

Urban residential density and public transport use: a case study of Sydney

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Urban Residential Density and Public Transport Use: A Case Study of Sydney

Darren Holloway

Master of Built Environment (Research)

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University of NSW**

2010

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For at least thirty years urban growth management policies in Australian cities have focused on increasing residential densities as a method of addressing environmental issues. This view has been supported by a number of researchers who hypothesise that to achieve reductions in transport emissions individuals need to be encouraged to use public transport, and the most appropriate method of increasing public transport use occurs predominately from building residential areas at high densities around public transport nodes. This notion is integral to recent urban growth management policies in Sydney, which have sought to increase residential densities under the rubric of urban consolidation.

There are a number of researchers who have promoted the benefit of increasing urban densities as a way of increasing public transport use. In Australia, the most cited research in this area is that of Newman and Kenworthy. Nonetheless, there are a number of commentators who have criticised the emphasis of density in increasing public transport use. These commentators assert that factors other than density, particularly socio-economic factors, are more important in influencing public transport use. Nevertheless, a major gap within this concept is that the research is conducted at the macro-level with minimal analysis at the meso or micro level.

This thesis attempts to fill a gap in our knowledge by assessing the relationship between urban density and public transport use, particularly trains, at the macro, meso and micro level. The analyses used data across the Sydney metropolitan area and by geographical location to assess the implications of the density-public transport debate, and its articulation in urban consolidation policies. Such an analysis also has implications for other Australian cities who have promoted urban consolidation.

The study concludes that residential density is not as important as socio-economic factors in influencing one form of public transport use, namely trains. Variables such as car ownership, country of origin, housing tenure, and the type and location of employment are more important in influencing train use than density. The study concludes that at the macro level the notion of increasing densities increases public transport use is plausible, yet at the micro level the relationship between high density housing and public transport use (in this case train use) is more complex. This suggests that the promotion of urban consolidation policies as a means to increase public transport use needs to be re-assessed. Importantly, there is still much research to be conducted to fully comprehend the relationships between housing and transport in order to better inform urban growth management policies in cities, including Sydney.

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PART 1: INTRODUCTION

1. INTRODUCTION

1.1 The Debate over Urban Form in Australia

At the end of World War II, housing development in Australia was dominated by the building of detached houses on individual plots of land. The construction of large suburbs of detached housing on individual lots led a number of commentators to refer to this period in Australia's development as one of 'urban sprawl' (see Howe 2000, Alexander 2000, Moran 2006). During the 1970s and 1980s debate raged in Australia, as in other parts of the world, about the benefits and consequences of urban sprawl (Real Estate Research Corporation 1974). Critics of urban sprawl view this form of developments as lacking in infrastructure, increasing car usage and the length of trips, and encroaching on agricultural land. Other commentators, however, contended that there were benefits to providing detached housing on individual plots of land including equity benefits (e.g. lower income households being able to grow their own fruit and vegetables), life cycle benefits (e.g. having the ability to expand a dwelling when a household increases in size), and environmental benefits (e.g. water retention) (see Troy 1996 for an overview).

Nevertheless, State governments in Australia particularly over the last twenty years, including NSW, have pursued urban development strategies that have sought to reign in the sprawling suburbs developed during the post-war period. This has been through the redevelopment of residential land in the existing urban area at higher densities, as well as increasing densities in new development on the urban fringe in a process commonly referred to as urban consolidation. In new housing developments on the urban fringe, consolidation is usually achieved through the building of houses on smaller plots of land or, generally, through two or three attached dwellings on the one lot. In the existing urban area, increasing densities are generally obtained through the construction of multi-unit dwellings, where a single detached house has been demolished or a disused industrial or commercial site is redeveloped. This involves the redevelopment of a site through the construction of attached dwellings (townhouses, villas, flats, units, apartments) (see Appendix 1).

1.2 Pursuing Increased Residential Densities

Initially, urban growth management strategies pursued under the rubric of urban consolidation were seen as panacea for some of the perceived problems of the sprawling suburbs in Australia (Bunker 1989). This included the large financial burden to governments in providing social and physical infrastructure to the suburbs, the losses of population from inner city areas as individuals moved to the suburbs, the saving of valuable agricultural land (Dieleman et al 1999, Breheny 1995 and 1997), and in Sydney, the topographical constraints of the urban area.

There has been a multiplicity of reasons why urban consolidation is pursued by policymakers and this has changed over time. Nonetheless, the suite of policies and initiatives that constitute urban consolidation reflect its role as an important and significant growth management policy. In recent years the focus on urban consolidation by planning authorities has also been built around the work of academics who promote the view that increasing residential densities around public transport nodes will increase public transport use.

There are a number of commentators who have promoted the benefits of increasing public transport use through urban consolidation policies. However, as Rickwood et al (2008) and Breheny (1992) note, the most cited research in this area is that presented by Newman and Kenworthy (1989, 1999). Since the mid 1980s Newman and Kenworthy have promoted that, by increasing urban densities particularly around public transport nodes, cities therefore encourage increased public transport use and in turn transport energy emissions are reduced through less car usage (Newman and Kenworthy 1989, 1991, 1994, 1999). This concept is also promoted as having a dual outcome by making public transport systems more economically viable. As we will see later Newman and Kenworthy are not the only researchers or policymakers to promote the density – public transport concept which has gained support across the world. More recently, a few authors (e.g. Cervero 1996a) have also suggested that if high density residential areas are

intertwined, or mixed, with retail and commercial uses, than this will increase walking and cycling and therefore further reduce car usage and emissions.

Although earlier urbanists presented similar arguments on the benefits of urban consolidation (e.g. Jacobs 1961) policymakers in Sydney, and other Australian cities, have promoted the links between density and increased public transport use to such an extent that it has become a core objective of metropolitan growth strategies. This is evidenced by the fact that in 2004 Peter Newman, a supporter of the policy linking density with increased public transport use, was appointed as a Sustainability Commissioner to the NSW State Government. Further, as the current Sydney Metropolitan Strategy states (Department of Planning 2005, p. 30):

Transport investment can be costly, and travel behaviour has impacts on the environment, the community's health, household budgets and the cost of doing business. Transport investment that reduces these costs and impacts, such as greater access to quality public transport, walking and cycling facilities, must be encouraged. In locations where public transport is available and it provides a competitive alternative to private cars, people choose to use it.

Nonetheless, the benefit of increasing public transport use through higher density development and its articulation in urban consolidation policies in Sydney, and other Australian cities, has not been without its critics (e.g. Troy 1996, Stretton 1994, Rescei 2005). Debate in Australia about urban consolidation policies has ensued mainly because of the lack of research and understanding that has underpinned the perceived benefits of urban consolidation policies (see also Breheny 1996). For example, a number of commentators have suggested that the perceived environmental (Searle 2004a, Troy et al 2003), infrastructure (Troy 1996), and affordability and social outcomes (Peel 1995, Lewis 2000, Burton 2000, Wulff et al 2004) of urban consolidation are questionable (Bunker et al 2002).

There are also a number of researchers who suggest that the concept of increasing public transport use through increasing densities is flawed and that transport use is not solely a function of land use (i.e. density) but is also influenced by socio-demographics, mobility, and cultural and behavioural attitudes (Hanson 1982, Stead 2001, Schwanen et al 2002, Giuliano and Narayan 2003). In general, these researchers suggest that the factors influencing transport usage are complex and that there are more influential factors than density.

The complexity of transport patterns also begins to question whether increasing public transport use can be solved by urban land use policies alone. While urban planners have the ability to influence urban form and structure, transport policies, government administrative structures and fiscal policies (e.g. road tolls), which may also influence public transport use and provision are not part of the planners' toolkit. Not surprisingly, this has also raised the issue as to why, based on limited research, the density – public transport concept is continually promoted by urban policy makers when more in-depth research may reveal that urban planners have limited abilities to influence public transport use (Holloway 2008).

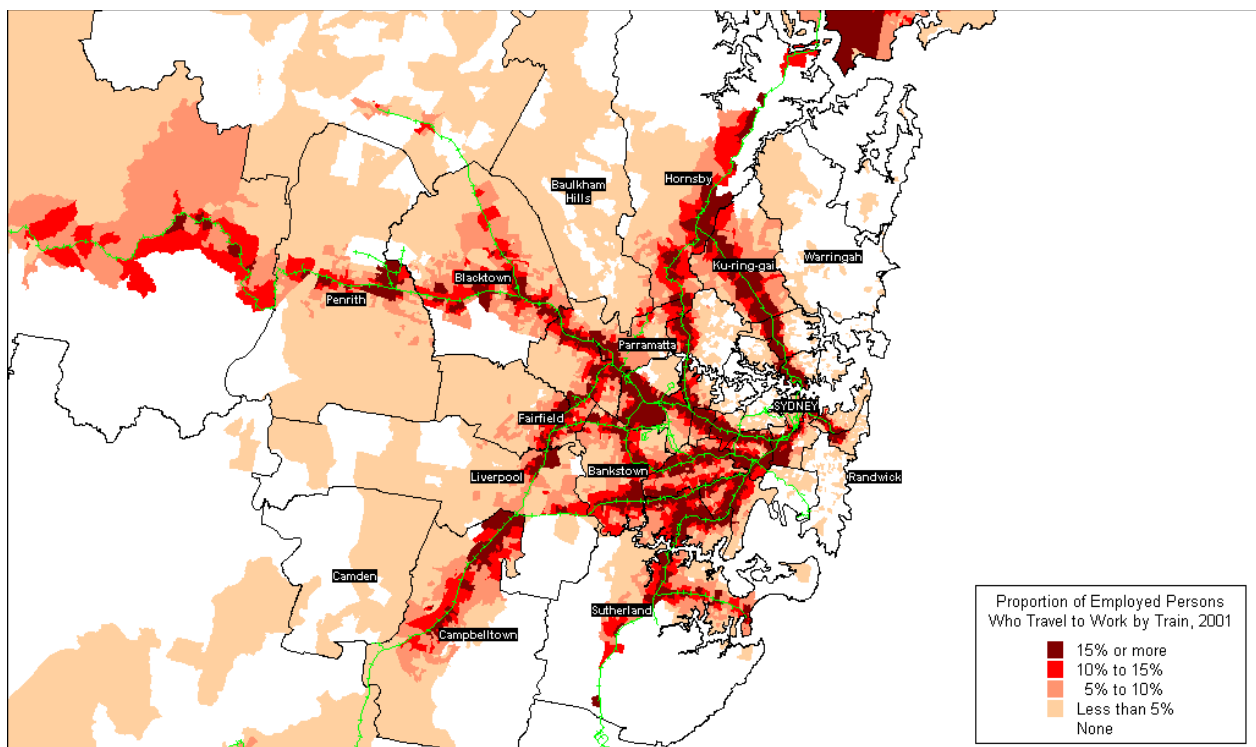
More recently, criticisms of the link between density and increased public transport use have also questioned the promotion of the concept at the local level. That is, within metropolitan areas there is a lack of research on the relationship between density and transport use below the city wide level (Giuliano and Dargay 2006, Stead and Marshall 2001). To date, research on the links between density and public transport use have been developed based on city wide level analyses and has not been supported by intra-metropolitan level or micro-level assessments. This criticism has also been identified in Australia, including Sydney (Bunker and Holloway, 2006).

At the macro level the link between increased density and increased public transport use seems plausible. As Figure 1.1 shows the largest proportion of train users in Sydney are located along the rail corridor, which also contains the highest proportion of higher

density housing. Nevertheless, whether the reason for this usage is a result of residential density or other factors is still to be explored in Sydney.

This thesis, therefore, attempts to fill the gaps in our knowledge by examining the relationship between high density housing and public transport use (particularly trains) in Sydney at the macro (metropolitan level), meso (intra-metropolitan case studies) and micro level (local level case studies). In particular, the thesis will examine whether other factors (i.e. socio-economic variables) are just as, or more, important than residential densities in influencing public transport use. The assessment of the density – public transport debate at different scales in Sydney will aid discussions in other cities in Australia and overseas on the validity of the concept (see Boarnet and Sarmiento 1998), as well as providing an assessment of urban consolidation policies and urban growth management strategies which have encapsulated this concept.

Figure 1.1: The Proportion of Employed Persons Who Travel to Work by Train, 2001



1.3 Research Objectives

Specifically, the study aims to:

1. Evaluate the validity of the notion linking residential densities to public transport, specifically train, use;
2. Assess the macro level relationship between public transport usage, housing and the socio-economic characteristics of individuals in the Sydney metropolitan area;
3. Assess the meso level relationship between train use, residential density and the socio-economic characteristics of individuals who live in higher density housing in Sydney;
4. Examine the micro level influences of public transport usage in higher density housing in different geographical localities in the Sydney metropolitan area; and
5. Assess the implications of these results for urban consolidation policies in Sydney.

1.4 The Data Sets

The three analyses presented in this thesis – macro, meso and micro – will be conducted using three different data sets. The macro level analysis will be undertaken using the Sydney Household Travel Survey (HTS), which is a three year rolling survey of approximately 5,000 households. The meso level analysis will be conducted using a data set which is a selection of census collector districts (CDs) from the 2001 Census of Population and Housing, which contain higher density housing¹. This data set provides a socio-economic profile of individuals and households in higher density CDs in Sydney. The third data set which will be used for the micro level analysis is also from the 2001 Census of Population and Housing, but is a specialised matrix requested from the Australian Bureau of Statistics (ABS) which provides a socio-economic profile for the different modes of transport from the Census journey to work data base.

¹ In this thesis the data refer to higher density housing as flats of 4 or more storeys.

1.5 Methodology

The first data set is a sample of households in Sydney, which will be used to provide a socio-economic assessment of the transport modes of individuals across the metropolitan area. This will provide a macro-level analysis of trip patterns in Sydney. A descriptive analysis, including tables and charts will be provided of the Sydney HTS, which will set the scene for the meso and micro level assessments.

The second data set will be used in a multiple regression analysis to examine the influence different socio-economic variables and residential densities are having on train use in the Sydney metropolitan area. The multiple regression analysis is a statistical technique that will be used to identify the influence of a number of socio-economic variables on train use. This analysis will complement the macro level analysis from the first data set and the micro level examination presented from the third data set. The second data set can be spatially represented and as such the analysis will be able to ascertain whether density is an important influence as distance from a railway station increases.

The third data set provides an opportunity to begin to explore the variables that are influencing one form of public transport use, namely trains, in different socio-economic areas within the Sydney metropolitan area. This third data set will use five small case study areas – Edgecliff, Cronulla, Liverpool, Fairfield/Cabramatta, St Leonards/Wollstonecraft - of approximately 700-1,100 dwellings each to begin to explore the micro-level relationship between high density housing and train use. A descriptive analysis, including charts and tables, will be provided of this specialised request matrix from the Australian Bureau of Statistics (ABS).

This study initially attempted to examine both bus and train use, however, in the end trains were selected for two reasons. The first is that planning policies over the last twenty years in Sydney have concentrated higher density development around rail

stations rather than major bus interchanges. Current planning policies in Sydney promote buses as feeder services for railway stations. This is also in part, due to the fact that there are significantly more rail stations in Sydney than major bus interchanges, and as we will see later train travel is more often used for longer commutes.

Secondly, in Sydney it is difficult to obtain digital information, for use in a geographical information system (GIS) on the location of bus stations and interchanges, whereas, information on train stations is much easier to obtain. It is also extremely difficult to include buses in the analysis due the limited capacity of a Masters thesis to explore both trains and buses, although this is one area that requires further research. Given these issues the emphasis in this thesis will be on train usage.

This study also considered the use of household surveys to better understand the factors that influence public transport use. However, given the timeframes to complete the thesis the focus was on using existing available data sets. This issue will also be discussed later in the thesis.

1.6 Contribution to Research

There are a number of gaps that exist in our knowledge on the relationship between urban residential densities and public transport use. This study can contribute to a better understanding of these gaps in our knowledge in Sydney, Australia, and to debates overseas. This includes an analysis of the relationship between higher density housing and public transport use (in this case trains) in Sydney at the macro, meso and micro levels, and the implications of these results for urban growth management policies and strategies in major cities. In particular, this research can enhance academic endeavours across the globe which have highlighted the lack of attention to micro-level analyses (Williams et al 2000) while at the same time contribute to the debate on density and public transport use, which is encapsulated in urban growth management strategies. That is, there is little research that has examined the effects of different geographical scales on the purported density-public transport relationship.

Given the recent study by Bunker et al (2005 a and b) that identified a number of different socio-economic housing sub-markets in higher density dwellings in Sydney, and potential planning issues associated with this (e.g. social infrastructure provision), the lack of research on the role of other variables beside density in influencing public transport use in Sydney is a significant omission. Such relationships also aid in the debates about the most beneficial urban growth forms in Sydney.

Further, there are a number of commentators including Mees (2000), Brindle (1996), Stretton (1994), Pund (2001), Troy (1992) and Yencken (1996) who contend that there are other ways of increasing public transport use, rather than focusing on residential density. Not all of other variables that are suggested to increase public transport use can be analysed in this thesis. It is envisaged that the results from this study will aid in those debates, however given the limitations of the data used in this study (e.g. lack of urban design information, parking policies etc) such alternatives will still require further research.

1.7 Thesis Structure

This thesis is divided into four parts. The first part outlines the study including the aims, objectives and methodology used, and the contribution to research this thesis endeavours to address. This part also explores the concept of urban consolidation, its perceived benefits and criticisms before investigating the evolution of urban consolidation policies in Sydney.

Following the introduction, the second part of the thesis reviews the current debates within the literature on the relationship between urban residential density and public transport use, along with the critiques that it has generated. This part provides a literature review and also sets the context for the analytical component of the thesis which is presented in part three.

The third part of the study, therefore, assesses the relationship between urban residential density and public transport use at the three different spatial scales – macro, meso and micro. The analyses, while complimentary, use a number of techniques and methods to ascertain the influence of density on public transport use (in this case trains) at the different spatial scales.

Finally, part four of the thesis concludes with a discussion of the results obtained and the outcomes of the research for both academics and urban policy makers, and where future research is needed. The findings of the study regarding the relationship between urban residential density and public transport use, and the implication for urban growth management policies in Sydney are enunciated.

2. THE CONCEPT OF URBAN CONSOLIDATION

2.1 What is Urban Consolidation?

Urban consolidation is a term that has, historically, had various definitions both in Australia and overseas (Michell and Wadley 2004, Collie 1990). Although definitions differ slightly between authors most current debates surrounding urban consolidation generally use the term to refer to the building of multi-unit dwellings in order to increase the proportion of residential dwellings in a particular area or locality. That is, urban consolidation refers to increasing residential densities. This can occur in both the current urban area (infill or brownfields development) or in new residential developments on the urban fringe (greenfields development). For example, in 1984 the NSW Department of the Environment and Planning (DEP) defined urban consolidation as (p. 1):

[I]ncreasing the density of dwellings or population, or both. It does not refer to one single policy, but rather a number of related land use measures and housing initiatives that can increase residential densities.

In other parts of the world urban consolidation is also referred to as ‘compact cities’, ‘urban compaction’, ‘urban intensification’ or ‘re-urbanisation’ (see Collie 1990, Roseth 1991, Burton 2000). These terms are used interchangeably within the literature but have a similar meaning to that of urban consolidation.

This thesis, however, will refer to urban consolidation as the increasing of residential densities within the existing urban area. This is because the majority of urban consolidation in Sydney has occurred within the existing metropolitan area.

2.2 The Perceived Benefits of Urban Consolidation

Urban consolidation is the centre piece of planning and urban growth management strategies and policies in most of the major cities in Australia. Historically urban consolidation has been seen as a panacea for the problems associated with urban sprawl (Bunker 1983), although in recent years the purported benefits of urban consolidation have been expanded to address environmental concerns. Advocates of urban consolidation initiatives contend that there are a number of benefits (see Holliday 2000, Holliday and Norton 1995, Collie 1990). This includes:

1. The minimisation of land take for new development thereby reducing the encroachment of urban areas into agricultural land.
2. The reduction of urban sprawl and its perceived problems including increased car travel and high car dependency.
3. An increase in the supply of affordable homes (higher density housing is cheaper than detached housing).
4. Revitalise older established areas predominantly in inner city locations.
5. Improved infrastructure efficiency by using spare capacity in the current system, thus reducing the costs of providing new infrastructure on the fringe.
6. Increased dwelling variety and choice.
7. Reduced environmental impacts of urban development (e.g. air pollution and reduced water quality).
8. Provide smaller dwellings for smaller households.
9. Increasing the accessibility of populations to transport and services (that is, consolidating around public transport nodes is expected to increase public transport usage).

These 'benefits' are promoted in a number of current metropolitan planning strategies in Australia including Sydney, Melbourne, Brisbane and Adelaide (Michell and Wadley 2004, Buxton and Tieman 2004 and 2005, Planning SA 2007, Department of Infrastructure VIC 2002, Department of Local Government, Planning, Sport and

Recreation QLD 2005). These strategies have been prepared by each of the relevant State governments in Australia rather than being imposed by the Federal or National government, as in other countries (see Dieleman et al 1999). In contrast, initiatives in the early 1990s, including the Building Better Cities Program, the Australian Model Code for Residential Development (AMCORD)², a House of Representatives Standing committee report on future settlement patterns, The National Housing Strategy initiative, a few transport reports from the then Department of Housing and Regional Development, National Capital Planning Authority and Australian Urban and Regional Development Review (AURDR), little has been produced at the National level on urban consolidation (see Troy 1996, Black 1996). In fact, the role of urban consolidation in the development of Australian cities has only rated a brief mention in one recent report, that of a House of Representatives Standing Committee on Sustainable Cities in 2005. Despite this State governments in Australia continue to promote increasing residential densities within the largest cities.

There are a number of commentators, however, who suggest that the proposed benefits of urban consolidation mentioned above are questionable (Troy 1996, Breheny 1997, Lewis 2000, Burton 2000, Searle 2004a, Wulff et al 2004, Birrell et al 2005). In fact, the Federal House of Representatives Standing Committee on Sustainable Cities comments on the lack of research and understanding surrounding urban consolidation (House of Representatives Standing Committee on Environment and Heritage 2005). Nevertheless, urban consolidation strategies are still commonplace in Australian cities.

² AMCORD (Australian Model Code for Residential Development) was released in 1995 and provides technical advice on best practice in residential development and design at that time. The document was developed at a national level but acknowledges the states need to adopt and adapt the approaches presented in the document.

2.3 The Outcomes of Urban Consolidation

At the 2001 Census there were 556,705 multi-unit dwellings³ in the Sydney Statistical Division (Table 2.1). This represented 36% of the total dwelling stock in Sydney at this time. Since 1981 the number of multi-unit dwellings in Sydney has increased by approximately 10,600 dwellings each year. The proportion of multi-unit dwellings has only increased by 6% since 1986 as a proportion of the total housing stock, although the number of multi-unit dwellings has increased by 61% between 1981 and 2001. Conversely, the proportion of separate houses has declined by 4% between 1981 and 2001 as a proportion of the total stock. Between 1996 and 2001 the number of multi-unit dwellings in Sydney increased by 98,382 whereas the number of separate dwellings increased by 56,066, nearly half of the increase in multi-unit dwellings.

Table 2.1: The number and proportion of separate houses and multi-unit dwellings in Sydney Statistical Division, 1981-2001

(Source: ABS Various Censuses; Urban Frontiers Program 2001)

	Separate House	Proportion of Total Dwellings	Multi-Unit Dwellings	Proportion of Total Dwellings	Total Dwellings	%
1981	765,449	66.7%	344,717	30.0%	1,147,650	100.0%
1986	822,839	66.9%	366,846	29.8%	1,230,399	100.0%
1991	874,040	66.5%	410,861	31.3%	1,314,167	100.0%
1996	904,931	64.0%	458,323	32.4%	1,413,953	100.0%
2001	960,997	62.1%	556,705	36.0%	1,546,691	100.0%

Notes: Total dwellings includes other dwellings (caravans, cabins, houseboats etc) and improvised dwellings

At the local level, multi-unit dwellings in Sydney are concentrated in the inner city, eastern suburbs, lower north shore and along the rail lines to west and south west (Figure 2.1 and 2.2). Between 1981 and 2001 there has been an increase in the proportion of

³ Multi-unit dwellings includes semi detached dwellings, townhouses, villa units, duplexes, flats and units, and other attached dwellings.

multi-unit dwellings in the inner city, the inner west, around Parramatta and along the railway lines in the west and south west (see Figures 2.1 and 2.2). Figures 2.1 and 2.2 also show that the planning policies that have targeted higher density growth in Sydney around railway lines (and other transport nodes) over the last twenty years have been successful. That is, there is a clear increase in the proportion of multi-unit dwellings (or increasing densities) around railway stations in Sydney.

