its Harbour City CBD, despite offering service to other centres. The journey to work pattern in Sydney reinforces the evidence that the city is divided east and west. Work trip-making from the outer west, and from a whole arc to the south west is not focused on the city CBD. There exists a dichotomy between the influence that the railway has on development in the outer areas, their high mode share and the relative low CBD-based trip making from them. The market for transit work trips, and hence the rail system tends to be the south, north and north western suburbs rather than the outer west and south west. This places into question the relative priority that is being given to the South West Rail Link in the Metropolitan Transport Plan, and to hopes that the River Cities might attract more transit share.

The other important determinant of peak transit use – education trips – has not been considered in this paper. School trips represent about 8% of daily rail travel (RailCorp 2008) and university student trips must be added to this for the full picture. These trips may be demographically-based, with areas that place a high premium on education adding demand onto the transit system, and this in itself is likely to reinforce rail's role in peak travel and to the areas that have a Harbor Cities jobs orientation.

The paper has shown that, while the rail network continues to be a key factor in Sydney's development, street-based transit does not have the same influence. This simply underlines the need for ongoing enhancement of the rail network and other off-road modes such as 'Quick-way' quality bus rapid transit (Hoffman 2008, Cervero 2010), and for their development and land use planning to be inextricably linked. This paper raises questions as to whether this is the case in Sydney's planning. Land use-transport interaction is more than mere rhetoric. It will be key to ensuring Sydney's economic sustainability. It is the purpose of the research program that is associated with this paper to quantify the extent to which we have failed to recognise this.

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