Figure 2.1: Multi-unit dwellings in Sydney by CD, 1981

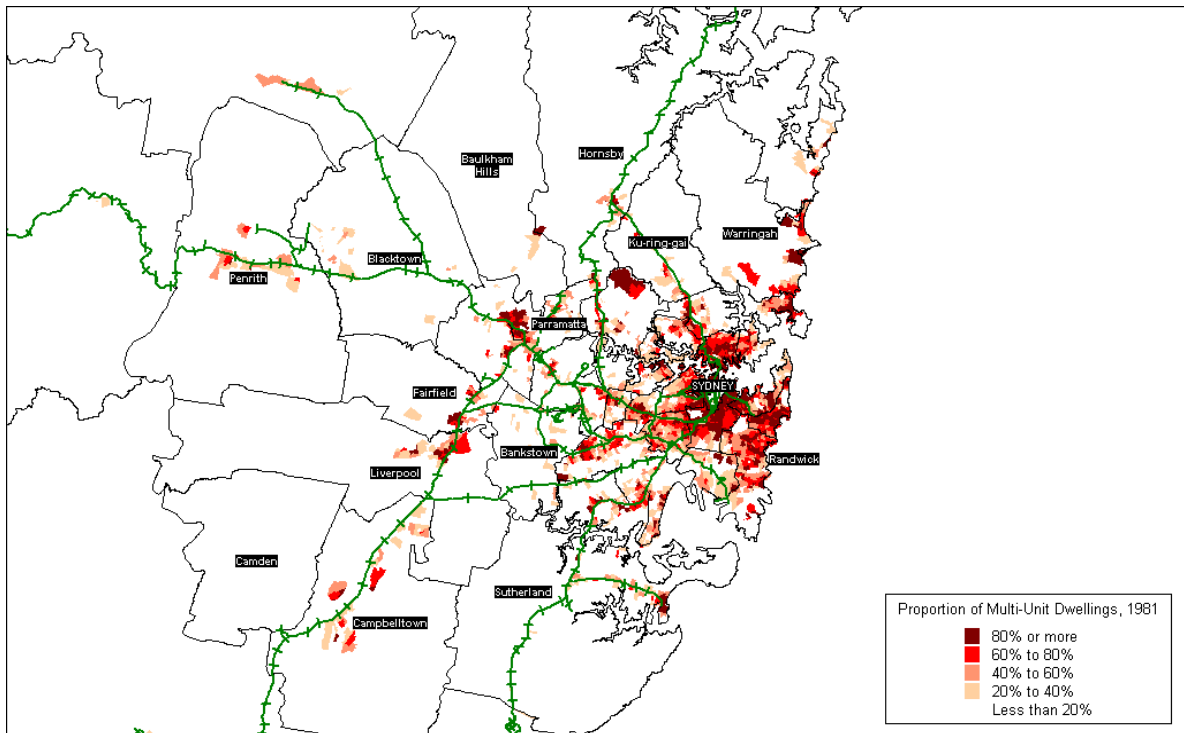
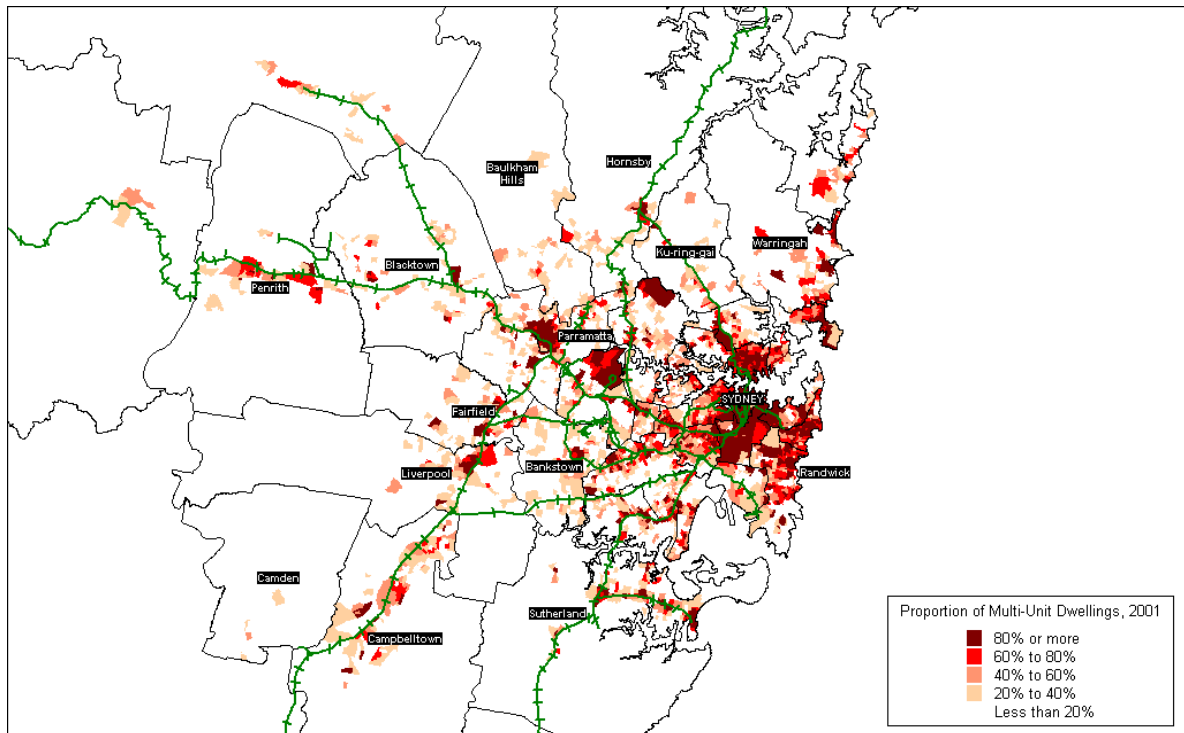


Figure 2.2: Multi-unit dwellings in Sydney by CD, 2001



Nevertheless, the increasing concentration of higher density dwellings across the Sydney metropolitan area over the last twenty years has created a number of sub-markets within this sector. In 2005 Bunker et al (2005a and 2005b) examined how the higher density housing market in Sydney had been segmented spatially as well as socio-economically. In their studies, Bunker et al found six distinct socio-economic submarkets (or segments) in the higher density housing sector in Sydney. The authors identified these six segments through a factor analysis conducted at the census collector district level with the first factor being more important (i.e. explaining more of the variance within the higher density sector) than the second, the second being more important than the third, and so on.

The first submarket identified by Bunker et al (2005a and 2005b) was dominated by low income households in rental accommodation and contained a significant proportion of immigrants from non-English speaking countries. This sub-market was geographically

concentrated in the south and western parts of the metropolitan area. The second higher density housing sub-market identified by Bunker et al was dominated by higher income households who lived in the inner city, east and northern parts of the Sydney metropolitan area. The other higher density housing segments identified by the authors were dominated by younger populations, public housing and the semi detached dwelling sector of private and public tenants.

Importantly, the Bunker et al studies identify the need to explore the relationship between higher density housing and public transport at a local level. As we will see below (Chapter 3) there are many commentators who argue that socio-economic factors are imperative in explaining the link between higher density housing and transport usage. The results discovered by Bunker et al imply that if socio-economic variables are an important determinant of housing sub-markets in Sydney then the implications for the levels of public transport use within localities may be influenced by the characteristics of these sub-markets. This is important if planning policies are being prepared at a macro level where such nuances may not be investigated. Whether this is the case or not will be explored later in this thesis. It is evident though from the current metropolitan strategy in Sydney that the socio-economic characteristics of households in different parts of the metropolitan area will only be considered at the local level through local government planning strategies and are not considered as part of the broader metropolitan strategy. The metropolitan Strategy also emphasises that the building of higher density dwellings around public transport nodes will lead to increased patronage. Other factors are not considered despite an abundance of alternative theories on how to increase public transport usage.

2.4 The Evolution of Urban Consolidation Policy in Sydney

The current metropolitan strategy for Sydney – *City of Cities*, is the latest urban growth management policy in Sydney and follows a history of planning initiatives in Sydney aimed at increasing residential densities. The development of urban consolidation policy in Sydney has occurred in a number of distinct stages (Searle, 1998). The Urban

Frontiers Program (2001) classifies the development of consolidation policy in Sydney into 5 distinct stages:

Pre-1968	Early managed containment
1968-1980	Managed urban expansion
1980-1988	Initial densification – dual occupancy
1988-1993	Policy intensification
1993-2000	Complexity and local determination

For the purposes of this study the classification used by the Urban Frontiers Program (UFP) (2001) will be used, with the last stage being expanded to the present to incorporate the recent release of *City of Cities*. A detailed list of urban consolidation policies and initiatives in Sydney is presented in Appendix 2 (see also Freestone 2000).

Stage 1: Early contained management - Pre 1968

One of the earliest attempts to plan for growth in Sydney was developed at the 1909 Royal Commission into the Improvement of the City of Sydney and Suburbs (Spearritt, 1978). Most of the proposals presented by The Royal Commission were concerned with urban transport (such as the underground railway in the city) and focused more on suburbanisation rather than consolidation. Nevertheless, one of the important planning regulations in Sydney that developed from it was the *Local Government Act* in 1919, which guided residential development in Sydney for a number of years following its introduction.

During the 1920s and 1930s there was a development boom which resulted in a large increase in flats in Sydney (Butler-Bowden 2007, Cardew 1970). Flats comprised 41 per cent of all new dwellings built in Sydney between 1933 and 1941, with most of these being for rental (Spearritt 1978). During this period there was no need to link flat developments to accessible transport, although a significant majority of the flats constructed during this period were located in the eastern suburbs and lower north shore

of Sydney, not far from the city centre. Many of these flats were well designed, although a small number were poorly designed (see Butler-Bowden 2007), which resulted in a public outcry for flats to be more adequately regulated. These concerns lead to the amendment of the *Local Government Act* in 1940. Schedule 7 was inserted into the Act which sought to instigate development controls for flat buildings (e.g. floor size, their site coverage and setbacks). Importantly, Schedule 7 generally controlled residential flat development across Sydney until the mid 1980s, and was arguable, the first broad-brushed policy response to early concerns about flat developments in Sydney.

It was not until 1948, however, when the Cumberland County Council (an authority established by the NSW State Government) introduced the County of Cumberland Plan that Sydney had any comprehensive planning framework. The principle methods used in the plan to achieve its objectives were co-ordination, consolidation and conservation (Winston 1957). One of the key outcomes of the Plan was the attempt to control the physical expansion of Sydney through a Green Belt. The Green Belt was meant to halt urban expansion, and encourage development in the existing metropolitan area at a time when infrastructure provision could not keep pace with growth. Ironically, this issue is still important in urban consolidation debates today.

As far as transport was concerned the County of Cumberland Plan focused solely on infrastructure provision (Winston 1957). That is, the plan emphasised the need to continue to improve rail and road infrastructure to reduce congestion in the city centre and move away from the radial nature of Sydney's transport system. This also included the proposal to develop suburban sub-centres to take the pressure of the city centre. Interestingly, this 'centres and corridors' approach is still one of the emphases of the current Sydney metropolitan strategy. However, the County of Cumberland Plan did not recommend the integration of land use and transport. It was not until the 1968 Sydney Region Outline Plan (SROP) that such initiatives were proposed.

By the late 1940s the notion of a more 'compact' city was being invoked to control urban growth and the costs and efficiency of urban infrastructure. The 'compact' approach was

also intended to maintain open countryside within a reasonable distance of urban areas (Winston 1957). The Green Belt, however, contained land suitable for development and it soon came under pressure from a variety of interests to be developed. By the mid 1950s given that some of the land within the designated Green Belt was already subdivided the Green Belt policy was eroded by encroaching development and a new plan was required.

Stage 2: Managed urban expansion – 1968 to 1980

In 1964, the NSW State Government replaced the Cumberland County Council with the State Planning Authority (SPA)⁴. By 1967 the SPA noted residential demand was exceeding supply and it was difficult to provide infrastructure and services to keep pace with this demand (SPA 1967). In 1968 there was a fundamental shift in the focus of metropolitan growth towards managed and staged urban expansion in Sydney through the release of the Sydney Region Outline Plan (SROP) by the SPA. The SROP was based on a number of assumptions and the seven guiding principles of SROP were broad in nature. Similar to the County of Cumberland Plan, SROP identified the need to reduce traffic congestion in the inner city particularly through the expansion of road and rail infrastructure as well as proposing the development of suburban sub-centres to promote employment opportunities outside the Sydney CBD. SROP also put forward the notion of building 35% of new dwellings at higher densities in the existing urban area and along existing rail and road corridors, however, in the event this idea was dismissed as being ‘rather a high proportion’ (p. 25) and it was not adopted.

By the mid 1970s Sydney had witnessed a second major boom in the development of flats following the 1920s boom. Spearritt (1978) notes that between 1954 and 1973, 153,800 flats were built in Sydney. This was 32 per cent of all new dwellings in Sydney during

⁴ Planning departments in NSW have undergone a number of name changes over the years. This includes the Cumberland County Council 1945-1964, State Planning Authority 1964-1974, Planning and Environment Commission 1974-1980, Department of Environment and Planning 1980-1988, Department of Planning 1988-1995, Department of Urban Affairs and Planning 1995-2001, Department of Planning (Planning NSW) 2001-2003, Department of Urban Transport and Planning 2003, Department of Planning Infrastructure and Natural Resources 2003-2005, Department of Planning 2005-present.

this time, although the majority were occupied private renters. Spearitt (1978) also notes that the major driver of the boom in flat development was the introduction of the Strata Titles Act, which allowed individual ownership of flats.

Although the preparation of SROP in 1968 sought to manage growth in Sydney, however, the political and economic climate of the mid to late 1970s caused a re-examination of urban growth policies, particularly in Sydney (Searle 1998). Searle (1998) contends that three issues explained the realigning of views on urban growth during this time. This included:

1. The Oil Crisis of the mid 1970s raised concerns over the costs of urban expansion and the high levels of petrol consumption associated with an expanding city and therefore increasing journey to work distances.
2. A change of Federal government in 1975 (what Searle refers to as Post 1975 New Federalism) saw a decrease in the amount of money provided to the States by the Federal government.
3. During the late 1970s and into the early 1980s the NSW government channeled significant funds into major infrastructure projects to capture coal and aluminum investments.

It was also during this time that the early environmental movements and urban design renaissance forced a re-think of the city's built form. All these factors lead to the development of what is now referred to as urban consolidation policy during the early 1980s, although numerous flats has already been constructed in Sydney. At this time, urban consolidation was as a panacea for a number of issues, particularly as a way to save on the costs of providing infrastructure in new developments on the urban fringe (see also Searle 2004b). Nonetheless, there was little intention at this stage to the promotion of higher densities around public transport nodes.

Stage 3: Initial densification through dual occupancy developments – 1980 to 1988

In 1980 the then NSW Planning and Environment Commission (PEC) under the auspices of the new NSW Department of Environment and Planning (DEP) reviewed the Sydney Region Outline Plan of 1968 (NSW Planning and Environment Commission 1980). It is quite clear from the report released from the PEC that there were major changes in the economic, demographic, environmental and political spheres in Australia that forced a review of the SROP Plan of 1968. The PEC report was quite critical of SROP in certain areas, particularly in policies and proposals relating to transport. The PEC report encouraged higher density development in the existing urban area, as well as increasing densities in new development on the fringe. This view was articulated through the need to revitalize the inner city which had been witnessing a decline in population, the need to be more environmentally savvy through encouraging greater use of public transport and the economic difficulties in providing new infrastructure on the fringe.

Undoubtedly, the PEC report set the scene for a change in direction of urban growth management policies in Sydney that emphasised urban consolidation in the existing area, rather than the staged expansion of the metropolitan area as evidenced under the SROP. Further, unlike the County of Cumberland Plan, green belts or urban growth boundaries were not presented as a means to encourage consolidation. As we shall see below other mechanisms were prepared to strongly encourage local councils to plan for higher density development.

Although, flats had previously been developed in Sydney the current State planning policies that exist under the rubric of ‘urban consolidation’ are identified as being linked to the 1981 Sydney Regional Environmental Plan No. 1 (REP No. 1) and REP No. 2 (Urban Frontiers Program, 2001). These two REPs allowed dual occupancies to be built in existing residential areas. They allowed the addition of an attached dwelling to an existing house or the conversion of an existing house into two dwellings (DEP 1984).

These original urban consolidation policies developed during the early 1980s were designed to increase densities gradually while maintaining the existing character of neighbourhoods, and these broad-brush policies were designed not to upset local Councils who were resisting such initiatives. The broad-brushed nature of the policies meant that particular targets or numbers of higher density dwellings were not identified, and development was not aligned to transport nodes. This is interesting given the DEP at the time considered local councils were not pulling their weight in providing areas for multi-unit development.

By 1984 the aims of urban consolidation policy were to (DEP, 1984):

- Reduce the rate at which the cost of housing was rising
- Contain the cost of urban expansion by utilising spare capacity in existing infrastructure
- Meet the changing nature of housing demand by increasing the variety of dwelling types available in all areas
- Enable additional housing to be built in accessible locations
- Reduce the rate of urban expansion as the opportunities for peripheral growth are limited in Sydney.

It is generally acknowledged that the dual occupancy policies introduced in the early 1980s (REP No. 1 and No.2) did not bring about the desired result of a marked increase in density within existing urban areas (Bunker 1983, Searle 1998). As a result the State government developed a Draft State Environmental Planning Policy (SEPP) on medium density housing in 1982. This met with stiff opposition from local Councils in some areas (Bunker, 1983) and the SEPP was dropped in favour of an alternative approach. This alternative approach involved an informal target of 12,000 medium density dwellings to be constructed across Sydney between 1981 and 1986 (Searle, 1998).

During the 1980s, the NSW Government fine-tuned some existing policies as well as introduced a number of other urban consolidation initiatives in an attempt to get the desired increase in densities that the state deemed appropriate (see Appendix 2). By

1986, it had become apparent though that the State level controls on flat development in Sydney were still based on the framework set out in the 1940 Schedule 7 of the *Local Government Act* and needed to be amended. A number of new policy developments were then gazetted. In particular, SEPP No. 25 in 1987 (Residential Allotment Sizes) reduced the minimum allotment size for residential subdivision to 450 square metres.

Between 1980 and 1988 urban consolidation saw the introduction of State level controls which over-rode local level controls. Initial policies were broad-brushed and designed to increase densities, as well as, being designed not to offend local Councils. Some Councils gained exclusion from these policies, although this was short lived as a new Metropolitan Strategy was formulated in 1988 to further increase residential densities.

Stage 4: Policy intensification – 1988 to 1993

The next major planning policy in Sydney was the 1988 Metropolitan Strategy *Sydney into its Third Century* (DEP 1988) which was dominated by the view to promote urban consolidation. The strategy set a target of 6,000 multi-unit dwelling commencements per year in existing areas, much higher than the previous target of 12,000 over 5 years. Importantly, this metropolitan strategy encouraged development of higher densities in corridors and town centres adjacent to public transport nodes. This is something that previous policies failed to emphasise, despite a similar view being expressed in the SROP of 1968.

The 1988 strategy particularly emphasised increasing residential densities around railway stations. Like the PEC a few years earlier this new metropolitan strategy for Sydney emphasised the need to promote urban consolidation as a means to use spare capacity in existing infrastructure.

Despite the release of the 1988 Metropolitan Strategy, later in that year a key development in urban consolidation policy in Sydney emerged. In 1988, the then Minister for Planning set up a public inquiry into urban consolidation. The inquiry

specifically examined SEPP No. 5 (Housing for Aged and Disabled Persons), SEPP No. 25 (Residential Allotment Sizes) and REP No. 12 (Dual Occupancy). The inquiry reported in early 1989 in what is known as the Simpson Report (Smith 1997). Overall, the inquiry concluded that there was a need to have all three of the planning instruments. Importantly, the Simpson Report concluded that a SEPP on urban consolidation should be developed, although local circumstances should also be taken into account.

The State government accepted many recommendations of the Simpson Report, and by 1993 had implemented or amended a number of policies including SEPP No. 28 (Town Houses and Villa Houses), Amendments to SEPP No. 25 in 1991 permitted the creation of a second title for a dual occupancy and in 1992 permitted the permanent subdivision of dual occupancy developments.

The changes that resulted from the Simpson Report, and the 1988 Metropolitan Strategy for Sydney represented a key turning point in the direction of urban consolidation policy in Sydney. The changes to dual occupancy regulations (allowing subdivision) increased dual occupancy applications. Nevertheless, during this period a number of higher density forms, as well as townhouses and villas were being promoted in a major expansion of urban consolidation policy in Sydney. As we seen in Figures 2.1 and 2.2 this suite of policies had the desired affect of increasing residential densities around railway lines.

Stage 5: Complexity and Local Determination – 1993 to 2004

Since 1993 there has been a wide diversity of initiatives from the NSW Government to increase residential densities in Sydney. There has been a greater variety of policy assistance from the State government including design guidelines and controls (e.g. SEPP No. 65). Importantly though, the approach to urban consolidation since 1993 has been the targeting of development around transport nodes and in town centres, and along major road corridors. There is also an emphasis on linking higher density development to public transport hubs.

In 1993, the then Department of Planning (DoP) released *Sydney's Future: A Discussion Paper*, which outlined a potential new approach to metropolitan planning in Sydney, overhauling the 1988 metropolitan planning strategy (DoP 1993). This discussion paper re-iterated the majority of initiatives put forward in the 1988 strategy. However, this new discussion paper promoted the construction of multi-unit dwellings at an even greater rate. The proportion of new multi-unit dwellings was proposed to increase from 40% of all new development to 65% by 2011. The discussion paper did propose the development of an integrated transport strategy which was later released in draft form as a separate strategic document by the NSW Department of Transport in 1993. The *Integrated Transport Strategy* was finally released in 1995, along with the *State Road Network Strategy* and the *State Rail Strategic Plan* in 1994. Despite attempts by the NSW State Government to promote these strategies as an improvement on previous attempts to integrate land use and transport, a number of criticisms were reported. In particular, the transport strategy was seen as a separate piece of work and in no way linked to the broader metropolitan strategy (Western Sydney Regional Organisation of Councils 1994).

A change in government in NSW in 1995, however, brought about two important statutory changes that impacted on urban consolidation policy. SEPP No. 25 was amended with dual occupancy subdivision controls given back to local councils. Also in 1995 the change in government saw the NSW Department of Planning (DoP) release the metropolitan strategy *Cities for the 21st Century*. This latest strategy confirmed that 65% of all new dwellings to be constructed were to be multi-unit, but also that new release or greenfields development had to be at least 15 dwellings per hectare (dwgs/ha), up from 10 dwgs/ha. The Strategy also encouraged: multi-unit development around public transport nodes and in town centres; mixed commercial and residential development in major centres, including shop top housing; medium density dwellings in existing residential areas; and the Strategy also emphasised the importance of promoting good urban design.

Despite the changes made by the incoming state government in 1995, in 1997 the NSW Department of Urban Affairs and Planning (DUAP) released *A Framework for Growth*

and Change: The Review of Strategic Planning for the Greater Metropolitan Area. The review expressed many of the underlying rationales for urban consolidation (housing diversity, accessibility, savings on infrastructure). Importantly though, the review brought forward the underlying principles that had evolved as the rationale for urban consolidation over many years to become the underlying policy for metropolitan planning as a whole in Sydney (Urban Frontiers Program 2001). That is, by the mid 1990s, the perceived advantages of building a more compact city were encapsulated into overall urban growth management in Sydney rather than as a specific element.

The notion that a compact city was the future of urban growth management policies in Sydney was further articulated in 1997 with the release of SEPP No. 53 – Metropolitan Residential Development. This SEPP aimed to pull together all the existing urban consolidation policies into one document. One of the major outcomes of this policy was that, for the first time, local Councils were required to develop Residential Strategies. The principle aim of SEPP No. 53 was to ensure that local government managed their residential development in a manner responsive to State government policy frameworks (i.e. dwelling targets) with local strategies encouraged to promote higher densities around public transport nodes (Urban Frontiers Program 2001).

Nevertheless, in late 1998, another metropolitan strategy for Sydney– *Shaping Our Cities* – was released. This strategy attempted to manage urban growth in Sydney, Newcastle and Wollongong. The strategy was developed around four main areas or sections – the environment, homes, work and travel – each with its own set of objectives and strategies. Underlying the section on ‘homes’, and implied in other sections, of the strategy was the need to continue pursuing urban consolidation strategies in Sydney. The strategy noted that between 1981 and 1991 the population of the Sydney region grew by 9 per cent, but that during the same period car use increased by 20 per cent. As such, part of the strategy was ‘reduced reliance on new fringe areas for housing coupled with the need to moderate the growth in car use will require unprecedented efforts to consolidate existing urban areas, improve accessibility and contain the cost of housing’ (pg. 18).

The Strategy reiterated the need to give priority to transport and land use interactions and to reduce car use through higher density development around railway stations. In fact the 1998 Strategy acknowledges that one of the achievements of the State government at this time was that ‘75-80% of the recent population increase in inner and middle ring suburbs of Sydney has been within 1 km of a rail station’ (p. 24). Further, the Strategy set a target of 65% of all new development to be multi-unit.

Nonetheless, it was not until 2001 when the State government released its *Integrating Land Use and Transport* (ILUT) policy (Transport NSW 2001) that an articulated strategy to integrate both land use and transport was prepared. The ILUT was formalized with the release of draft SEPP 66 in 2001 which aimed to better integrate land use and transport planning at the local level. The ILUT still remains government policy although the SEPP has never been finalised. Part of the SEPP is incorporated into the 2005 Metropolitan Strategy which also refines some aspects of the previous ILUT. Other parts of the ILUT are subsumed into a Ministerial Direction (called a Section 117 Direction) which will provide guidance to Councils on the zoning of retail and commercial activity.

In sum, the period between 1993 and 2004 witnessed a plethora of urban consolidation policies in Sydney and a number of metropolitan strategic documents. The period marked an important step in the development of consolidation policy in Sydney. Urban consolidation policies changed from being one of a number of growth management strategies to underpinning metropolitan growth initiatives. Policies were developed at the state level to compel local councils to pursue urban consolidation initiatives, although some local detail was left up to councils. Consolidation policies at this time also articulated the integration of higher density housing with public transport nodes.

2.5 The Current Sydney Metropolitan Strategy

In early 2004 the NSW State government announced that it was about to commence preparations for a new metropolitan strategy in Sydney. In May 2004 the NSW government released a Ministerial Directions Paper outlining directions that the new

metropolitan strategy was to take (Department of Infrastructure, Planning and Natural Resources 2004a). Some of the Directions included:

- Between 60-70 per cent of development should occur in established areas, predominantly in centres and corridors;
- Only release Greenfield land where developers help provide infrastructure and meet a set of sustainability criteria/benchmarks;
- Prioritise infrastructure to ensure continued jobs growth in strategic employment locations, including Sydney's 'Global Arc'⁵;
- Provide a mix of housing and employment in new development areas;
- Maintain and improve the management of the existing transport system;
- Ensure urban design and planning policy discourages car travel where alternatives exist;
- Direct growth and development to town centres where there is capacity at rail stations and interchanges;

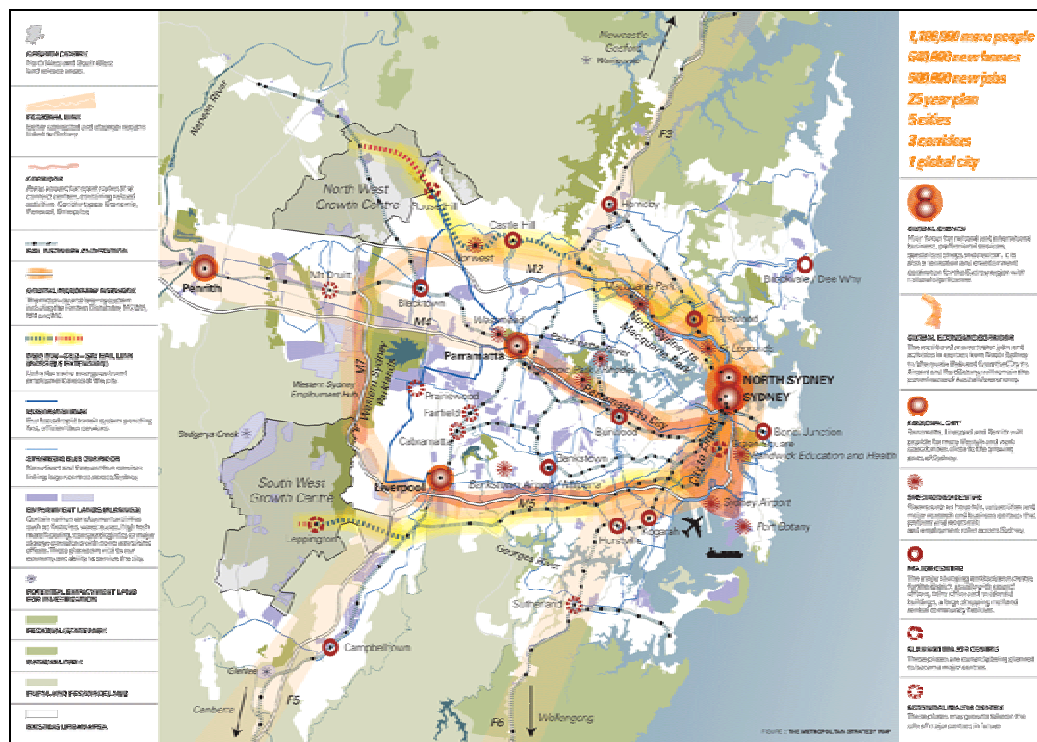
As can be seen by some of these 'directions' the role of urban consolidation, particularly around existing transport nodes, was a major element of the proposal.

In September 2004, the NSW government released a metropolitan strategy discussion paper (Department of Infrastructure, Planning and Natural Resources 2004b). Most of the emphases and initiatives discussed in this paper were similar to the ones presented in the Directions Paper in early 2004. In December 2005, the NSW government released its new Metropolitan Strategy (Department of Planning 2005). Interestingly, little had changed since the earlier Discussion Paper and Ministerial Directions Paper in 2004. The Strategy emphasises future development in corridors and centres. There will be five important cities (or sub-centres) within the Sydney metropolitan area. Sydney and North Sydney (or Global Sydney) will continue to be the major focal point. However, there will

⁵ The 'global arc' is a term used to describe a geographical area in Sydney in which a large number of high tech industries and business and financial services are concentrated that are important for Sydney in its role as a global city. This area runs from Macquarie Park (North West of the CBD), to the CBD and then south to the Airport and Port Botany (see Figure 2.3).

be three regional cities (or River Cities) – Penrith, Liverpool and Parramatta. There will also be 11 Major Centres which will also be required to provide higher density housing. There will also be three strategic corridors that are concentrated around transport nodes which will be the focus of employment activity. This includes Parramatta to the City (along Parramatta Road), Liverpool to the Airport (along M5 motorway) and the Macquarie Park-North Sydney-City-Airport Corridor (Global Arc).

Figure 2.3: The Global Corridor and Elements of the Sydney Metropolitan Strategy
(source: NSW Department of Planning 2005)



The current metropolitan strategy contends that it differs from previous metropolitan strategies in Sydney by articulating targets at a sub-regional level rather than metropolitan level targets. The development of sub-regional strategies is a new layer of planning being developed in Sydney as part of the metropolitan strategy. These ‘meso’ level plans will be developed from which local level plans by councils will be prepared. The strategy clearly states that future employment and residential development should be

linked and built around existing transport nodes. However, the strategy is somewhat contradictory in the fact that while employment is being concentrated in the Global City, three Regional Cities and 11 Major Centres, some 70% of future residential development in the existing urban area will be outside of these areas. The strategy basically contends that these areas will be linked to rail stations by bus feeder services. Currently, 43% of housing in Sydney is within a transit node (within 800 metres of a rail station or 400 metres from a high frequency bus service) but this is planned to increase to 66% by 2013, not even half way through the strategy's time frame. Whether this increases public transport use in Sydney is debateable. Nonetheless, similar concerns have also been raised about the short timeframes to increase higher density housing in Melbourne metropolitan strategy (Hodgetts 2003, Birrell et al 2005).

2.6 Overview

It is clear from the latest Sydney metropolitan strategy that urban consolidation is still the major tool for managing urban growth in Sydney. In 1968 SROP encouraged higher density housing but dismissed a target of 35% of all residential construction to be multi-unit dwellings as too high. SROP also promoted policies that integrated land use and transport planning. By the 1980s it was evident that urban consolidation policies were being promoted in Sydney as a means of reversing population losses from the inner city as well as addressing economic and environmental issues at that time. This initiated a suite of urban consolidation policies that were broad-brush in nature. In the mid 1990s the role of urban consolidation in urban growth management strategies in Sydney changed from being part of a suite of policies to one that underpinned growth management policies across the city (see also McGuirk 2005). The current Metropolitan Strategy confirms the NSW State government's commitment to urban consolidation and the priority given to the building of higher density developments around railway stations. While town centres and road corridors are also being targeted as sites of consolidated development it is clear that railway stations are the preferred option.

Throughout this period there has also been a significant amount of academic debate on the merits of pursuing an urban growth management policy emphasising urban consolidation. The work presented by the pro-consolidation advocates (or centrists as Breheny calls them) have been influential in the development of urban consolidation policy in Sydney. This is despite a vast array of criticism from academics and policymakers on the actual benefits that accrue from pursuing urban consolidation initiatives. At the macro or metropolitan level the link between higher density housing and increased public transport use may seem plausible, and a reason why it is adopted in Sydney, but the lack of research and its ambiguous nature at the meso and micro levels needs to be clarified.

PART 2: URBAN RESIDENTIAL DENSITIES AND PUBLIC TRANSPORT USE

3. THE RELATIONSHIP BETWEEN URBAN RESIDENTIAL DENSITY AND PUBLIC TRANSPORT

3.1 Introduction

The previous chapter reviewed the range of perceived benefits presented by advocates of urban consolidation policy in Australia. One of these was that urban consolidation around public transport nodes is expected to increase public transport usage. It can be argued that this perceived benefit is the core objective of current metropolitan planning in Sydney. In Sydney, as in other cities, academic research that links higher density housing with increased public transport use has generally provided the support for such planning policies (Breheny 1992) despite the criticisms that this research has encountered.

The notion that consolidating or intensifying residential development around railway or bus stations encourages greater public transport use has been promoted for over thirty years. Early pundits who encouraged such planning policies included Pushkarev and Zupan (1977) and Keyes (1982), although Mees (2000) notes the existence of such policies in Stockholm proceeding World War II. At a broad level, research that promotes the intensification of development as a means to increase public transport seems plausible. Rickwood et al (2008) note that studies in the US that have looked at the US-wide (i.e. between cities) variations have concluded that density matters.

One of the key texts that supports the policy of higher residential densities as a means to increase public transport use is that presented by Newman and Kenworthy (1989, 1999), although there are a number of other researchers, for example Holtzclaw (1994) and Ewing et al (2001), who also support a similar position.

Nonetheless, there are also a number of researchers who question the validity of the relationship between higher density housing and increased transit⁶ use (and therefore decreasing car usage). The criticism leveled at those who support the relationship between higher densities and public transport use generally revolves around the notion that transport patterns are complex and that there are a number of factors which influence individual transport use. That is, there is a multiplicity of factors that encourages an individual to use public transport (Stead and Marshall 2001). The range of factors that are suggested as being important for increasing public transport use include the quality, frequency, reliability and aesthetics of the transport system; the location of employment opportunities; the environmental capacity of motor vehicles; the cultural and historical development of cities; urban structure and design; government policies including taxes, tolls, and other fiscal measures to discourage car use; and socio-demographic factors. Each of these factors has created a stream of research and a brief overview is presented below. However, before this it is important to better understand the debate on the relationship between higher density housing and public transport use.

3.2 Higher Density Development and Public Transport Use – The Supporters

As previously mentioned, support for higher density development as a means to increase public transport use has been identified in academic literature for over thirty years. There are a number of individuals, in many countries, who have presented research to suggest that there is a positive association between higher density housing and increased public transport use. For example, Holtclaw (1994) in the US, ECOTEC (1993) in the UK and Naess et al (1995) in Europe. Nonetheless, the most cited research within this field, particularly in Australia, is that of Newman and Kenworthy (1989, 1999). Newman and Kenworthy's work has extended too many countries and cities, but has been gained a great deal of support in Australia. As Rickwood et al (2008) note '[S]till the most compelling work suggesting a strong link between urban form and energy use is Newman

⁶ Newman and Kenworthy use the word 'transit' to refer to public transport. Both are used interchangeably in this thesis to refer to public transport.

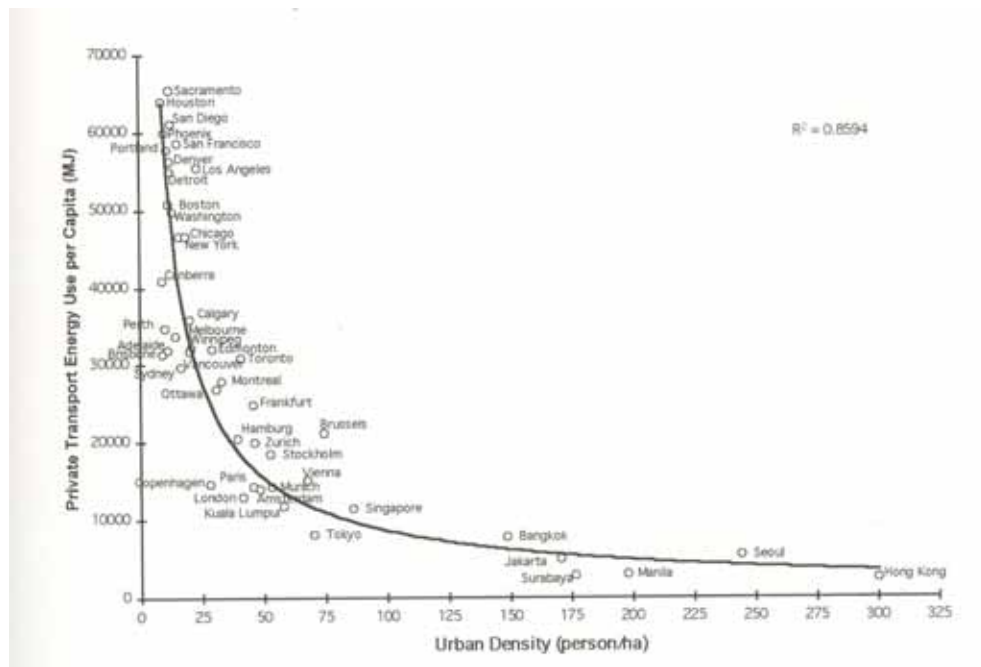
and Kenworthy (1989)...The study is still one of the most comprehensive (in terms of data collection) of any international study on the effect of urban form' (p. 69).

The research of Newman and Kenworthy has a number of different elements, however, their data has been used by researchers and policymakers alike to support the notion that higher densities directly increase public transport use. From an examination of thirty two (32) cities around the world in 1989 Newman and Kenworthy concluded that fuel price and the efficiency of the vehicle fleet explain 40 per cent of the energy consumption in the transportation system, while the remaining 60 per cent can be attributed to the level of urban density (see also Newman et al 1992 and 1995). That is, policies promoting higher residential densities around public transport nodes will encourage individuals to use public transport rather than a motor vehicle. This will, therefore, lead to reduced car usage, which will in turn reduce energy consumption in the transport sector.

Newman and Kenworthy expanded their analysis in 1999 by examining energy use, transport use and urban density in forty six (46) cities in the United States (US), Australia, Asia and Europe (Figure 3.1). Their conclusions in 1999 were similar to that presented in 1989, although they attempted to address a selected number of criticisms that were raised from their earlier piece of work. According to Newman and Kenworthy (1999), fuel use in American and Australian cities constitutes 86% of total transportation energy use, while in Tokyo fuel use only contributes to 44% of total transportation energy use. They contend that the reason for the higher transportation energy use in the 'auto dependent' cities of Australia and America is embedded in the land use characteristics of these cities. In cities like Tokyo and Hong Kong greater walking and cycling and the linking of trips by transit are important in reducing car use, thus building residential development around public transport nodes, particular railway stations, as in Tokyo and Hong Kong, is the most appropriate method for reducing transportation energy use. It should be noted that Newman and Kenworthy also promote other factors (e.g. traffic calming) as being important in increasing public transport use. However, as in 1989, their work in 1999 also concluded that 60 per cent of energy consumption in the transport system is attributed to the level of urban density.

Figure 3.1: The Relationship Between Urban Density and Private Transport Use in Forty Six (46) Cities

(Source: Newman and Kenworthy 1999, p. 101)



Newman and Kenworthy use the term ‘urban villages’ (see Box 3.1) to identify the urban form that is the most appropriate in reducing transport emissions and increasing public transport use. Other commentators use the term ‘transit oriented developments’ (TODs) (Australian Urban and Regional Development Review 1994, Western Australian Land Authority 2005) to refer to a similar urban form. There are a number of key characteristics of ‘urban villages’, however, high densities are a key component.

Box 3.1: Key Characteristics of Urban Villages according to Newman and Kenworthy

(source: Newman and Kenworthy 1999, p. 166)

- High density land uses, especially in the core, so that everything is in walking or cycling distance;
- A mix of land uses so that there is more local activity;
- A heavy rail or light rail station near the core;
- Considerable landscaping and attractive gardens in public spaces;
- A mix of public, private and cooperative housing with an emphasis, where possible, on families and thus large internal spaces and spacious community areas;
- Extensive provisions for children, such as playgrounds and play spaces in view of dwellings for security purposes;
- Sporting facilities;
- Community facilities such as schools, libraries, child care and senior centres (if not within the village, they are always nearby);
- Special areas for secure storage, not only for extra storage space but for other items such as boats;
- Pedestrian and cycle links with parking facilities (parking to be preferably underground) and traffic calming on peripheral roads;
- Public spaces with strong design features (e.g. water, sculptures, street furniture);
- A high degree of self sufficiency in the community to meet local needs, but with good rail and bus links to the wider city for employment, higher education and so on.

3.3 Higher Density Development and Public Transport Use – The Critics

At the broad or macro scale there has been a number of studies that have shown that higher urban densities around public transport nodes increases public transport usage, and therefore reduces transport emissions (Rickwood et al 2008). This simplistic relationship has also been adopted by urban policymakers across the globe.

The concept that urban density is the main driver of increasing public transport use, however, has been criticised by a number of authors. Being one of the key texts in this debate Newman and Kenworthy have also come under criticism. In particular questions have been raised about the statistical basis for Figure 3.1 (Gomez-Ibanez 1991, Brindle 1994 and 1996, Pund 2001, Mindali et al 2004), which is often cited by promoters of the links between density and public transport use. An analysis of the statistical methods

used by Newman and Kenworthy is beyond the scope of this thesis. Suffice to say that as the research of Newman and Kenworthy is one of the most cited pieces of work, particularly, given its global focus, it has come under criticisms from other researchers.

There are a number of other commentators who have examined the impact of density levels on transportation use in particular countries with results varying within and between countries. Bernick and Cervero (1997), for example, contend that the level of public transport is influenced by density but that the largest benefits come from redeveloping low density areas to densities of 10-15 units per acre (25-37 units per hectare).

On the other hand, Stead (2001) suggests there is an upper limited of 50 persons per hectare beyond which density has little impact on travel. Stead's research is important in that it puts an upper limited on the amount of density required to lower public transport usage whereas the work of other researchers (e.g. Bernick and Cervero 1997 and ECOTEC 1993), does not suggest an upper limit but rather minimum levels of density.

Although Newman and Kenworthy is cited by many researchers debating the relationship between density and public transport use they have attempted to examine the role that factors other than density play in influencing transport energy emissions. In particular, they examine variables such as fuel efficient vehicles, type of public transport, and economic instruments (e.g. road and parking pricing). Nevertheless, their contention is that traffic calming, more fuel efficient vehicles, pedestrian and cycling strategies and fuel taxes are important in reducing car use but that these are inadequate on their own and therefore land use/planning mechanisms (i.e. increased densities) are required.

This is an important element of the debate which links urban densities to increased public transport use, and which is cited in the literature as a distinguishing element of the 'urban village' concept, from others such as 'new urbanism' (Katz 1994) and 'smart growth' (Cervero 1996b and 2001). The latter two promote lower transport emissions through higher than average urban densities and urban design features (e.g. pedestrian and cycle

paths that encourage less car use). However, 'new urbanist' developments are often located on the suburban fringe of American cities and are not well served by public transport. Even developments identified in Australia as 'new urbanist' are often poorly served by public transport (Australian Council for New Urbanism, 2006). The 'urban village' concept emphasises development (or re-development) within the existing area (i.e. urban containment) which is sometimes differs to the approach of 'new urbanists'.

In Sydney, as in other Australian cities, the links between higher urban densities and public transport use is promoted in lieu of the potential reductions in transport energy emissions. In their research Newman and Kenworthy conclude that, on average, car travel uses 2.91 megajoules per passenger (MJ/P), bus 1.56 MJ/P, electric heavy rail 0.44 MJ/P, diesel heavy rail 1.44 MJ/P and light rail 0.79 MJ/P. Based on these results urban policy makers in Sydney encourage development around rail stations in order to reduce emissions. They also promote the use of buses as feeder services to rail stations for those households who are not within walking distance from rail station. The Sydney Metropolitan Strategy notes that the Strategy '...addresses environmental protection by concentrating activities around public transport, thereby reducing car reliance and leading to less emissions and pollution, and minimising the urban footprint' (p. 82).

3.3 Alternative Views to the Link Between Higher Density Housing and Public Transport Use

As we have seen the relationship between higher density housing and public transport use has been rigorously debated for over thirty years. There are some researchers who support the notion that higher urban densities around public transport nodes increases patronage and reduces transport emissions, including Steiner (1994), ECOTEC (1993), Holtzclaw (1994), Gollner (1996), Kenworthy and Laube (1999) and Naess et al (1995). There is a large body of work, however, that has been critical of the purported linkages between higher urban densities and increased public transport use, including Gordon and Richardson (1989 and 1997), Brindle (1994, 1996), Troy (1992) and Mindali et al (2004).

Breheny (1996) has referred to this debate as the ‘centrists’ versus the ‘decentrists’. Breheny contends that the views expressed by early commentators such as Ebenezer Howard, Frank Lloyd Wright and Le Corbusier have been reinvigorated over the compact cities debate. Breheny contends that Newman and Kenworthy represent the epitome of the centrists, ignoring the views of decentralisation advocates (the decentrists) such as Gordon and Richardson (1989 and 1997) and Evans (1991). Importantly though, Breheny identifies that the centrists leave a number of questions unanswered in their pursuit of a compact cities agenda.

Nonetheless, the largest string of criticisms that have emerged over the higher density – public transport debate is the view that public transport patterns are more complex than the advocates of the density – public transport debate would suggest. That is, the relationship between urban residential densities and public transport use is complex and that there is a multiplicity of factors that influences public transport use (Stead and Marshall 2001). The range of factors that have been noted in the literature as influencing public transport use includes:

- the quality, frequency, reliability and aesthetics of the transport system (Stretton 1994, Yencken 1996, Mees 2000)
- employment opportunities (Horridge 1994, Bell 1991)
- the environmental capacity of cars (Dudson 2000)
- the historical and cultural development of individual cities (Gerondeau 1997, Wachs 1993, Bovy et al 1993, Schwanen et al 2002)
- urban structure (Schwanen et al 2002, Giuliano and Small 1993)
- urban design principles (Crane and Crepeau 1998)
- other government policies outside of land use policies (Dieleman et al 1999, Cameron et al 2004)
- socio-demographic factors (Hanson 1982, Schimek 1996, Stead 2001);

The role and influence of each of these factors has created a stream of research for each of these individual issues. To detail research for each issue is beyond the scope of this thesis. Nevertheless, the next section presents an overview of the debates within the

individual factors presented above (see also Yigitcanlar et al 2005). Importantly, this overview begins to explore the role of residential density in influencing public transport use and whether the emphasis urban consolidation policies place on this relationship is justified.

3.4 Variables that Potentially Influence Public Transport Use

3.4.1 *The Transport System*

There are a number of commentators who suggest that the most important factor in encouraging individuals to use the train is the quality, frequency, reliability and aesthetics of the train system itself (Mees 2000, Yencken 1996, Stretton 1994). This line of thought suggests that if the train system is readily accessible, reliable, has frequent services, is clean and secure, and the network is flexible and integrated than individuals will be more willing use this form of transport.

In his examination of the economic, equity, environment and community arguments for increasing residential densities Stretton (1994) concludes that if we wish to reform urban transport then we should reform the transport system directly, not indirectly by offering tax and price inducements or by trying to rebuild cities compactly. Similarly, in his examination of public transport usage Yencken (1996) contends that the problem with Australian cities is the management of the transport system. Yencken argues that urban form is not the problem and that changing to this process would take too long to roll out. He also suggests that the size of the network is not the issue. Yencken (1996) contends the advantage of Toronto (Canada) over similar sized cities in Australia is the higher service frequencies of rail services and the high frequencies of buses feeding the rail stations.

In a similar vein to Stretton (1994) and Yencken (1996), Gleeson et al (2004) are very critical of the transport planning system in Australia. The critique of Gleeson et al (2004), among others, pertains to the fact that transport planning in Australia is heavily focused on the construction of roads rather than emphasising an integrated transport

system whereby rail (and public transport) systems are appropriately funded. This line of inquiry also emphasises the need to provide adequate public transport to encourage patronage.

One of the most recent comprehensive analyses examining the role of public transport systems, particularly in Australia, was that produced by Mees (2000). Mees' research assessed why two similar cities – Toronto and Melbourne – have significantly different levels of public transport usage. Mees concluded that the comprehensive level of involvement by government in planning in Toronto had allowed the transport system in this city to maintain its levels of public transport usage. This compares with Melbourne, where Mees suggests that poor and declining levels of rail patronage are associated with a lack of government planning and a market dominated by private interests, a view shared by Gleeson et al (2004). Further, he contends that one of the successes of the public transport system in Toronto as well as Zurich is the structure of the network. In these cities Mees (like Yencken 1996) states that the integrated network, frequency, reliability and accessibility of the rail system are important in encouraging individuals to use public transport as opposed to a motor vehicle.

The ability of the public transport system to encourage patronage has also been purported by Newman and Kenworthy (1999). Similar to Mees (2000), Yencken (1996), Stretton (1994) and Gleeson et al (2004) Newman and Kenworthy contend that accessibility, reliability, service frequency, cleanliness and security of a public transport system are factors that encourage, or discourage usage levels. However, the difference with the arguments proposed is that Stretton (1994), Yencken (1996) and Mees (2000) suggest the state of the transport system itself is more important in encouraging public transport use rather the density of residential development surrounding rail stations.

3.4.2 Employment Opportunities and Mixed Use Development

A number of commentators state that the location of employment opportunities in relation to the location of higher density housing is an important factor in encouraging public

transport use (Schwanen et al 2004a). This notion emanates from research which suggests that levels of walking and cycling increase if facilities and services are located near residential developments (Cervero and Duncan 2006). For example, Cervero (1996a) concludes from his analysis in the US that if retail shops are within 300 feet, or several city blocks, from a dwelling unit, workers are more likely to commute by public transport, or walk or cycle. Cervero suggests that beyond this distance it is more efficient for individuals to link shopping and work trips by motor vehicle.

This concept is also emphasised in the current Sydney Metropolitan strategy. The Strategy contends that 50% of trips in Sydney are less than 5 kilometres in distance with the majority of these by car. Thus, the Sydney Strategy advocates mixed use development as a method for increasing walking and cycling and therefore reducing car trips, and by implication energy emissions.

This line of inquiry has also been researched in Melbourne. In 1994 Horridge used a general equilibrium model to analyse three scenarios of transport demand in Melbourne. The assumption was that a shift of population to inner and central Melbourne because of the focus of higher density development in these areas would have lower overall average transport use. According to Horridge transport use only declined by 0.3%. He suggests there are two reasons why the decline in transport use is minimal. Firstly, transport usage does not fall at the same rate as land per person. On existing travel patterns a reduction in area by 20% results in a 10% fall in total distances travelled. Secondly, the reduction in housing prices (flats are generally cheaper than houses) leaves consumers with more money for other goods. As such, Horridge argues that households will purchase more valuable transport opportunities anyway. He concluded that 'a desire to reduce transport energy use is a poor motivation for urban consolidation policy' (pg 455).

Further research in Melbourne by Bell (1991) examined the travel related impacts of Coles Myer relocating from inner Melbourne to a suburban location 9 kilometres from the CBD. Surveys were conducted before and after the relocation had occurred. Bell found the public transport use of employees declined from 63% prior to the relocation to

11% after relocation. There were multiple reasons for this move away from public transport, in particular, the poorer public transport options available to get to the new suburban location.

Hodgetts (2003) study adds further complexity to the role of employment opportunities and consolidated development through his study of inner Melbourne. Hodgetts analysis of eight higher density case study areas (and eight comparator control areas) found that closeness to the CBD and employment opportunities, and the highly pedestrianised nature of some areas, were more important in encouraging walking and cycling than density.

It is evident from the literature that mixed use development may provide opportunities for reducing car use through increased walking and cycling. All the research emanating in this area suggests that density is not the crucial factor in encouraging greater walking and cycling but rather the location of employment. It is also evident from the minimal research conducted in Australia that the location of employment opportunities is important in influencing public transport use.

3.4.3 Environmental Capacity of Cars

In 2000, Dudson critically assessed an article by Kenworthy and Laube (1999) in which they presented data for forty seven (47) cities across the globe supporting the view that higher urban densities increase public transport use. In particular, Kenworthy and Laube (1999) state that public transport uses 40% less energy per passenger per kilometre than cars. Assuming that this is correct Dudson argues that if the use of public transport doubled from 3% of all trips to 6% in the United States then this would reduce energy by about 1.5%. Dudson contends that this does not compare with the 20%-75% reduction in energy expected to result from technological improvements in cars. Troy (1992 and 1996) has also argued that the link between density and public transport use is superfluous as motor vehicles become more energy efficient.

3.4.4 The Historical and Cultural Development of Cities

In some of the overseas literature, particularly in Europe, there is an acknowledgement by a few commentators that the historical development of cities is an important factor in influencing car and public transport use. Gerondeau (1997), for example, notes that the older core areas of many European cities were developed before the advent of the car and that this is important in understanding car trips in these areas. In relation to older city localities he states that “[T]hey consist in ‘islands’ with an area of a few square kilometres, with traditional streets and roads where it is practically impossible to drive at high speed whatever the time of day...” (p. 268). Salomon et al (1993) also imply that the socio-cultural development of European cities influences mobility patterns, while Schwanen et al (2002) note that the historic development of the Randstad in the Netherlands is important in influencing the high proportion of cycling and walking trips.

Outside of Europe this debate is rarely commented upon, however, Wachs (1993) is particularly critical of the research the links increased urban densities with increased public transport use. According to Wachs (1993) this research does not take account of the historical development of a city. Wachs argues that some cities were major metropolises before the invention of the automobile and were developed in line with non-automobile transport systems. He implies that this is why some cities are densely populated, and in more recent years are becoming less dense as suburbs emerge on the urban fringe, which have higher rates of car ownership. Salomon et al (1993) also support this notion after they showed that the rate of car ownership in Europe was nearly three times that of the ‘auto dependent’ USA, and that from 1970 to 1987 private car use had increase from 79% to 83%.

3.4.5 Urban Structure

There is some debate in the literature about the role that urban structure plays in encouraging individuals to use certain modes of transport. While there is some overlap between other factors mentioned in this chapter, the focus of research in this area is to

differentiate the impacts of polycentric, as opposed to, monocentric urban systems⁷. This research moves slightly away from the hypothesis that higher urban densities increase public transport use, in that urban structure rather than urban form is important in reducing car use. Nonetheless, an overview of the studies conducted in this area provides a useful insight into research that contributes to the urban density – public transport use debate.

Studies examining the relationship between urban structure and transport make an indirect link with public transport through a city's transport system rather than urban form. The research on mixed use development (noted above) is predominantly about short trip patterns and providing and linking short trips, whereas the debate surrounding polycentric and monocentric structure is more broad and focuses on the metropolitan structure rather than linking trips at a more localised level, and does not necessarily incorporate higher density housing into the debate.

Researchers in this area contend that polycentric urban areas allow individuals to travel shorter distances for their needs as jobs, services and facilities are available in all parts of the metropolitan area, and if major centres in the polycentric city are linked by rail then this can also increase public transport usage. This concept is also encapsulated in other notions such as 'smart growth' or 'new urbanism', while some researchers have also adopted the notion of the collocation hypothesis (Gordon et al 1989), jobs-housing balances or mismatches (e.g. Cervero 1989) or the 'edge city' (Mees 1994) in discussing the impact of structure and transport patterns, although the predominant discourse is encapsulated through monocentric versus polycentric structures.

The general consensus is that in polycentric cities, the population in suburban areas increases and businesses to support the local economy also emerge, and intertwined with is the relocation of jobs from other areas to the suburbs to be closer to an employee base as well as cheaper land. In addition, the linking of areas by public transport encourages

⁷ Monocentric urban structures generally refer to an area in which employment is concentrated in the CBD whereas polycentric urban structures generally refer to a city which has a number of suburban or sub-centre

patronage on this form of transport as a significant proportion of trips will be shorter and more viable on public transport. There are other contested issues associated with this line of inquiry, for example, whether jobs follow people or people follow jobs, but are outside the scope of this study. Nevertheless, there is still some debate within the literature on the implications of different urban structures. For example, Schwanen et al (2002 and 2004b) concluded that in the polycentric region of the Randstad in the Netherlands, travel times were longer than in other regions dominated by a monocentric urban structure.

In their study of Los Angeles (LA) Giuliano and Small (1993) state that commuting distance and time are not very sensitive to variations in urban structure and that large scale changes in urban structure would only have small effects on commuting. They contend that policies aimed at increasing jobs-housing imbalances (i.e. suburbanising employment) will have little effect on journeys to work. Giuliano and Small suggest that there are number of reasons why individuals chose to live where they do with the most important being commuting costs rather than commuting times or distances. Cervero (1996b) adds more complexity to the debate through his study of San Francisco. Cervero (1996b) contends that during the 1980s there was a significant relocation of jobs to suburban areas in San Francisco, however, this did not result in lower commuting time. On the other hand, Gordon et al (1989) contend that there is no relationship between city size and trip lengths, times and speeds in the US and that sprawl is necessary to reduce congestion. Gordon et al (1989) also suggest that a high density spatial structure does not lead to shorter travel times in the US.

In Australia, there has been little debate about city structure or size on commuting patterns. O'Connor (1992) and Brothie (1992) in Melbourne argue that a dispersed city of multi-functional suburban centres leads to lower trip times due to the dispersal of trip patterns and lower levels of longer commutes to the central city, although the emphasis of this work is on connected freeway systems rather than public transport. This is in contrast to the model supported by Mees, which emphasises public transport linkages.

employment zones including the CBD (see Richardson 1988).

In Sydney, Parolin (2005) examined the commuting patterns and modal splits of employed persons in employment centres (ECs) from the 1981 and 2001 Censuses. Parolin notes that over the 20 year period the polycentric nature of Sydney increased as the number of ECs increased across the metropolitan area. Nevertheless, Parolin found that despite the obvious polycentric nature of Sydney the journey to work distance of employed persons increased by 20%, supporting the research presented by Schwanen et al (2002). Interestingly, Parolin contends that there was an increase in car use to ECs and a decline in the share of trips for buses and trains between 1981 and 2001. He therefore concludes that there will be no foreseeable increase in public transport use unless infrastructure planning is integrated with future employment centres.

In sum, the debate still continues on the merits of polycentric versus moncentric urban structures. This debate attempts to merge public transport use into discussions about broad urban structure rather than linking public transport with residential density. Nonetheless, the debate about urban structure provides an important background the debate in this thesis through its indirect linkages with public transport.

3.4.6 Urban Design

There are a number of commentators who argue that the design of ‘urban villages’ or Transit Oriented Developments (TODs) is just as important as density in reducing car use (see Crane and Crepeau 1998, Yigitcanlar et al 2005, Soltani and Bosman 2005). The basic premise of this design debate (including the New Urbanism debate) is that the physical design of an area or neighbourhood can influence transport patterns. For example, ‘friendly’ streetscapes and the pedestrianisation of neighbourhoods encourage walking and cycling, and accessibility to public transport can foster this mode of transport. This debate still continues and concentrates on whether design influences travel behaviour, but is beyond the scope of this thesis. Nevertheless, it is evident from the literature that the influence of urban design is viewed as being important to a number of commentators who are also critical of the link between density and public transport use.

3.4.7 Other Government Policies

There are a number of researchers who have argued that land use planning regulations on their own are insufficient to encourage higher levels of public transport usage. That is, there are a range of other initiatives required to complement land use regulations to achieve the high levels of public transport usage recorded in countries such as Tokyo, Hong Kong and Singapore. For example, in 1992 Troy raised the issue about whether petrol prices and public transport fares are also factors in influencing the levels of public transport use.

In an interesting piece of work in 2004 Cameron et al examined the factors that influence travel distances in North America, Australia, Canada, Europe and Asia, with specific case studies in Stockholm, Munich, Singapore, Hong Kong, New York, Perth and Phoenix. The focus of Cameron et al's work was on vehicle kilometers traveled (VKT) by cars rather than public transport, but despite this their results are important in the context of this study. Cameron et al found that despite increases in affluence and car ownership that increases in VKT were not recorded in some of the case study areas. They conclude that in Asia clear fiscal policies (e.g. petrol taxes, high registration fees etc) had restrained VKT, however, in Stockholm high urban densities were a significant factor in reducing car use. Cameron et al suggest that an integrated package of fiscal measures, density and adequate public transport are important in reducing car use.

Hensher (1998) also agrees that fiscal or economic measures on motor vehicles are needed to encourage individuals to use public transport. Hensher (1998) uses the example of the Northern Suburbs Transit System (NSTS) in Perth. Upon its opening in 1992 the NSTS attracted both car and bus users, with 64% of patronage coming from previous bus passengers. However, vehicle volumes per weekday have only dropped by 3%. Hensher argues that such an expensive heavy rail system like the NSTS attracted bus users but did little for car demand, suggesting that other mechanisms were needed to reduce car use.

In the Netherlands, Dieleman et al (1999) go even further by suggesting that the level of government involvement in land allocation and housing policies are just as important as taxes and urban form criteria. Dieleman et al note that over the last thirty years urban consolidation in the Netherlands has been successful for four reasons. Firstly, the Dutch national government had strict land use regulation policies which were backed up by national level infrastructure priorities. Secondly, these policies were forcefully implemented through taxes and finances. That is, the majority of local government finances in the Netherlands come from the national government which has pressured local authorities to pursue national level priorities. Thirdly, the Dutch government could influence the location of development through its housing policies, in particular the construction of public housing stock, which represents 40% of the total stock. Fourthly, Dieleman et al contend that the urban land market has previously been successfully controlled by government authorities from pricing to infrastructure provision, rent setting and land use controls. However, Dieleman et al (1999) note that in the last few years housing and land policies in the Netherlands have been deregulated with much more private involvement in the process, and state grants for public housing have been in decline. According to Dieleman et al these changes have put a question mark over whether consolidation policy objectives can be achieved considering the reasons for its previous success are being eroded.

A similar view is also expressed by Giuliano and Dargay (2006) in their exploration of car ownership, travel and land use in the US and Great Britain. The modeling exercise conducted by Giuliano and Dargay suggests that land use and transport systems work together to reduce travel. As Giuliano and Dargay state, 'current efforts in the US to reduce travel by promoting higher density, mixed use development are not likely to be successful in the absence of stronger policies to control automobile use' (p. 122).

Similarly, Kirwan (1992) contends that the deliberate policy in Europe to contain urbanisation along with the relatively higher petrol prices have created conditions for a high level of public transport use. This is a similar view to that expressed by Troy (1992).

Importantly, Kirwan suggests that in Australia these policies will not work unless they are accompanied by policies which encourage higher public transport speeds. Kirwan's theory suggests that higher residential densities in Australia will not lead to increase public transport use but that other policies are just as important.

In sum, a number of commentators contend that government policies, particularly fiscal policies, are more important in influencing public transport use than urban densities.

3.4.8 Socio-Demographic Factors

Intertwined throughout the research presented by Kirwan (1992) and Giuliano and Dargay (2006) above is the importance of socio-economic variables in explaining travel patterns, particular mode of travel. Without a doubt the influence of socio-economic factors in explaining public transport use is a common theme throughout the literature, despite the emphasis placed by some researchers on other factors such as urban structure or government and fiscal policies.

In the pursuit of trying to identify the factors that influence public transport usage the socio-economic characteristics of individuals is considered to be one of the most important (Stead 2001). The socio-economic variables that encourage greater public transport usage have been studied for over twenty years. Research has continued for this length of time mainly due to data limitations which have presented themselves to researchers. A significant number of studies use Census data to examine the relationship between land use and transport, or more precisely, to better understand the actual influence of residential density on public transport usage and whether this relationship is not as simply some researchers contend, despite the limitations of using such data. This study will also use Census data as it is the only reliable information source for examining public transport use at a micro level, without resource intensive surveys. Most studies in this area have confined themselves to metropolitan level analyses due to data restrictions on individual household data from travel surveys which provide a sample of households

across a metropolitan area but are not necessarily statistically reliable for investigations at the local level.

One of the earliest studies to assess the impact of socio-economic variables on transport use was that by Hanson (1982) in Sweden. Hanson used the data of 300 individuals from the 1971 Uppsala Travel Survey. The objective behind Hanson's work was to examine both the spatial and socio-demographic factors influencing travel activity patterns. She concluded from her stepwise regression that socio demographic variables particularly gender, household size, employment status, marital status and age remain important in explaining most of the aspects of travel even when the effects of relative location have been controlled. However, Hanson noted that an individual's location within a city plays a relative important role in explaining travel distances. At the intra-urban scale socio-demographic factors outweighed spatial ones in explaining overall trip frequency and travel for particular purposes, but spatial factors cannot be overlooked in explaining patterns of trip distribution.

The results of Hanson's early work on the relationship between socio-economic variables and travel have lead to numerous studies on the relationship between household characteristics and travel. These studies have examined a large range of socio-economic variables, although the actual influence of certain socio-economic variables is still contested. For example, women generally have shorter commuting times than men due to the division of household responsibilities, although a number of studies have found exceptions where this is not the case (Hanson and Johnston 1985, Golob and McNally 1997).

One of the other major influences on travel distances and time purported in the literature is income. Hanson and Pratt (1995) argue that there is a positive correlation between income and commuting time whereas Levinson and Kumar (1997) found the same association for car users but not for public transport commuters. On the other hand, Schwanen et al (2002) suggest that socio-economic variables are an important influence on travel time but the significance of income is relatively small.

After income another important influence of travel propensities is suggested to be car ownership. A number of commentators argue that the larger the number of cars per household the greater the travel propensities of individuals in that household (Lu and Pas 1999), although Shen (2000) contends that this relationship is more modest than some research has suggested. According to Dieleman et al (2002), in the Netherlands having a car strongly reduces the propensity to go to work by public transport. This result is not surprising given the results of other research, however, Dieleman et al conclude that in order to reduce car use in the Netherlands there needs to be a good supply of public transport. This argument is similar to that presented by Australian researchers such as Mees (2000), however, differs from that of Hanson (1982). Dieleman et al suggest that socio-economic factors influence public transport usage, but not to the same extent as the availability of public transport.

Conversely, Schwanen et al's (2002) study of the 1998 Netherlands National Travel Survey found that socio-demographic factors and residential context influence daily travel time. Men spent more time commuting to work than women, although women were more inclined to use a bicycle to shop (14% compared to 7% for men). For shopping and leisure trips adults in two-earner households devoted little time to these activities, whereas, older persons spend more time on shopping and leisure trips than younger persons, due to the higher proportion of older persons not in the labour force. Schwanen et al suggest that female part time workers, particularly with children travel less than women in a household without children and in full-time work. This is similar to the findings of Hanson and Pratt (1995). Furthermore, they concluded that highly educated workers tended to spend more time commuting by car.

In the UK comprehensive research exploring the relationship between socio-economics, land use and travel has recently been conducted by Stead (Stead 2001, Stead and Marshall, 2001). In 2001, Stead examined the relationship between land use, socio-economics and travel at both the national and local levels in the UK. The results of this study at the local level are presented elsewhere. Suffice to say that he argues the socio-

economic characteristics of a household are more important than land use variables. For example, from an examination of National Travel Surveys in the UK Stead contends that socio-economic characteristics explain 19-24% of the variation in travel distance⁸ per person while land use variables explain up to 3% of the variation in travel distance per person. The most important socio-economic variables were age, gender, occupation and possession of a drivers license. Overall, the analysis at the national level suggests that socio-economic and land use variables explain about a quarter of the variation in travel distance per person. That is, travel patterns are complex and a multiplicity of factors explain these patterns suggesting that higher density development alone will not increase public transport usage.

Similarly, in 1996 Schimek examined the link between population density and automobile travel in the US. He concluded that the impact of density on travel is so small that even a relatively large increase in density would have a negligible impact on total vehicle travel. Schimek contends that much of the difference in household travel associated with the presence of transit comes from lower rates of vehicle ownership, also identified by Dieleman et al (2002). However, Schimek also concludes that household income had the largest elasticity of all the factors studied. This implies a modest growth in income may result in a higher level of automobile use. This theory is supported by research in some Asian countries, who continue to show increases in car ownership as income levels rise (see Cameron et al 2004). Nevertheless, Schiemk's results for income in his US study are slightly different to that presented by Schwanen et al (2004) in the Netherlands.

In the US, Genevieve Giuliano along with Robert Cervero have been two of the most productive researchers in studying the factors that influence transport use. Early research from both Giuliano and Cervero was more focused on the impacts of urban structure on travel and the value of integrating employment and housing opportunities (i.e. jobs-housing mismatches). More recently, however, Giuliano has attempted to investigate whether socio-economics play a role in influencing transport use. In 2006 Giuliano and

⁸ Stead (2001) contends that travel distance is a reasonable proxy for transport energy emissions.

Dargay investigated the relationship between travel and land use in the US and Great Britain. The study did note that socio-economics were a variable that was important in explaining travel. Giuliano and Dargay contend that differences in travel between the two countries were associated with lower levels of income and labour force participation in Great Britain. Earlier studies by Giuliano also come to similar conclusions. In 1999, for example, Giuliano argues that rising per capita incomes and changing demographics, as well as economic restructuring explain trends in travel patterns in the US and Europe. In 2003, Giuliano and Narayan also argued that differences in travel in the US and Great Britain can be partly explained by population characteristics.

3.5 Overview

Undoubtedly, the notion that higher density development around public transport nodes lowers the level of car use and therefore energy emissions has been adopted by urban policymakers in Sydney. The current Sydney metropolitan strategy emphasises this link to the point where approximately two-thirds of future residential development will be higher density housing concentrated around public transport nodes and corridors. Whether train or bus usage will increase as a result of this policy focus is yet to be evaluated. From the work conducted in Australia (and overseas) the relationship between density and public transport use suggests that the relationship is complex and that there is a multiplicity of factors involved including socio-economic variables, fiscal measures and the transport system itself. It is evident from the literature reviewed in this section that socio-economic variables are an important component, although the importance of individual socio-economic variables is contentious. Importantly though, the studies that have explored the relationship between urban densities and public transport use have been predominantly at the macro or metropolitan wide level. Few studies have been conducted at the meso or micro (local level).

In Sydney little research has been conducted on whether density is the most appropriate means to encourage greater public transport use. Most commentators would agree that increasing public transport patronage does have benefits, but whether density is the major

influence or not is still debatable. Combined with the recent research of Bunker et al (2005a and b) which suggests that certain socio-economic groups occupy different spatial segments of the higher density housing market in Sydney there is a serious gap in our knowledge across the metropolitan area as to the influence of socio-economic variables and residential density in promoting public transport use. This gap also extends within the metropolitan area to the meso and micro (local) levels where very limited research in different locations has been conducted.

4. THE RELATIONSHIP BETWEEN URBAN RESIDENTIAL DENSITY AND TRANSPORT AT THE LOCAL LEVEL

4.1 Introduction

Studies conducted to date into the relationship between land use and transport, have generally, been conducted at the city wide level using household sample surveys or Census data (Newman et al 1985, Meurs and Haaijer 2001). One of the objectives of this thesis is to examine the relationship between higher density housing and public transport at the local level to enhance debates on this issue, which have been lacking in Sydney. This is also important in order to make a detailed assessment of the implications for urban growth management strategies in Sydney.

4.2 Overseas Studies that the Examine the Relationship between Land Use and Transport at the Local Level

There have been a few studies in Europe, the UK and US that have examined the relationship between residential density and transport use at the local level. In the Netherlands Van Wee and Maat (2003) and more recently Geurs and Van Wee (2006) provide an overview of the research investigating the relationships between urban consolidation and transport use. Geurs and van Wee (2006) note that, '[G]enerally, there is enough evidence to show that land use variables influence travel behaviour at several geographical scales, but the strength of the relationship differs considerably between studies' (p. 145).

In North Western Europe there have been a number of studies undertaken by Naess and his colleagues in Norway (Naess et al 1995). Naess and his colleagues have examined the relationship between energy use, transport and urban form in towns in Sweden and Oslo. Another study also examined this relationship in twenty two (22) towns across four Nordic countries (for an overview see Naess et al 1995). All of these conclude that energy use in transport is significantly influenced by population density. Perhaps most

interesting is the study of thirty (30) residential areas in Oslo, Norway (Naess et al, 1995). The study was conducted based on a survey of 321 households in 30 residential areas distributed across the greater Oslo region. Despite the contestable nature of the small sample, Naess et al's results provide an interesting perspective on the density and transport debate. A multiple regression analysis across all households suggests that five factors were important in explaining travel distance per capita – distance from downtown Oslo, car ownership, number of children in the household, the provision of local facilities near the residence and public transport provision near the residence. These five variables explained 37% of the variation within the data set.

The most interesting argument to stem from Naess et al's work is the link to higher density development. The study argues that higher density housing is the most important influence because it *indirectly* affects the variables emanating from the multivariate analyses. For example, it is argued that population density is important for attracting local service facilities and provisions. That is, two of the five variables (provision of local facilities and public transport provision) are influenced by the provision of higher density housing. Naess et al further argue that poorer parking conditions in higher density areas influence car ownership, and that households with children live in low density areas, thus density is indirectly influencing this variable as well.

The 1995 study comments that in a previous study going from an area of 600m² per capita to 400m² per capita in Oslo would only reduce energy use per capita by about 6%, however, in their Swedish study Naess and colleagues found a reduction in energy use by 12%-13% by reducing the urban area by a similar amount suggesting that other considerations besides densities need to be considered, which is surprising given their general support of the notion that higher urban densities reduce energy use.

In the US, Holtzclaw (1994) measured automobile use and personal transportation costs from different characteristics of a neighbourhood. Holtzclaw evaluates the effects of four neighbourhood characteristics (residential density, transit accessibility, distance from neighbourhood shops and pedestrian accessibility) on motor vehicle use and vehicle miles

traveled (VMT) per household in twenty eight (28) communities in San Francisco, Los Angeles, San Diego and Sacramento. Holtzclaw contends that motor vehicle use and VMT are both explained by the level of density. His statistical analysis found that variables such as household size, household income and transit accessibility were significantly correlated with auto ownership, however, the best predictor of auto use was density which explained 85% of the variance in the data set. Similarly, Holtzclaw suggests VMT was negatively correlated with density. From his analysis as density doubles VMT declines by 16% but as transit service doubles VMT only declines by 5%.

In the UK, Stead has examined the relationship between the socio-economic characteristics of a population, residential density and travel distance at the local level (Stead, 2001). From an analysis of National Transport Surveys and local authority travel surveys Stead (2001) contends that socio-economic variables are more important in explaining travel distances than density. For example, Stead's analysis of 738 travel zones from the 1991/93 National Travel Survey in Britain suggests that socio-economic variables explained 51% of the variation in travel distance while land use explained 25% of the variation in travel distance. When both the socio-economic and land use variables were entered into a multiple regression analysis they accounted for 56% of the variation in travel distance with socio-economic variables contributing to the majority of this variance.

In Stead's examination of the local authority level data he found that both land use and socio-economic variables accounted for two-thirds of the variation in travel distance in Leicestershire and three-quarters of the variation in Kent. The socio-economic variables, however, contributed a much larger proportion of the variance than the land use variables. Stead concludes that land use, i.e. density, does have a role to play in reducing transport emissions, although a minor one.

From his research Stead notes that lower socio-economic groups traveled smaller distances, however, in areas where there were fewer jobs, individuals in these areas traveled further to work. Importantly, Stead suggests that there is little evidence between

proximity to a railway station and travel distance. In Leicestershire the data suggested that being closer to a railway station *increased* travel distance by up to 12 kilometres per person per week. Stead's results imply that while density may have a role to play in reducing travel distances, the socio-economic characteristics of a household are more important. This research, like that of Giuliano and Dargay (2006) has implications for urban policy makers which is discussed later in the thesis.

In 1993 the Department of the Environment and Department of Transport in the UK commissioned ECOTEC Research and Consultancy to evaluate the potential of residential density to reduce transport emissions. The focus of the study was on reducing travel and encouraging more public transport use and less car travel. Consideration was given to the influence of settlement sizes, density and land use mix, as well as other non-planning policies (parking controls, traffic calming, pedestrian and public transport priority zones). The ECOTEC report used a range of research methods at both the regional and local scale including household interviews and model simulations, however, for such a range of research methods the published results are scant.

The report generally supports the view that density is the most important factor in reducing car use and encouraging a shift towards public transport. The ECOTEC report does not give a specific density at which development should occur, however, it notes that below 15 persons per hectare travel demand increases and at densities above 50 persons per hectare travel demand decreases dramatically. The report is also supportive of mixed use development and the revitalization of existing town centres with accessible public transport nodes. The ECOTEC study also supports the notion that planning policies should be complemented with non-planning policies such as parking controls, traffic calming measures, pedestrian and public transport priority zones. Together the report contends that these planning and transport measures could reduce transport emissions by 16% over a 20 year period.

Although the conclusions reached by the ECOTEC support the link between higher density housing and increased public transport use, the local area study conducted as part

of the broader study provides some interesting results. Eight small case study areas (two from the South East and six from the West Midlands) were selected as part of a household survey. The results suggest that population density is important at the local level in reducing emissions although when the case study areas were grouped the influence of density became blurred. The case study areas did, however, suggest that accessibility to local facilities (e.g. food shops, post office, medical services) was important in reducing car use as was the accessibility to public transport.

4.3 Local Level Studies of Residential Density and Transport in Australia

Micro or local level analyses of the relationship between higher density development and transport patterns across the globe are limited, however, in Australia research into this issue is even more limited. As with other international studies the limited research to date has focused on journey to work data from the Census due to the limitations of household travel surveys and the expense of large scale surveys that would enable a more robust analysis at the local level to be undertaken.

One of the earliest studies examining land use, transport and energy in Australia was that conducted by the Australian Institute for Urban Studies (AIUS) in Melbourne in 1982, although there was little analysis of the relationship between energy patterns and other urban variables (Newman et al, 1985). This was followed in 1985 by a study of transport energy for small areas in Perth (Newman et al, 1985).

In an early piece of their research effort Newman et al (1985) examined the transport energy in thirty eight (38) zones across the Perth metropolitan area. Of these thirty eight (38) zones, sixteen (16) were classified as inner areas, twelve (12) as middle suburban areas and ten (10) as outer suburban. The study found that inner area residents have considerably lower energy use than the Perth average while residents in the outer suburbs had the highest energy use. For example, total energy use per capita in the inner areas was 16% lower than the Perth average while work trips in the inner areas used 26% less energy than the Perth average. Conversely, energy use for work trips from the outer

suburbs was 39% higher than the Perth average. Newman et al (1985) concluded that location, that is, distance from the CBD was the most important factor in explaining transport energy use in Perth with density being the second most important factor. This, of course, is different to the results presented in 1989 and 1999 by Newman and Kenworthy, despite both authors being involved in the 1985 study of Perth. Importantly though, this study points to the fact that micro level studies are important and may lead to different results than macro level studies.

Newman et al (1985) contend, however, that there are also two important results that flow from their study in Perth. The first is that in some middle suburban areas energy use was relatively low. They suggest that these areas had shopping, recreation and employment facilities within close proximity, and were highly accessible. It was therefore concluded that mixed use development is also important in reducing energy use. Secondly, Newman et al question the socio-economic impacts of policies, and fuel prices, which they suggest have forced lower income households to the outer suburbs and increased the proportion of their income they spend on travel.

During the late 1980s and 1990s there were only a few studies that investigated the relationship between density and transport at the local level in Australia. Of the studies that examined this relationship the focus of research was in Melbourne. For example, Buxton (2000) notes both the Victorian Greenhouse Neighbourhood Project and the Victorian Urban Villages Project supported the link between higher density development, mixed use centres, public transport and lower car use. The Victorian Greenhouse Neighbourhood Project noted that carbon dioxide emissions reduced by up to 42% through a combination of land use (higher dwelling densities), dwelling design and transport related factors. The Victorian Urban Villages Project was, however, more modest concluding that if planning policies emphasised urban villages as a major form of urban development then energy emissions would decline by approximately 14% but up to 27% depending on job self-containment while public transport distances per passenger would increase up to 100%. Some of the design elements mentioned in the Victorian Greenhouse Neighbourhood Project, prepared in 1994, as reducing emissions have gone

on to become industry standards. Nonetheless, this study identified that it was not just density alone that decreased carbon emissions, but design and mixed used development was also important.

Of the more recent studies Hodgetts (2003) examined the journey to work travel patterns of eight case study areas in inner Melbourne which recorded significant levels of higher density development between 1991 and 2001 and compared these to nearby areas which had changed very little during this period and were a mix of both high and low density development. The case study areas and the comparator areas were between one and three census collector districts (CDs) in size⁹.

Hodgetts suggests that the areas which showed higher rates of urban consolidation close to the CBD have a higher proportion of walking/cycling trips but as the case study areas moved further away from the CBD there was lower walking/cycling and higher public transport use. Such results would support the notion that higher densities increase public transport use. However, Hodgetts found only a marginal difference in car travel between the consolidated case study areas and the unchanged areas. Car travel within the consolidated areas ranged from 24%-54%, with increasing car travel further from the CBD. Hodgetts contends that the results are quite a mix and that urban consolidation does not necessarily mean less car travel. Basically walking/cycling was a substitute for public transport in the consolidated areas close to the CBD. Further, Hodgetts results show that in inner higher density areas where public transport is available there is a tendency to use this rather than walking/cycling. He also implies that where walking/cycling is higher in the consolidated areas non-residential activities are closer and individuals may be moving closer to the CBD for this reason rather than the type of housing.

Importantly, Hodgetts also shows how the case study area closest to the CBD with the highest density had the highest proportion of drive alone commuters of all the consolidated areas. He also concludes that if a case study area was close to a railway

⁹ A census collector district has, on average, 225 households.

station this did not mean higher public transport usage. Hodgetts found that residents in his higher density case study areas did not appear to drive less, use public transport and walk/cycle significantly more than residents in pre-existing developments questioning whether the Melbourne metropolitan planning strategy (Melbourne 2030) will produce a reduction in car use.

Overall, Hodgetts concludes from his study that closeness to the CBD and employment opportunities and the highly pedestrianised nature of some neighbourhoods are more important than density in reducing car use. Further, he concludes that mixed use developments may be useful and also supports Mees' (2000) claim that accessibility, frequency and quality of public transport is just as important.

The other recent study that specifically examined transport use in higher density developments was that conducted by Randolph et al (2005) for the Sydney Olympic Park Authority (SOPA). Part of the study assessed the travel patterns of individuals in higher density developments surrounding Sydney Olympic Park (SOP) in order to provide the Authority with an understanding of the travel implications of similarly designed developments it was proposing as part of the redevelopment of the Sydney Olympic Park site.

Randolph et al (2005) found that 59% of work trips in three case study areas – Newington, Homebush Bay and Liberty Grove – were by car, 15% were by train and 11% were multi-modal trips. Bus use in the three case study areas, however, was only 1%. In Liberty Grove, the area closest to a rail station, a quarter of work trips were by train, but this fell to 4% in both Newington and Homebush Bay further away from a rail station. Significantly, there were more flats and units in both Newington and Homebush Bay. Importantly, Randolph et al suggest that the workplace destination of individuals whose trips were by rail were concentrated in areas along the railway lines. Like Hodgetts (2003) the Randolph et al study suggests factors other than high density development, as promoted through urban consolidation policy influence public transport use.

The other potential source of local level research in Sydney is that conducted by local government. In NSW, local government authorities rarely attempt to undertake travel surveys due to the cost, but also because other data from the Sydney Household Travel Survey (see below) and the Census is made available to local authorities. Some local authorities, however, are beginning to survey their residents as part of their social and community planning obligations under the *Local Government Act*. Under this process local authorities, generally, survey their local residents in order to measure their concerns and perspectives on services and facilities in the local area.

Fairfield City Council, for example, recently surveyed 802 residents in order to measure community concerns and perceptions of services and facilities in the Fairfield area (Newton Wayman Chong (NWC) 2005). The survey asked a series of questions of public transport use which produced some interesting results. Some 69% of residents stated that they rarely or never use public transport, while 15% said they used public transport often or quite often. These figures are comparable with the average number of public transport users across Sydney. Those who rarely or never used public transport lived in separate houses (87%) in newer residential areas (90%), were buying their home (90%), and mainly spoke English at home (87%). On the other hand, those who used public transport more regularly tended to live in established urban areas (20%), rented from the State Housing Authority (43%), aged 18-24 years (35%), born in Vietnam (22%), spoke mainly Chinese at home (35%) and lived in attached housing (26%).

Importantly, the NWC report asked respondents whether they would use public transport more often if a number of changes were made. This included making public transport safer, cheaper, more frequent and available in more areas. Table 5.1 below shows the results of the survey. Approximately half of all respondents stated that they would not use public transport even if changes were made to the system, whereas, one-quarter to one-third suggest that these changes would mean they 'were more likely' to use public transport.

The findings of the survey suggest that those who are unemployed, born overseas, and of lower incomes are more likely to use public transport in Fairfield as a result of changes to the public transport system. Conversely, those not in the labour force, who own their own home, and those who are predominantly Australian born are less likely to use public transport even if public transport is made safer, cheaper or services are more frequent.

Table 4.1: Overview of responses to whether changes to the public transport system in Fairfield would encourage individuals to use public transport more

(source: NWC 2005)

Change to be Made to the Public Transport System	Characteristics of Those More Likely to Use Public Transport	Characteristics of Those to Which Changes Make No Difference
Safer	<ul style="list-style-type: none"> Established Urban areas (35%) Buying their home (34%) Renting Privately (38%) Born in Iraq (46%) Born in Vietnam (46%) Speak mainly Vietnamese at home (46%) Involved in home duties (41%) Unemployed (43%) 	<ul style="list-style-type: none"> Male (60%) Own their home (61%) Born in Australia (64%) Speak mainly English at home (64%) Retired (62%)
Cheaper	<ul style="list-style-type: none"> Established Urban areas (39%) Born in Iraq (65%) Born in Vietnam (50%) Speak mainly Vietnamese at home (46%) Speak mainly Arabic at home (51%) Unemployed (51%) 	<ul style="list-style-type: none"> Own their home (60%) Aged 70 or more (80%) Household income \$80,001-\$100,000 (71%) Born in Australia (64%) Speak mainly English at home (63%) Retired (62%)
More Frequent Services	<ul style="list-style-type: none"> Renting from State Housing Authority (60%) Born in Iraq (52%) 	<ul style="list-style-type: none"> Born in Australia (59%) Speak mainly English at home (59%)
Went to Different Areas	<ul style="list-style-type: none"> Born in Vietnam (45%) Speak mainly Vietnamese at home (44%) Unemployed (50%) 	<ul style="list-style-type: none"> Own their home (58%) Aged 60 or more (64%) Speak mainly English at home (60%) Retired (61%)

4.4 Overview

This chapter has focused on presenting some of the findings of the few studies that have been conducted at the local level in the UK, US, Europe and Australia on the relationship between density, socio-economic variables and transport use. It is clear from the limited amount of research completed that at the local level the relationship between density and transport use is still ambiguous. A number of research projects contend that higher density housing is an important factor in reducing car use. On the other hand, there are others which have found mixed results and, which, suggest that density plays only a minor role in reducing car travel at the local level. Most of these latter studies have suggested that the socio-economic characteristics of a household and level of accessibility to employment are also factors that influence public transport use. Importantly, this debate has been absent in Sydney despite the views held by policy makers in Sydney on the benefits of pursuing urban consolidation policies.

The local level studies begin to open up the debate about what outcomes may occur as a result of urban consolidation policies in cities like Sydney. Urban consolidation policies in Sydney promote increased residential densities as a means to increase public transport use without taking into account other factors or the spatial implications of such policies. These findings suggest that research needs to be conducted into this specific issue to examine whether current urban consolidation policies in Sydney will be successful.

**PART 3: A STAGED ASSESSMENT OF HIGH
DENSITY HOUSING AND PUBLIC TRANSPORT
USE IN SYDNEY**

5. A MACRO LEVEL ANALYSIS OF SOCIO-ECONOMIC CHARACTERISTICS OF TRAVEL PATTERNS IN SYDNEY

5.1 Introduction

This section presents a macro-analysis of trip and modal patterns of individuals from the Sydney Household Travel Survey (HTS). The aim of this section is to shed some light on the travel patterns of individuals in Sydney by their socio-economic characteristics before a micro or local level analysis is undertaken. The HTS is a rolling three year survey with a sample size of about 5,000 households. Individuals are asked to keep a record of their travel patterns for a selected day of the year. Data is collected for all days of the week throughout the year. The data over three years is pooled together to provide information down to the statistical local area (SLA) (see Appendix 3 for more details on the sample methodology and limitations of the HTS). The current data set is for the three year period ending 2002. The advantage of using this data set is that it provides information for all trips not just for journey to work trips. Conversely, there are also disadvantages in using this data set. The data set is concatenated and does not provide individual level records, and is less robust at levels below that of the Sydney metropolitan area. The data, however, still provides the most comprehensive assessment of all trips undertaken in Sydney.

5.2 Linked and Unlinked Trips

The analysis below of household travel patterns in Sydney uses 'linked' trip data. As the name suggests a 'linked' trip is one which goes from Point A to Point B and can encompass a number of 'unlinked' or separate trips (see Appendix 4). For example, if we take an individual who catches a train to work then this would constitute three 'unlinked' trips. The first would be from home to the rail station, the second would be from the railway station near a persons' home to the railway station near their place of employment. The third 'unlinked' trip would be the trip from the railway station near

work to their place of employment. However, these three ‘unlinked’ trips would form one ‘linked’ trip, that is, from home to work. The mode of transport assigned to a ‘linked trip’ is designated through a hierarchy or ‘priority mode’. The mode of travel given the highest priority is aircraft, followed by ferry, train, bus, motor vehicle, taxi, cycling and walking (see Appendix 5). Therefore, a person whose journey consisted of a walk trip from home to the railway station, a train trip, then a walk trip from the train station to their place of employment (as above) would be given the ‘priority mode’ of a train trip. For this analysis it was decided that linked trips would be appropriate as the emphasis was on train travel. Other researchers such as Mees (2000) have used unlinked trips. Mees argues that ‘unlinked’ trips are important for understanding how an entire network system is functioning. However, a network analysis is not part of this analysis and ‘linked’ trips were deemed suitable for the analysis.

5.3 Historic Trends in Trip Patterns and Modes in Sydney

Like many countries and cities across the world the proportion of trips by car has increased in Sydney over the last twenty (20) years (Table 5.1). Between 1981 and 2002 the proportion of trips by car in Sydney increased by 17%. The proportion of trips by train has remained constant over this period. The increase in car trips has been at the expense of bus and walking trips, which have decreased by 2% and 15%, respectively, over the period.

Table 5.1: Historic travel trends in Sydney 1981-2002 – Mode of travel (%)

	1981	1991	2000	2001	2002	Change 1981- 2002
Vehicle Driver	38.6	40.1	48.1	48.3	48.9	10.3
Vehicle Passenger	14.8	18.0	21.9	21.8	21.3	6.5
<i>Total Vehicle</i>	<i>53.4</i>	<i>58.1</i>	<i>70.0</i>	<i>70.1</i>	<i>70.2</i>	<i>16.8</i>
Train	4.8	4.4	4.9	4.9	4.8	0.0
Bus	7.5	5.8	5.9	5.6	5.5	-2.0
Walk Only	32.3	30.1	17.4	17.2	17.3	-15.0
Other Modes	2.0	1.6	1.9	2.1	2.3	0.3
Total	100.0	100.0	100.0	100.0	100.0	

(Source: Hensher 2000, Transport and Population Data Centre 2005)

5.4 Analysis of the Sydney Household Travel Survey¹⁰

5.4.1 Introduction

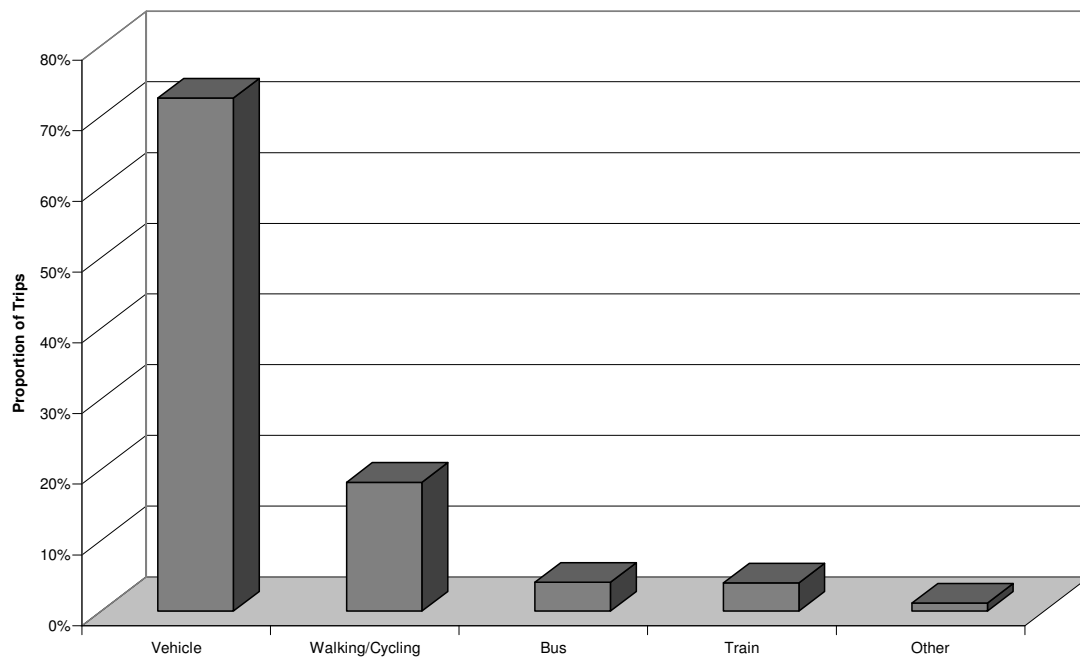
The aim of the analysis presented below is to begin to explore the relationship between transport use and the socio-economic characteristics of individuals in Sydney. The analysis will set the scene for the meso and micro level analyses that will be presented below. The data also shows how the HTS can be used to begin to ‘unpack’ this relationship. The HTS is a valuable data set but is rarely used to better understand the socio-economic influences of transport use in Sydney, which are identified as being important in overseas research.

5.4.2 Trip Purpose

In the 2002 Sydney Household Travel Survey (HTS) there were 66,231 trips over the three year pooled period with the majority undertaken by motor vehicle (Figure 5.1). The trip most commonly undertaken in Sydney is ‘returning to home’ which represents 35% of all trips (Figure 5.2). This is followed by social/recreation trips (15%) and shopping

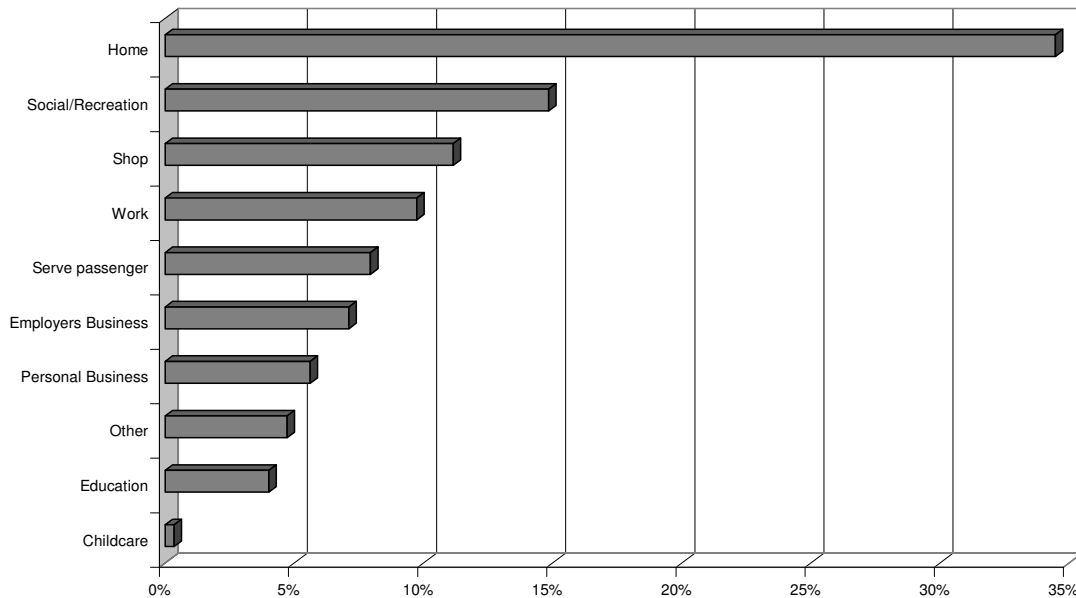
trips (11%). Journey to work trips came in fourth representing (10%) of all trips. If we surmise that all trips to work were followed by trips home than journey to work trips would only represent about one-fifth of all trips in Sydney.

Figure 5.1: The proportion of all trips by mode, Sydney, 2002 (weighted)



¹⁰ See also Appendix 6.

Figure 5.2: The proportion of trips for all modes by trip purpose, Sydney, 2002



The majority of trips in Sydney are by motor vehicle (Table 5.2 and 5.3 and Figure 5.2). Some 35% of all motor vehicle trips are for home trips, 13% for social/recreation trips and 10% for serve passenger. Only 9% of motor vehicle trips are for journeys to work. This differs from public transport trips. While 39% of train trips and 41% of bus trips are for home trips, 26% of train trips are for journeys to work, significantly higher than for motor vehicle trips. Bus trips to work are slightly higher than that for motor vehicles at 11%. That is, compared to other trip purposes those who undertake work trips are more likely to use the train, while educational trips constitute the largest proportion of trips on buses (Figures 5.3 and 5.4).

Trips for educational purposes are less likely to be conducted in a motor vehicle than for any other trip purpose (Figure 5.3). Just over 7% of trips on trains and 19% of trips on buses are for education trips. This is not surprising given that a large proportion of school children use a bus or train to get to school. Conversely, public transport trips are significantly lower for business, social/recreation and serve passenger trips. 'Employers business' trips on public transport are at least half that of similar trips in motor vehicles.

Further, those individuals who undertake shopping or social/recreation trips are more likely to walk/cycle than for any other trip purposes.

Figure 5.3: The proportion of all trips by all modes by trip purpose, Sydney, 2002

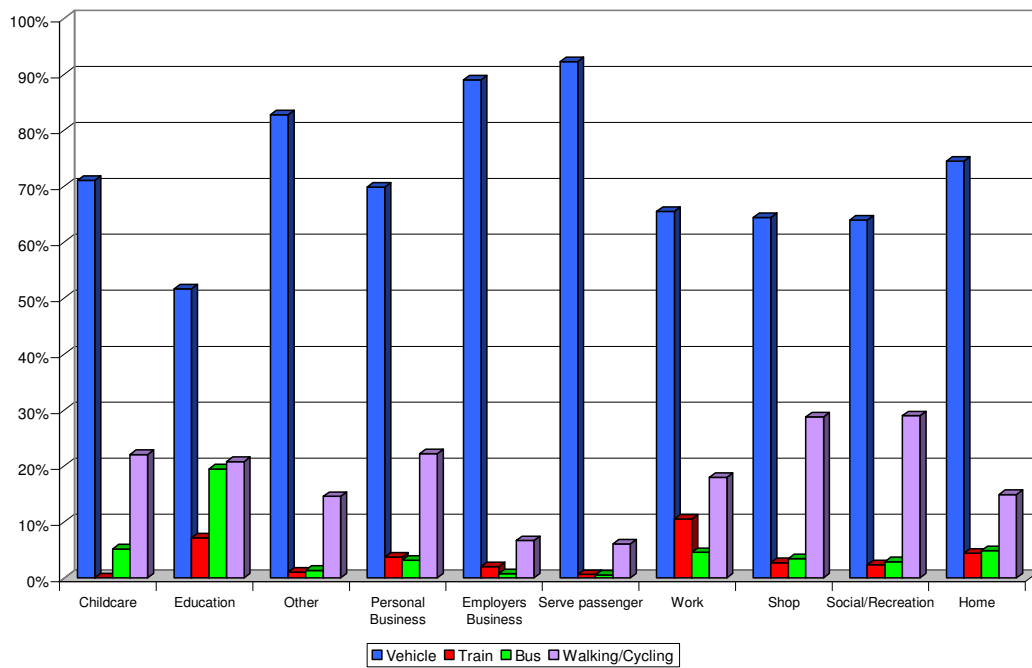


Figure 5.4: The proportion of trips for those who use a train or bus by trip purpose, Sydney, 2002

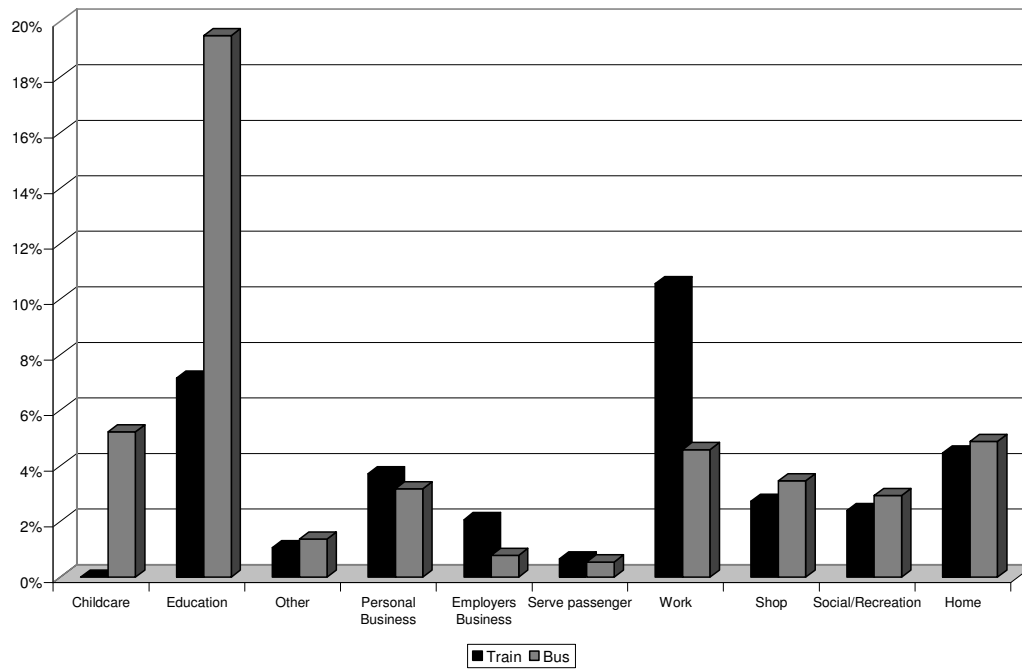


Table 5.2: Socio-economic profile of all trips made by individuals by mode, Sydney
2002 (weighted column percentages)

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
number of trips (unweighted)	47,249	2,762	3,004	12,490	816	66,321
Trip Purpose						
Childcare	0.3%	0.0%	0.5%	0.4%	0.5%	0.4%
Education	2.9%	7.2%	19.1%	4.6%	3.1%	4.0%
Other	5.4%	1.3%	1.6%	3.8%	1.0%	4.7%
Personal Business	5.4%	5.3%	4.4%	6.9%	4.9%	5.6%
Employers Business	8.7%	3.7%	1.4%	2.6%	8.9%	7.1%
Serve passenger	10.1%	1.3%	1.1%	2.7%	3.0%	8.0%
Work	8.8%	25.9%	10.9%	9.6%	11.5%	9.7%
Shop	9.9%	7.7%	9.5%	17.6%	6.0%	11.2%
Social/Recreation	13.1%	8.9%	10.6%	23.6%	22.9%	14.8%
Home	35.4%	38.8%	41.1%	28.2%	38.4%	34.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Dwelling Structure						
Separate house	85.6%	65.4%	68.9%	64.8%	60.6%	80.0%
Semi detached	7.4%	10.9%	11.5%	13.9%	9.6%	8.9%
Flat under 4 storeys	5.8%	19.4%	14.4%	16.3%	21.3%	8.8%
Flats 4 or more storeys	1.0%	4.0%	5.1%	4.8%	8.4%	2.1%
Other	0.2%	0.4%	0.2%	0.3%	0.0%	0.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Tenure						
Owned	46.6%	37.8%	41.4%	39.8%	33.5%	44.7%
Being Purchased	34.1%	26.7%	25.0%	25.0%	26.4%	31.7%
Rent Publicly	3.0%	5.7%	7.6%	7.5%	7.1%	4.2%
Rent Privately	15.6%	29.4%	25.2%	27.3%	31.3%	18.9%
Other Tenure	0.7%	0.4%	0.8%	0.4%	1.7%	0.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Household Type						
Person living alone	6.8%	11.1%	12.9%	13.8%	17.1%	8.6%
Couple only	17.8%	21.2%	13.9%	19.5%	27.2%	18.2%
Couple living with children	60.7%	45.6%	47.5%	42.8%	31.8%	56.0%
One person living with children	9.3%	12.1%	16.0%	14.1%	10.9%	10.6%
Other	5.4%	10.0%	9.7%	9.8%	13.0%	6.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Age						
0 - 14 years	15.4%	6.5%	29.4%	18.4%	12.7%	16.1%
15-24 years	11.5%	25.8%	23.1%	13.9%	14.3%	13.0%
25-34 years	14.6%	21.1%	10.5%	16.2%	25.4%	15.1%
35-44 years	22.6%	18.7%	10.5%	16.3%	16.9%	20.7%
45-54 years	17.9%	13.7%	7.8%	12.7%	10.5%	16.3%
55-64 years	10.1%	6.4%	6.3%	10.3%	8.7%	9.8%
65+ years	7.9%	7.7%	12.5%	12.2%	11.5%	8.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
number of trips (unweighted)	47,249	2,762	3,004	12,490	816	66,321
Gender						
Male	50.3%	51.3%	45.6%	46.2%	53.4%	49.4%
Female	49.7%	48.7%	54.4%	53.8%	46.6%	50.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Birthplace						
Australia	75.5%	61.9%	73.2%	72.3%	75.0%	74.2%
Overseas	24.5%	38.1%	26.8%	27.7%	25.0%	25.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Household Income						
Less than \$200	4.3%	6.4%	7.6%	9.3%	7.0%	5.5%
\$200-\$399	8.4%	8.9%	13.2%	14.0%	8.8%	9.7%
\$400-\$599	9.2%	9.4%	11.4%	11.3%	8.9%	9.7%
\$600-\$799	9.9%	6.6%	9.1%	9.0%	5.1%	9.6%
\$800-\$999	9.4%	9.1%	10.2%	8.3%	6.4%	9.2%
\$1,000-\$1,199	11.6%	8.6%	9.7%	9.7%	5.9%	11.0%
\$1,200-\$1,499	9.9%	10.7%	7.9%	7.4%	3.4%	9.3%
\$1,500-\$1,999	12.0%	12.3%	11.3%	8.3%	11.4%	11.3%
\$2,000 or more	25.2%	28.0%	19.7%	22.6%	43.0%	24.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Labour Force Status						
Employed	55.7%	62.9%	30.2%	43.7%	58.9%	52.6%
Unemployed	2.0%	1.8%	1.3%	2.7%	1.3%	2.1%
Studying	16.9%	22.7%	48.6%	23.0%	17.9%	19.8%
Retired	11.6%	10.3%	16.2%	18.0%	15.4%	13.0%
Keeping House	6.9%	1.7%	2.2%	6.4%	4.0%	6.4%
Other	6.9%	0.6%	1.4%	6.1%	2.3%	6.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Occupation						
Managers and Administrators	8.7%	5.8%	4.9%	7.2%	12.5%	8.3%
Professionals	23.3%	30.7%	26.0%	33.2%	42.5%	25.5%
Associate Professionals	8.9%	10.3%	9.7%	8.1%	14.0%	8.9%
Tradespersons and Related Workers	14.3%	6.3%	4.5%	5.6%	3.9%	12.2%
Advanced Clerical and Service Workers	2.3%	4.5%	3.5%	3.4%	2.8%	2.6%
Intermediate Clerical, Sales and Service Workers	21.0%	25.2%	24.4%	24.3%	15.5%	21.7%
Intermediate Production and Transport Workers	7.7%	2.5%	1.8%	2.8%	0.4%	6.5%
Elementary Clerical, Sales and Service Workers	7.8%	7.3%	16.6%	9.5%	2.6%	8.2%
Labourers and Related Workers	5.9%	6.7%	8.5%	6.0%	5.7%	6.0%
Not Stated	0.1%	0.6%	0.0%	0.0%	0.1%	0.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Distance Traveled						
0 - 2 km	16.9%	0.1%	2.2%	72.1%	17.3%	25.7%
2.01 - 5 km	25.8%	2.8%	19.4%	22.8%	26.0%	24.1%
5.01 - 10 km	24.7%	12.9%	39.2%	4.0%	23.1%	21.0%
Greater than 10 km	32.6%	84.2%	39.2%	1.1%	33.6%	29.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

(source: Sydney Household Travel Survey)

Table 5.3: Socio-economic profile of all trips made by individuals by mode, Sydney 2002 (weighted row percentages)

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
number of trips (unweighted)	47,249	2,762	3,004	12,490	816	66,321
Trip Purpose						
Childcare	71.1%	0.0%	5.2%	22.1%	1.6%	100.0%
Education	51.7%	7.2%	19.5%	20.8%	0.9%	100.0%
Other	82.8%	1.1%	1.4%	14.6%	0.2%	100.0%
Personal Business	69.9%	3.7%	3.2%	22.3%	1.0%	100.0%
Employers Business	89.0%	2.1%	0.8%	6.7%	1.4%	100.0%
Serve passenger	92.3%	0.7%	0.5%	6.1%	0.4%	100.0%
Work	65.5%	10.6%	4.6%	18.0%	1.4%	100.0%
Shop	64.4%	2.7%	3.5%	28.8%	0.6%	100.0%
Social/Recreation	63.9%	2.4%	2.9%	29.0%	1.8%	100.0%
Home	74.5%	4.5%	4.9%	14.9%	1.3%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Dwelling Structure						
Separate house	77.6%	3.2%	3.5%	14.8%	0.9%	100.0%
Semi detached	60.1%	4.9%	5.3%	28.5%	1.2%	100.0%
Flat under 4 storeys	48.1%	8.8%	6.7%	33.7%	2.8%	100.0%
Flats 4 or more storeys	35.8%	7.7%	10.0%	41.9%	4.7%	100.0%
Other	65.3%	7.4%	4.2%	23.1%	0.0%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Tenure						
Owned	75.8%	3.4%	3.8%	16.2%	0.9%	100.0%
Being Purchased	78.1%	3.4%	3.2%	14.4%	1.0%	100.0%
Rent Publicly	52.6%	5.4%	7.4%	32.6%	1.9%	100.0%
Rent Privately	60.1%	6.2%	5.5%	26.4%	1.9%	100.0%
Other Tenure	76.5%	2.5%	5.3%	12.4%	3.2%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Household Type						
Person living alone	57.2%	5.2%	6.2%	29.2%	2.3%	100.0%
Couple only	70.9%	4.6%	3.1%	19.6%	1.7%	100.0%
Couple living with children	78.7%	3.2%	3.5%	13.9%	0.7%	100.0%
One person living with children	63.9%	4.5%	6.2%	24.2%	1.2%	100.0%
Other	59.1%	6.0%	5.9%	26.7%	2.2%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Age						
0 - 14 years	69.3%	1.6%	7.4%	20.8%	0.9%	100.0%
15-24 years	64.1%	7.9%	7.3%	19.5%	1.3%	100.0%
25-34 years	70.1%	5.6%	2.8%	19.5%	1.9%	100.0%
35-44 years	79.1%	3.6%	2.1%	14.3%	0.9%	100.0%
45-54 years	79.8%	3.4%	2.0%	14.2%	0.7%	100.0%
55-64 years	74.7%	2.6%	2.6%	19.1%	1.0%	100.0%
65+ years	64.4%	3.4%	5.7%	25.0%	1.5%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
number of trips (unweighted)	47,249	2,762	3,004	12,490	816	66,321
Gender						
Male	73.8%	4.1%	3.8%	17.0%	1.2%	100.0%
Female	71.4%	3.8%	4.4%	19.4%	1.1%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Birthplace						
Australia	73.8%	3.3%	4.0%	17.7%	1.2%	100.0%
Overseas	69.1%	5.9%	4.3%	19.6%	1.1%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Household Income						
Less than \$200	57.4%	4.6%	5.7%	30.9%	1.5%	100.0%
\$200-\$399	63.3%	3.7%	5.6%	26.4%	1.0%	100.0%
\$400-\$599	68.9%	3.8%	4.8%	21.4%	1.1%	100.0%
\$600-\$799	75.5%	2.7%	3.9%	17.2%	0.6%	100.0%
\$800-\$999	74.3%	3.9%	4.5%	16.5%	0.8%	100.0%
\$1,000-\$1,199	76.6%	3.1%	3.6%	16.0%	0.6%	100.0%
\$1,200-\$1,499	77.1%	4.6%	3.5%	14.5%	0.4%	100.0%
\$1,500-\$1,999	77.0%	4.3%	4.1%	13.4%	1.2%	100.0%
\$2,000 or more	73.6%	4.5%	3.3%	16.6%	2.0%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%
Labour Force Status						
Employed	75.4%	5.0%	2.6%	15.6%	1.4%	100.0%
Unemployed	68.0%	3.6%	2.9%	24.7%	0.8%	100.0%
Studying	61.0%	4.8%	11.1%	22.0%	1.1%	100.0%
Retired	63.6%	3.3%	5.6%	26.0%	1.5%	100.0%
Keeping House	77.5%	1.1%	1.6%	19.1%	0.8%	100.0%
Other	79.4%	0.4%	1.0%	18.7%	0.5%	100.0%
Total	71.2%	4.2%	4.5%	18.8%	1.2%	100.0%
Occupation						
Managers and Administrators	80.2%	3.3%	1.6%	13.1%	1.8%	100.0%
Professionals	69.8%	5.6%	2.7%	19.9%	2.1%	100.0%
Associate Professionals	75.9%	5.4%	2.9%	13.8%	1.9%	100.0%
Tradespersons and Related Workers	89.3%	2.4%	1.0%	7.0%	0.4%	100.0%
Advanced Clerical and Service Workers	67.8%	8.0%	3.5%	19.4%	1.3%	100.0%
Intermediate Clerical, Sales and Service Workers	73.7%	5.4%	3.0%	17.0%	0.9%	100.0%
Intermediate Production and Transport Workers	90.8%	1.8%	0.8%	6.5%	0.1%	100.0%
Elementary Clerical, Sales and Service Workers	72.6%	4.2%	5.4%	17.5%	0.4%	100.0%
Labourers and Related Workers	74.7%	5.2%	3.7%	15.2%	1.2%	100.0%
Not Stated	72.2%	25.7%	1.1%	0.0%	1.1%	100.0%
Total	76.3%	4.7%	2.7%	15.2%	1.2%	100.0%
Distance Traveled						
0 - 2 km	47.8%	0.0%	0.3%	51.1%	0.8%	100.0%
2.01 - 5 km	77.8%	0.5%	3.3%	17.2%	1.2%	100.0%
5.01 - 10 km	85.2%	2.4%	7.6%	3.5%	1.3%	100.0%
Greater than 10 km	81.0%	11.5%	5.5%	0.7%	1.3%	100.0%
Total	72.6%	4.0%	4.1%	18.2%	1.1%	100.0%

(Source: Sydney Household Travel Survey)

5.4.3 Dwelling Structure

In the 2000-2002 period the HTS was conducted 86% of motor vehicle trips were from individuals in separate houses, 7% from persons in semi detached dwellings and 6% in flats in a block under 4 storeys (low rise flats) (Table 5.2). Only 1% of all motor vehicle trips were from individuals in flats in a block of 4 or more storeys (high rise flats). For train and bus trips the situation is starkly different. Just over 65% of train trips and 69% of bus trips are from individuals in separate houses, significantly lower than the proportion of motor vehicle trips from persons in separate houses. The proportion of train trips and bus trips for persons in multi-unit housing is significantly higher than the proportions recorded for motor vehicle trips. That is, 19% of train trips and 14% of bus trips are from persons who live in low rise flats (compared to 6% for motor vehicles). Further, 11% of train trips and 12% of bus trips are from individuals who reside in semi detached dwellings. Similarly, a higher proportion of bus and train trips were recorded from individuals in high rise flats than that recorded for motor vehicles. For walking/cycling trips 64% of these trips are from persons in separate houses, 16% from individuals in low rise flats and 14% from individuals in semi detached dwellings.

These figures are also influenced by the housing stock that is available on the ground. That is, the largest proportion of motor vehicle, train, bus and walking/cycling trips are from individuals in separate houses. This is not surprising given that the majority of the housing stock in Sydney is of this form.

Nevertheless, when we take a closer look at each individual dwelling type some interesting pictures emerge. Those individuals in high rise flats are less likely to use a motor vehicle than for other dwelling types (Table 5.3 and Figure 5.5). Some 36% of trips for persons in high rise flats are in motor vehicles whereas 78% of trips for those who live in separate houses are by motor vehicle. Moreover, 42% of trips for persons in high rise flats are by walking/cycling (compared to 15% for those in separate houses).

Examining the data in another way reveals that those in low rise flats are more likely than individuals in other dwelling types to use trains, while those persons who reside in high rise flats are more likely to use a bus (Figure 5.6). Some 9% of trips by individuals in low rise flats are by train, compared to 8% for individuals in high rise flats, and 5% and 3% for those who live in semi detached dwellings and separate houses. Further, 10% of trips by persons in high rise flats are by bus, whereas, 7% of trips by persons in low rise flats, 5% of trips from those in semi detached dwellings and 4% from persons in separate houses are by bus.

5.4.4 Tenure

Approximately 81% of all motor vehicle trips are undertaken by those households who own or are purchasing their dwelling, while 16% are conducted by private renters (Table 5.2 and 5.3). These proportions change when train and bus trips are considered. Of all train trips 65% are by owners and purchasers, while 66% of bus trips are by owners and purchasers. These proportions are much lower than that for motor vehicle trips. Conversely, a significantly higher proportion of train and bus trips are conducted by private renters. Some 29% of train trips and 25% of bus trips are by private renters. The proportions of walking/cycling trips for different tenure groups is similar to that for train and bus trips – around two-thirds of trips by owners and purchasers and one-fifth by private renters.

If we examine the difference between tenure categories rather than trip modes some interesting results emerge. Public renters are less likely than other tenure groups to use motor vehicles (53% compared to 78% for purchasers) (Figure 5.7). Public renters are also more likely than other tenure groups to walk/cycle. In other words, purchasers are more likely than other tenure groups to use a motor vehicle and less likely to walk/cycle. Looking at the data another way, public renters are more likely to use buses than the other tenure groups (7%), however, private renters are more likely than other tenure groups to use trains (Figure 5.8). Overall, 13% of public renters' trips and 12% of trips by private renters are either by train or bus, compared to 7% of trips for owners and purchasers.

5.4.5 Household Type

In 2002, 60% of all motor vehicle trips were by couples with children. This is much higher than the proportion of train, bus and walking/cycling trips by couples with children (46%, 48% and 43%, respectively) (Table 5.2 and 5.3). The proportion of train, bus and walking/cycling trips by lone person households and single parent families was higher than that of motor vehicle trips. That is, 11-14% of non-motor vehicle trips were by lone person households while only 7% of motor vehicle trips were by lone persons. Similarly, 12-16% of non-motor vehicle trips were by single parent families compared with 9% of motor vehicle trips. Further, only 14% of bus trips were by couple only households, whereas, 18% of motor vehicle trips, 21% of train trips and 20% of walking/cycling trips were by couple only households.

On closer inspection of household types lone person households are less likely than other household types to use a motor vehicle (58% of trips), while these household are more likely to walk/cycle (29% of trips) (Figure 5.9). Not surprisingly, couple families with children are more likely than any other household type to use a motor vehicle (79% of trips) and are less likely to walk or cycle (14% of trips). Examining the data another way, lone person households and single parent families are more likely to use a bus than other household types (6% of all trips) (Figure 5.10). Interestingly, while lone person households are more likely to use a train than other household types (excluding 'other tenure'), couple only households are more likely to use the train more than single parent families or couples with children.

5.4.6 Age

In examining the proportion of different modes by age some interesting results emerge. For motor vehicle trips those aged 35-44 and 45-54 had the highest proportion of trips (23% and 18%, respectively) (Table 5.2). Those aged 15-24 and 25-34 provided the highest proportion of train trips (26% and 21% of train trips). Not surprisingly, those aged 0-14 and 15-24 years provided the highest proportions for bus trips (29% and 23%

of all bus trips). For walking/cycling these trips were more likely to be undertaken by those aged 0-14, although these proportions were evenly distributed compared to other trip modes. Further, those aged 65 and over provided a higher proportion of bus and walking/cycling trips compared to motor vehicle and train trips, while those aged 35-54 provided a higher proportion of motor vehicle trips (compared to other trip modes).

If the difference between age groups is analysed some surprising results are also obtained. Some 80% of trips made by those aged 45-54 years are by motor vehicle, compared to 64% of trips by those aged 15-24 years and 65 years or more (Figure 5.11). Those aged 0-24 years are more likely to use a bus (7% of trips for this age group), due mostly to the large number of students who catch a bus (Figure 5.12). Those aged 65 years or more are the next likely to use a bus (6% of trips). Interestingly, the proportion of trips by train for each age group is highest for those aged 15-24 years (8% of trips) but then declines to the 55-64 year age group (3% of trips). In particular there is a large decline from those aged 25-34 years to those aged 35-44. Persons aged 35-54 are the least likely to use a bus. Further, those aged 15-44 years are more likely to use a train than persons aged over 65 years. Those over 65 years clearly use a bus more than the train.

5.4.7 Gender

As far as gender is concerned there was very little difference between males and females in terms of trip mode. Approximately half of all motor vehicle trips are by males and half by females (Table 5.2 and 5.3). Some 51% of train trips are by males while 49% are by females. The largest gap between males and females is between bus and walking/cycling trips. Nearly 46% of bus and walking cycling trips are by males, whereas 54% of these trips are by females. This is also reflected in Figures 5.13 and 5.14. Approximately 70% of trips by males and females are by motor vehicle. Females are more likely than males to walk/cycle. Males are more likely than females to catch a train while the reverse is true for buses. That is, females are more likely to catch a bus.

5.4.8 Birthplace

For motor vehicle, train, bus and walking/cycling trips the largest proportion of these trips are by persons born in Australia (Table 5.2). This is not surprising given the majority of the population were born in Australia. However, while vehicle use is highest amongst those born in Australia, there is a higher propensity for overseas born persons to use the train, bus and walking/cycling when total population numbers are considered (Figure 5.15 and 5.16). In particular, train usage by those born overseas is approximately double that of Australian born persons, once account is taken of population size. The propensity to use the bus between Australian born persons and those born overseas is higher for overseas born persons but the difference is minimal.

5.4.9 Household Income

Some 37% of motor vehicle trips are undertaken by households earning more than \$1,500 per week (Table 5.2). This is slightly less than the proportion of train trips households earning over \$1,500 per week (40%), but higher than that for bus trips (30%). For bus trips a higher proportion of households earn less than \$1,000 per week (52%), when compared with motor vehicle (41%) and train trips (40%). For walking/cycling trips 23% earn more than \$2,000 per week while 35% earn less than \$600.

Looking at the data another way, 77% of trips made by persons earning between \$1,000 and \$1,999 per week are by motor vehicle, significantly higher than that for those who earn less than \$200 (58%) (Figure 5.17). Those households on lower incomes are also more likely than higher income households to walk or cycle. From these results we could surmise that higher income households use motor vehicles more than lower income households. However, this is not the case. Some 74% of households who earn more than \$2,000 per week do use a motor vehicle, however, 17% also walk or cycle. This is higher than the proportion of walk/cycle trips undertaken by more moderate income households. Further, 5% of trips undertaken by households earning less than \$200 per week are by train. This is also the case for households earning more than \$2,000 per week and those

earning \$1,200-\$1,499 per week (Figure 5.18), although, those earning more than \$2,000 per week have the lowest level of bus usage. Overall, it is clear that low income households do not use a motor vehicle as much as higher income households and have higher bus usage. However, higher income households use the train more than middle income households in Sydney.

5.4.10 Labour Force Status

Interestingly, 63% of all train trips are by employed persons and a further 22% are by people who are studying (Table 5.2). This is higher than motor vehicle trips where 56% are employed. Conversely, only 30% of bus trips are by persons employed. The largest proportion of bus trips are by those who are studying (49% of all bus trips). Further, 43% of walking/cycling trips are by those in employment, 23% by those individuals who are studying and 18% from those who are retired.

When the differences between labour force categories are examined a different picture emerges. Excluding the small 'other' category, the largest user of motor vehicles is for those individuals who are 'keeping house' (Figure 5.19). Employed persons are the next largest user of motor vehicle for all trips. The largest proportion of walking/cycling trips is by those individuals who are retired, followed by those unemployed. Those individuals who are studying are more likely than other labour force categories to use a bus (Figure 5.20), followed by those who are retired. Further, employed persons are more likely than other labour force cohorts to use a train. Some 5% of trips by employed persons are by train. This is closely followed by those persons studying. Overall, train use is higher than bus usage for those employed or unemployed, whereas bus usage is higher for those studying, retired or keeping house.

5.4.11 Occupation

Professional workers, Intermediate Clerical, Sales and Service Workers and Tradespersons have a higher proportion of motor vehicle trips than other occupations

(Table 5.2). As far as train trips are concerned Professionals and Intermediate Clerical, Sales and Service Workers also constitute a significant proportion of these trips (56%). This is similar for bus trips and walking/cycling trips. In other words, for non-motorised trips, Professionals and Intermediate Clerical, Sales and Service Workers constitute about half the proportion of trips for these modes.

Nevertheless, when we examine the trips made by occupations some interesting trends emerge (Figure 5.21). Not surprisingly, Intermediate Production and Transport Workers (91%) and Tradespersons (90%) have the highest levels of motor vehicle use. This is followed by Managers and Administrators (80% of all trips by this group). These three occupational groupings also have the lowest level of public transport usage and walking/cycling trips. The lowest level of motor vehicle use is for trips by Advanced Clerical and Service Workers (68% of trips). Professionals have the largest proportion of walking/cycling trips (20% of all trips by this occupational group). Importantly, Advanced Clerical and Service Workers may have the lowest level of motor vehicle usage but they clearly have the highest level of train usage across all occupational groupings (Figure 5.22). This is followed by Professionals, Associate Professionals and Intermediate Clerical, Sales and Service Workers. This also confirms the previous income analysis. That is, individuals with higher paying occupations tend to use the train just as much or even more than, traditional, moderate paying occupations. However, bus usage is a different story. Bus usage is highest amongst those occupations at the lower end of the occupational hierarchy (Labourers and Related Workers and Elementary Clerical, Sales and Service Workers), although Labourers tend to use the train more than buses. Further, there was only one occupational category – Elementary Clerical, Sales and Service Workers - in which bus usage was higher than train usage.

5.4.12 Distance Travelled

The distance travelled is a variable collected in the HTS which estimates the distance traveled in a trip. The 2002 HTS estimates that 72% of all walking/cycling trips are less than 2 kilometres (km) and 84% of all train trips are greater than 10 km (Table 5.2). For

motor vehicle trips the distance traveled is more evenly distributed, with 33% of all motor vehicle trips being greater than 10 km, 25% being 5-10 km and 26% being between 2 and 5 km. The majority of bus trips (78%) are greater than 5 km, although 50% of these trips are between 5 and 10 km and 50% are over 10km.

Interestingly, of all trips under 2 km, the largest proportion is walking/cycling (Figure 5.23). In other words, motor vehicle use is the lowest for trips under 2 km. Motor vehicle usage is highest for distances of 5-10 km. Beyond 10 km train travel becomes an important component (Figure 5.24). Further, bus use is more significant than train usage at distances of 5-10 km.

5.5 Overview

This chapter has examined the relationship between socio-economic variables and transport use in Sydney using the Sydney Household Travel Survey to provide a macro analysis of travel patterns in the metropolitan area. It was envisaged that this analysis would begin to evaluate whether density was a major influence on public transport use at the metropolitan level as articulated in urban consolidation policies in Sydney, or whether other variables are important in influencing public transport use.

The analysis found that 9% of trips from those in low rise flats and 8% from those in high rise flats are by train compared to only 3% of those in separate houses. The obvious finding from this would be to contend that those in flats use the train more than those persons in separate houses. There are, however, even at this macro level a number of findings that suggest dwelling type may not be the only factor in influencing train use, or for that matter all forms of public transport.

Private renters and public housing tenants are more likely to use trains and buses than owner and purchasers. Couples with children in Sydney have high car use confirming the findings of other researchers (e.g. Dieleman et al 2002) while couple only households

have high train use. Single persons and lone persons also have higher levels of public transport usage.

Higher income households use a motor vehicle more than lower income households in Sydney, a factor also identified by other researchers in other countries (e.g. Schwanen et al 2002, Schimek 1996). The analysis supports other researchers who have found income to be important in influencing public transport usage (e.g. Holtzclaw 1994). On the other hand, higher income households are more likely than 'middle' income households to use a train, although their bus use is lower, and those in higher paying occupations are more likely to use a train. Thus, even at this macro level these results begin to question the role of income in directly influencing transport patterns in Sydney. This result is also supported by the fact that employed persons are more likely to use public transport. Interestingly though, those in lower paying occupations are more likely to use a bus.

Both males and females at the macro or metropolitan level in Sydney use a motor vehicle in similar proportions, although males are more likely to use a train while females are more likely to catch a bus or walk/cycle. Interestingly, for short trips walking and cycling is predominant, confirming the results presented by Hodgetts (2003) in Melbourne. Beyond this car use is more important. As far as public transport is concerned bus use predominates for trips 5-10 kilometres, but beyond this the train is used more often. This suggests that at the macro level the current metropolitan planning strategy in Sydney which advocates bus feeder services to rail stations, and supported by Newman and Kenworthy may be appropriate. It does not suggest, however, that there are large numbers of individuals who take bus trips for longer trips.

Nevertheless, there is enough evidence at this macro level to suggest that socio-economic factors may be influencing public transport use in Sydney. What this analysis lacks though is an assessment of whether or not these socio-economic factors are important in different geographical locations in Sydney, that is a meso and micro level analysis, and which variables are the most important.

Figure 5.5: The proportion of trips for all modes by dwelling structure, Sydney, 2002

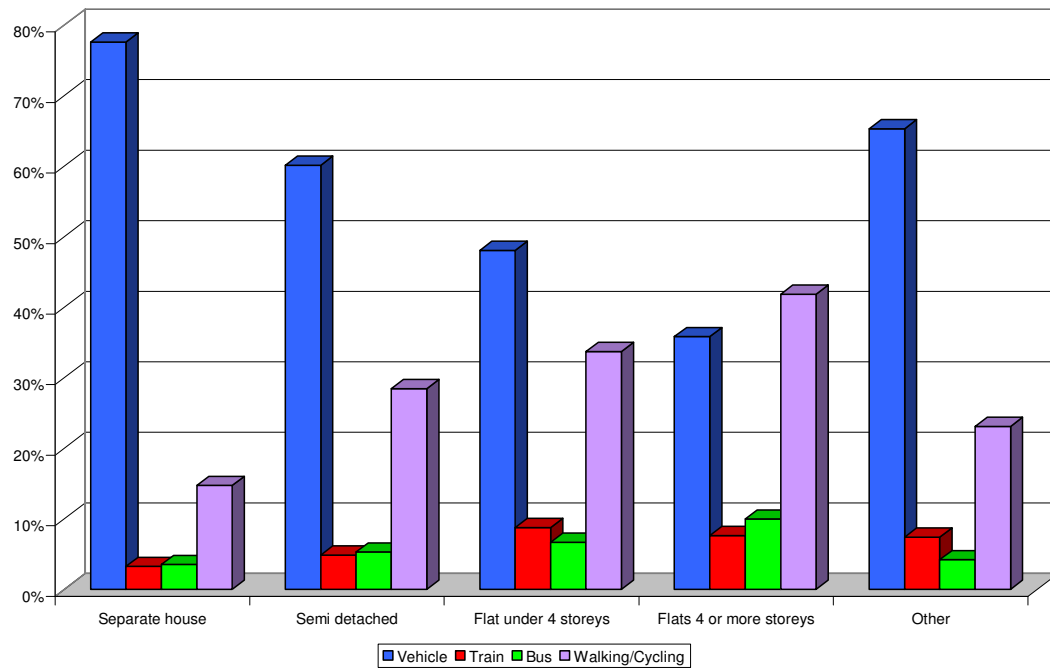


Figure 5.6: The proportion of trips for those who use a train or bus by dwelling structure, Sydney, 2002

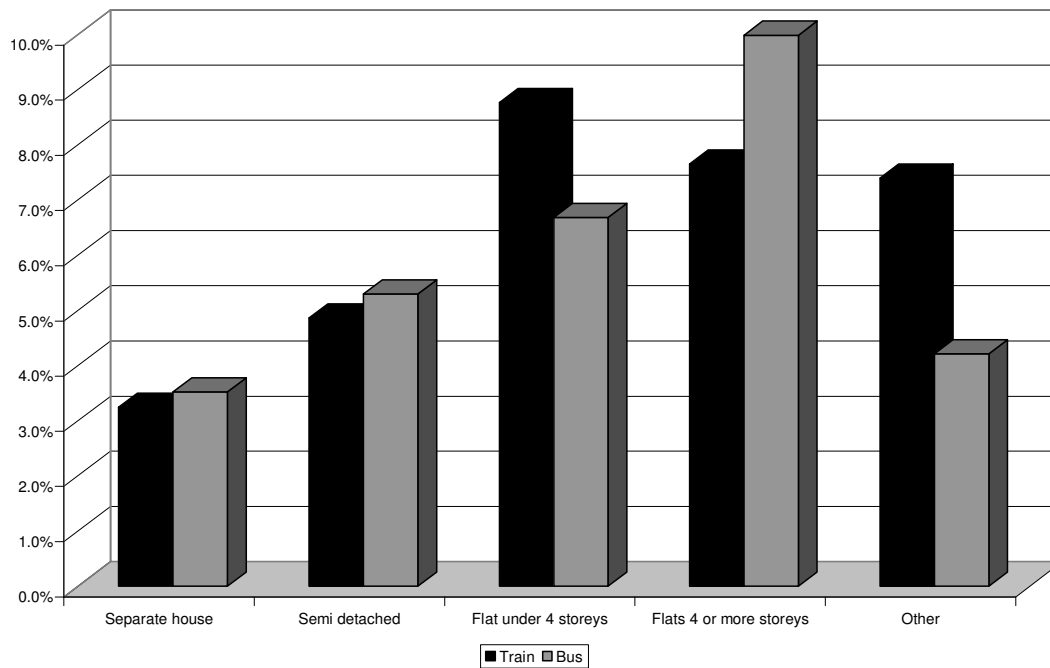


Figure 5.7: The proportion of trips for all modes by tenure, Sydney, 2002

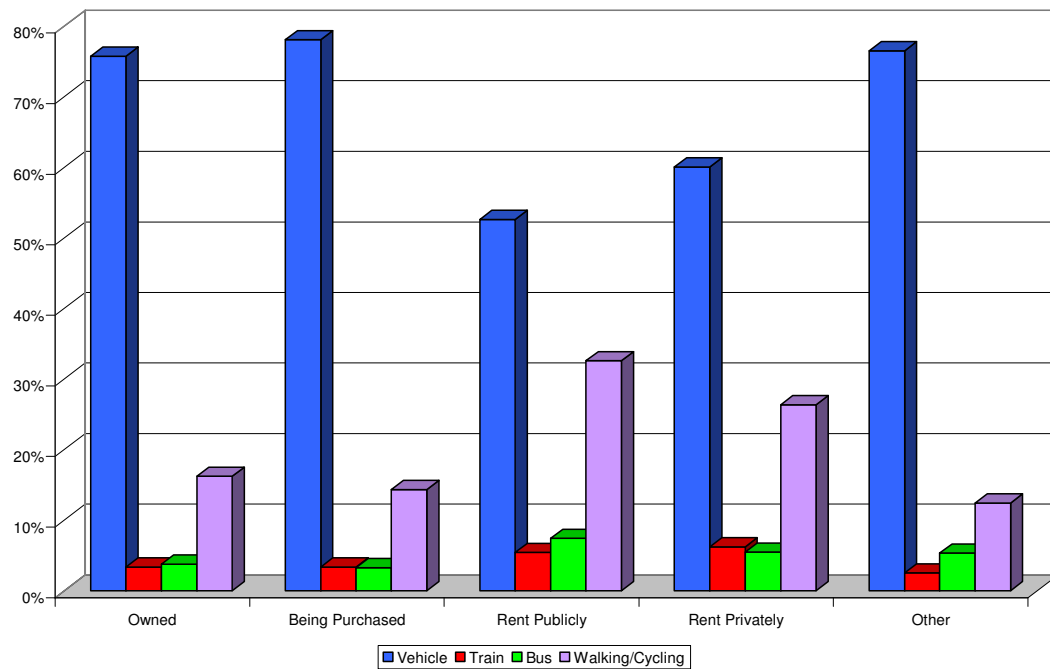


Figure 5.8: The proportion of trips for those who use a train or bus by tenure, Sydney, 2002

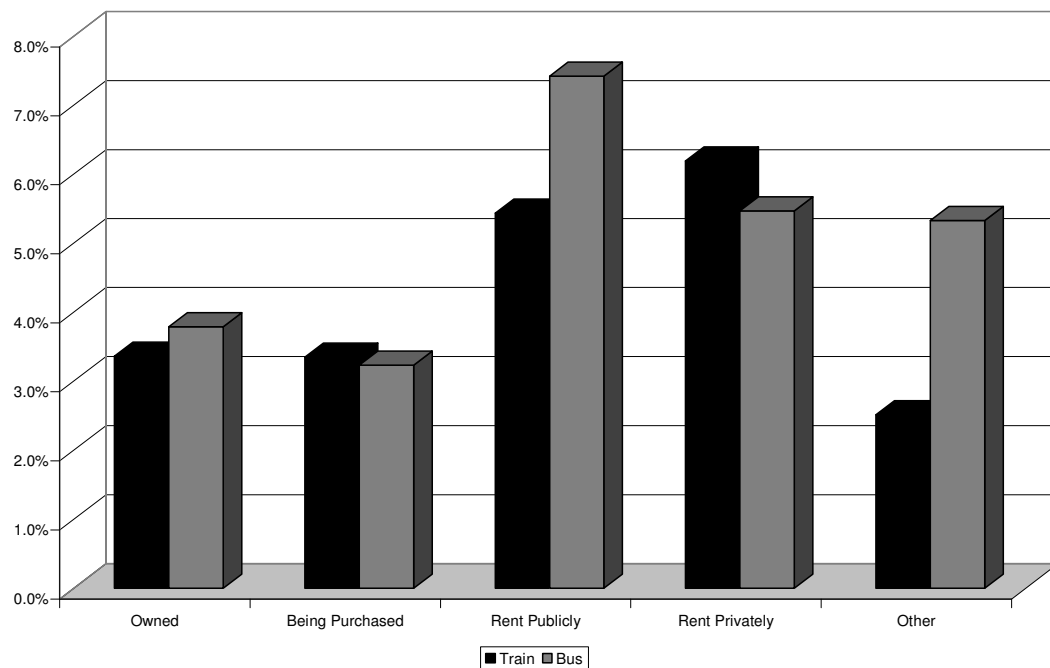


Figure 5.9: The proportion of trips for all modes by household type, Sydney, 2002

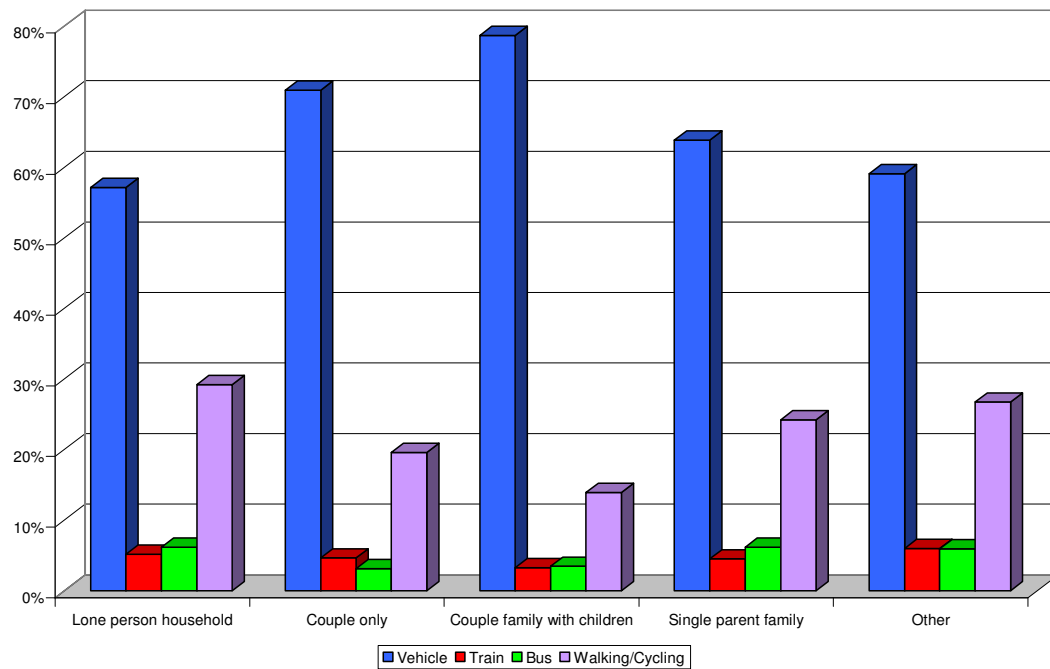


Figure 5.10: The proportion of trips for those who use a train or bus by household type, Sydney, 2002

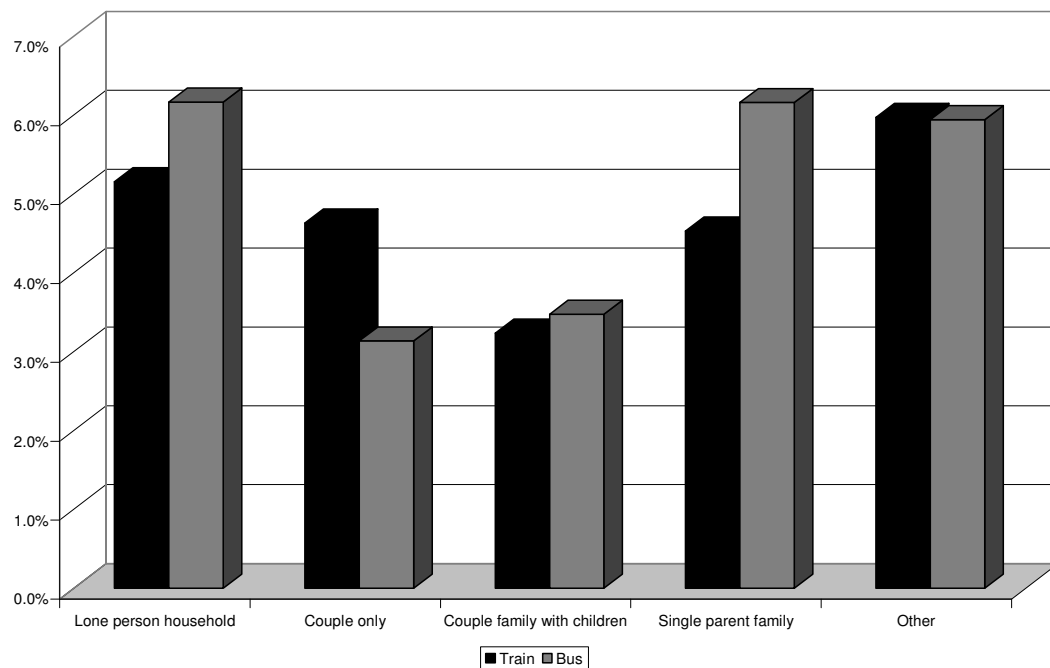


Figure 5.11: The proportion of trips for all modes by age group, Sydney, 2002

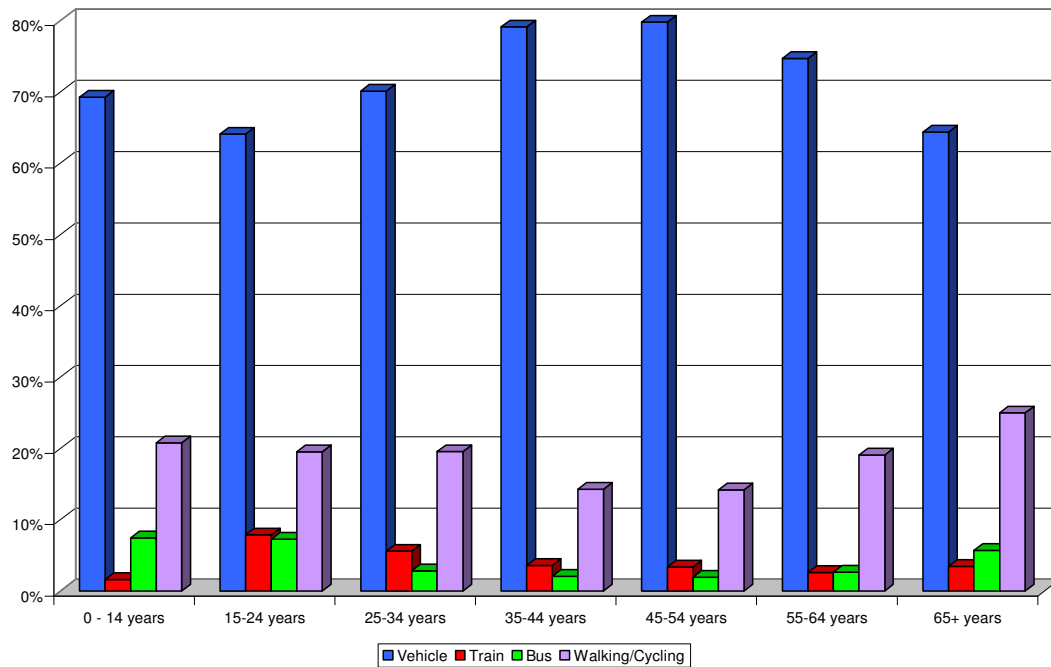


Figure 5.12: The proportion of trips for those who use a train or bus by age group, Sydney, 2002

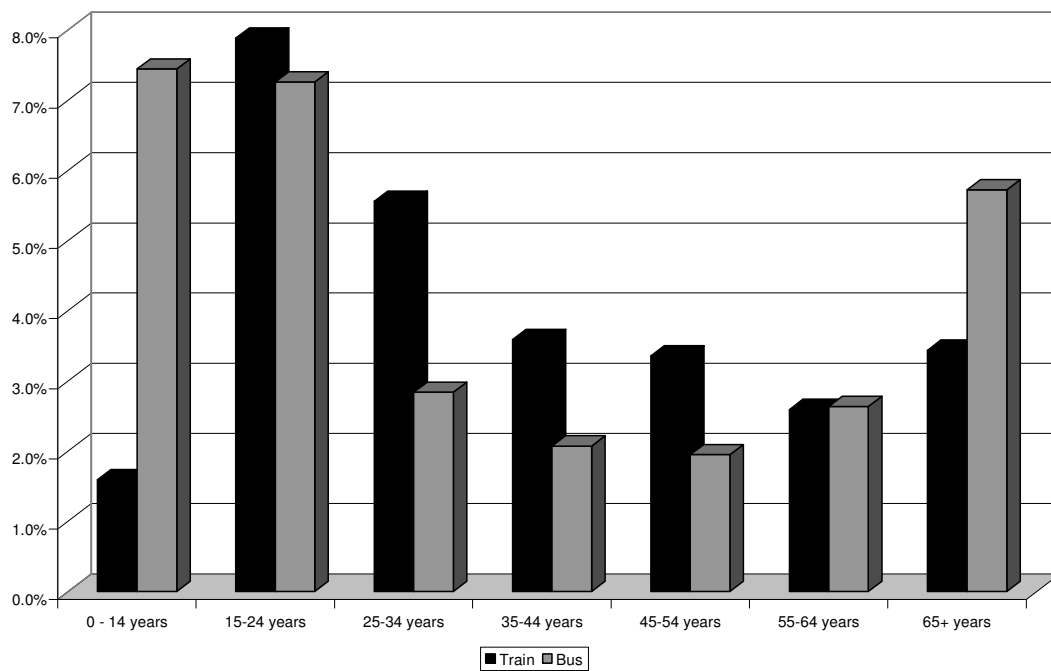


Figure 5.13: The proportion of trips for all modes by gender, Sydney, 2002

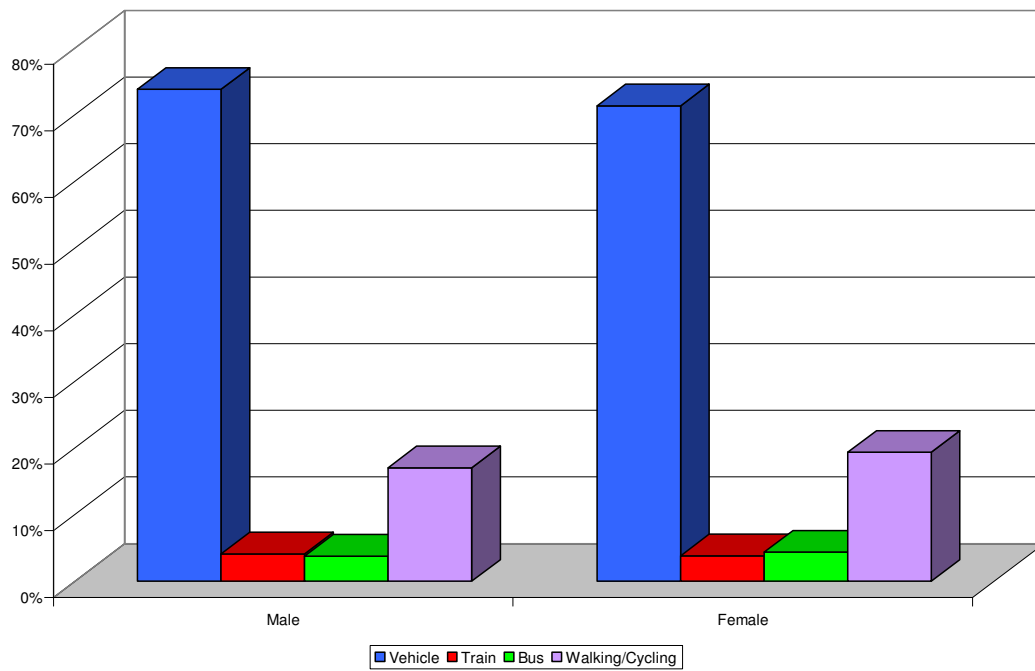


Figure 5.14: The proportion of trips for those who use a train or bus by gender, Sydney, 2002

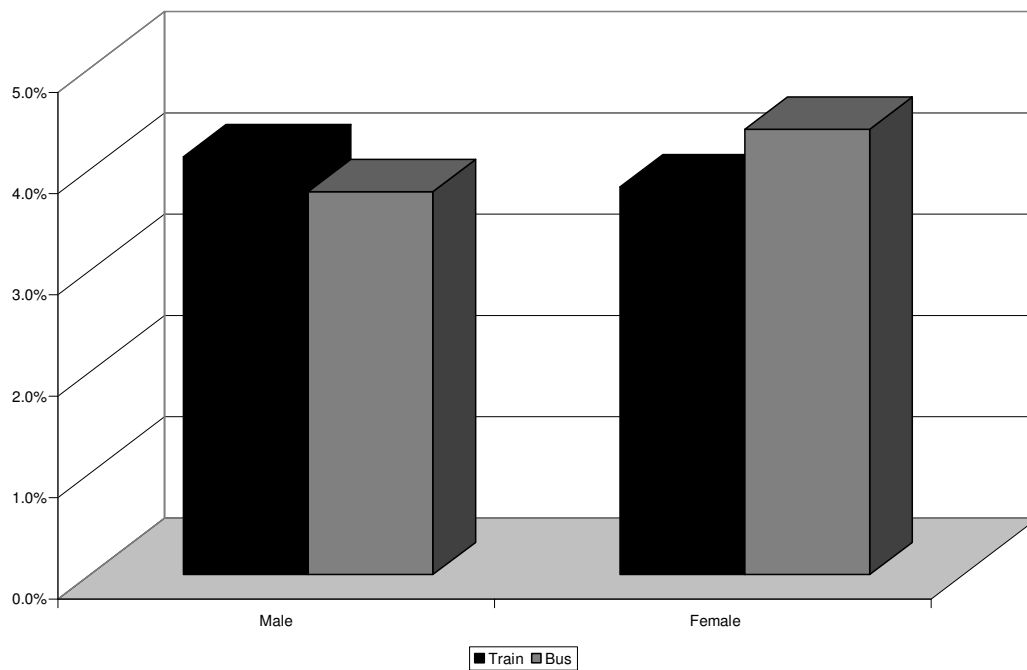


Figure 5.15: The proportion of trips for all modes by birthplace, Sydney, 2002

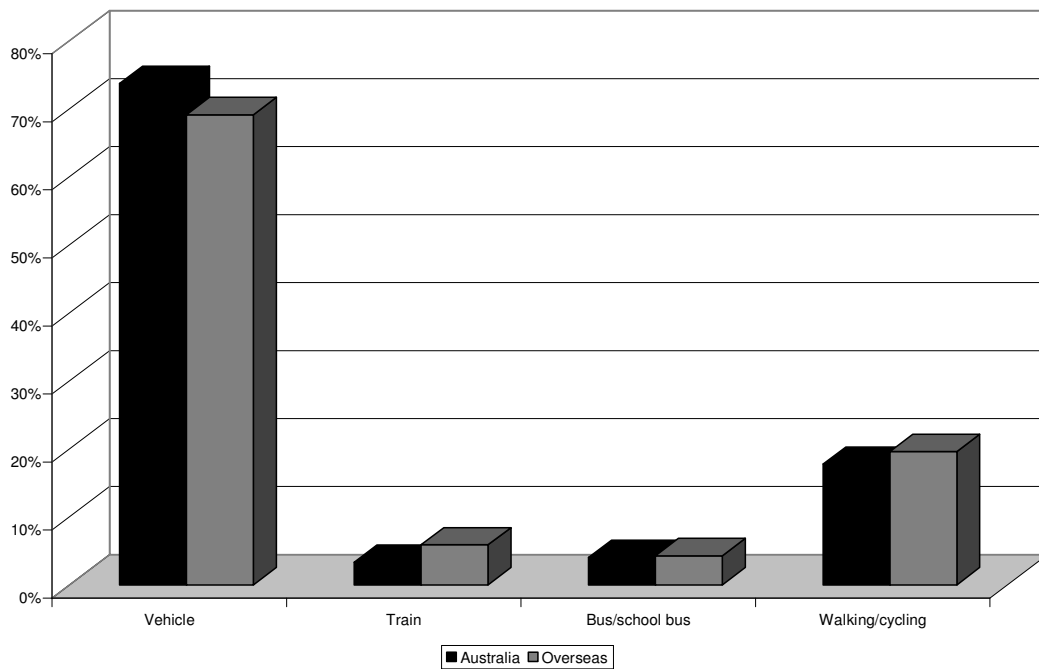


Figure 5.16: The proportion of trips for those who use a train or bus by birthplace, Sydney, 2002

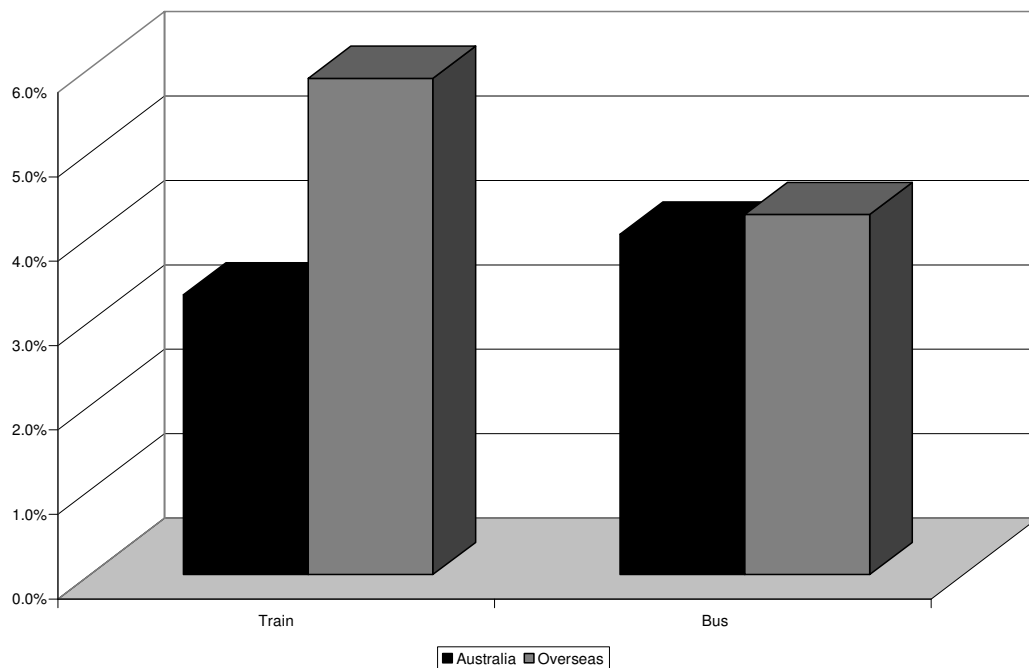


Figure 5.17: The proportion of trips for all modes by household income, Sydney, 2002

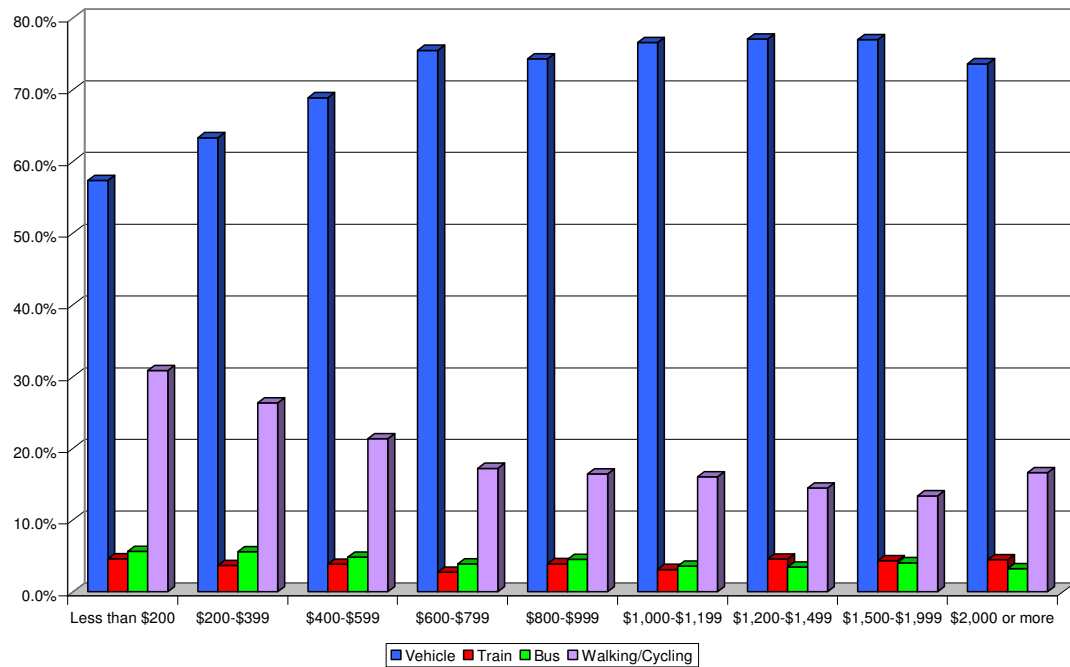


Figure 5.18: The proportion of trips for those who use a train or bus by household income, Sydney, 2002

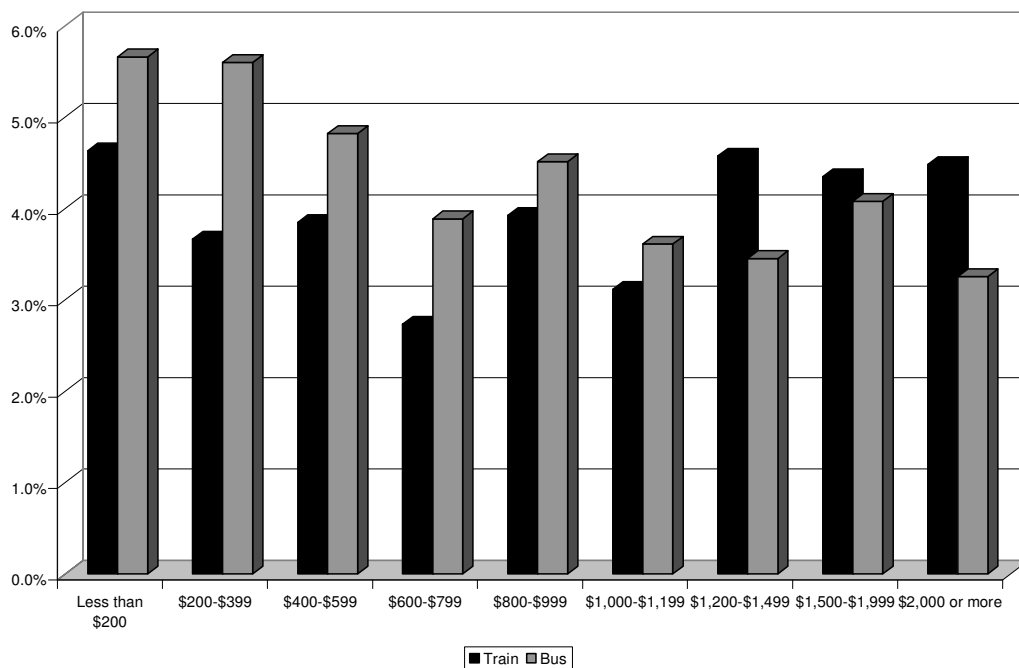


Figure 5.19: The proportion of trips for all modes by labour force status, Sydney, 2002

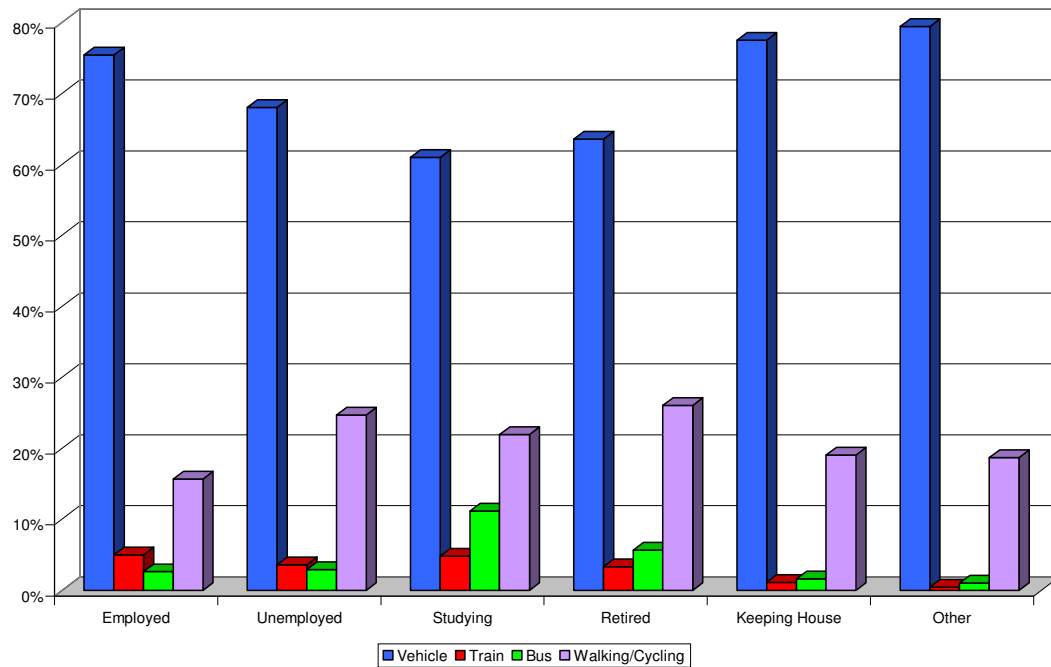


Figure 5.20: The proportion of trips for those who use a train or bus by labour force status, Sydney, 2002

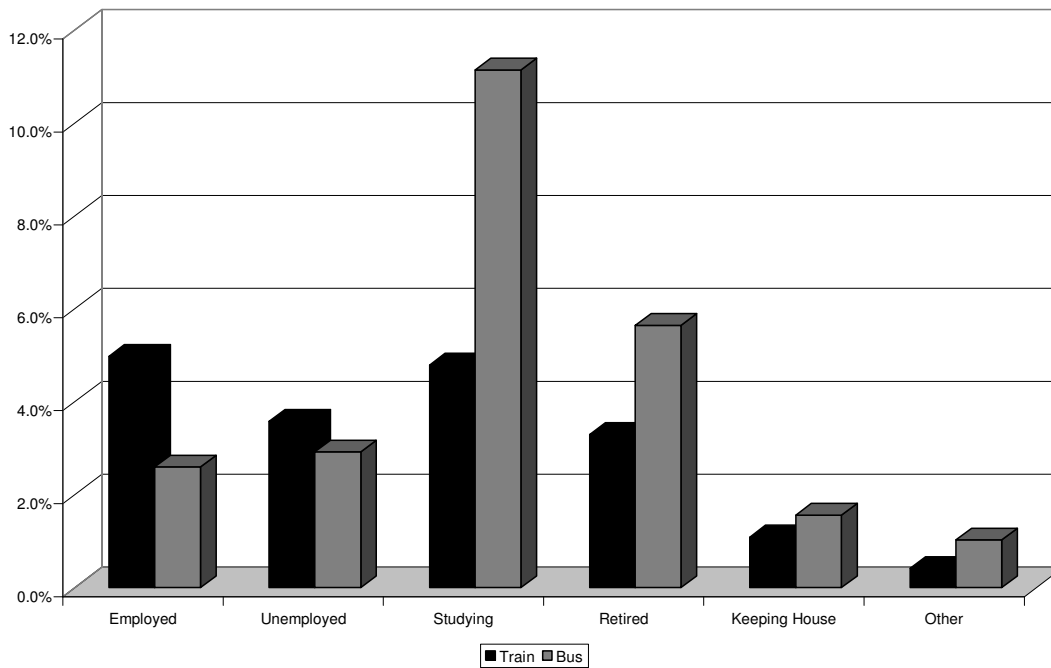


Figure 5.21: The proportion of trips for all modes by occupation, Sydney, 2002

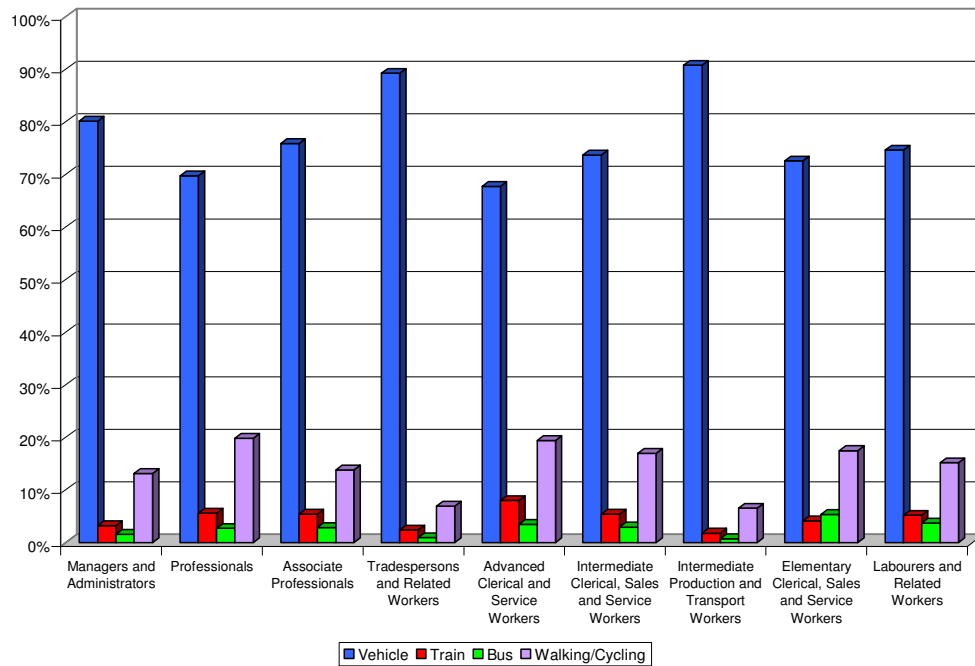


Figure 5.22: The proportion of trips for those who use a train or bus by occupation, Sydney, 2002

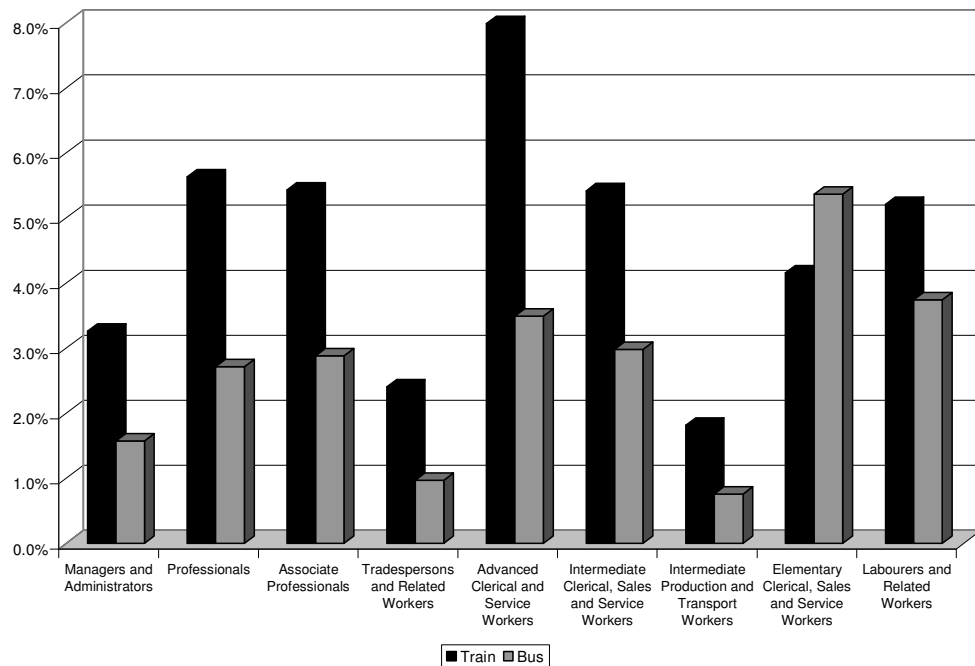


Figure 5.23: The proportion of trips for all modes by distance traveled, Sydney, 2002

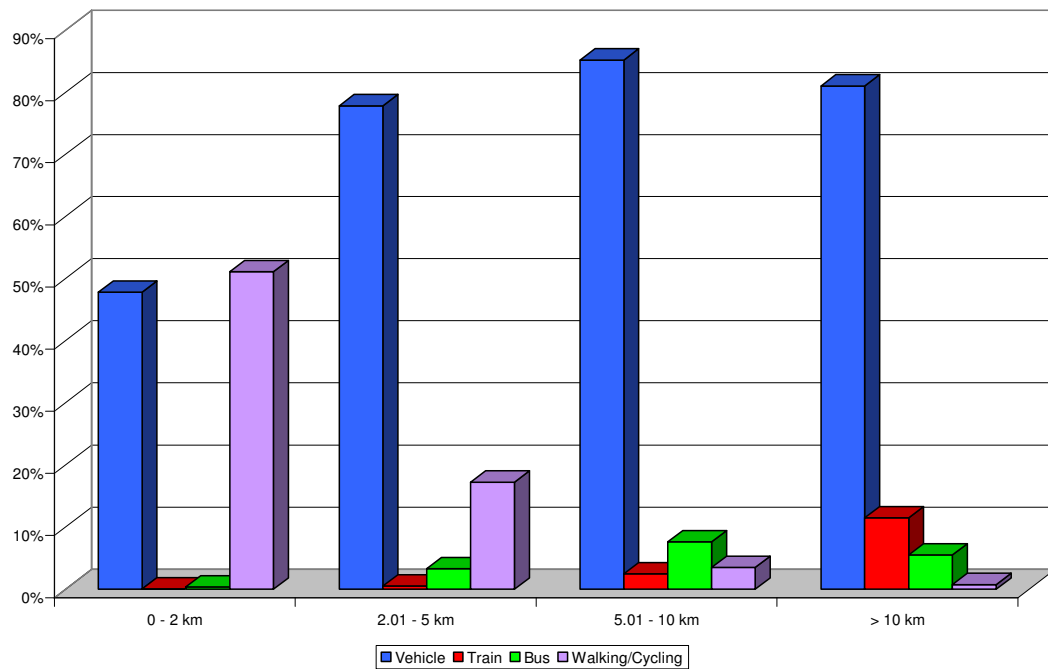
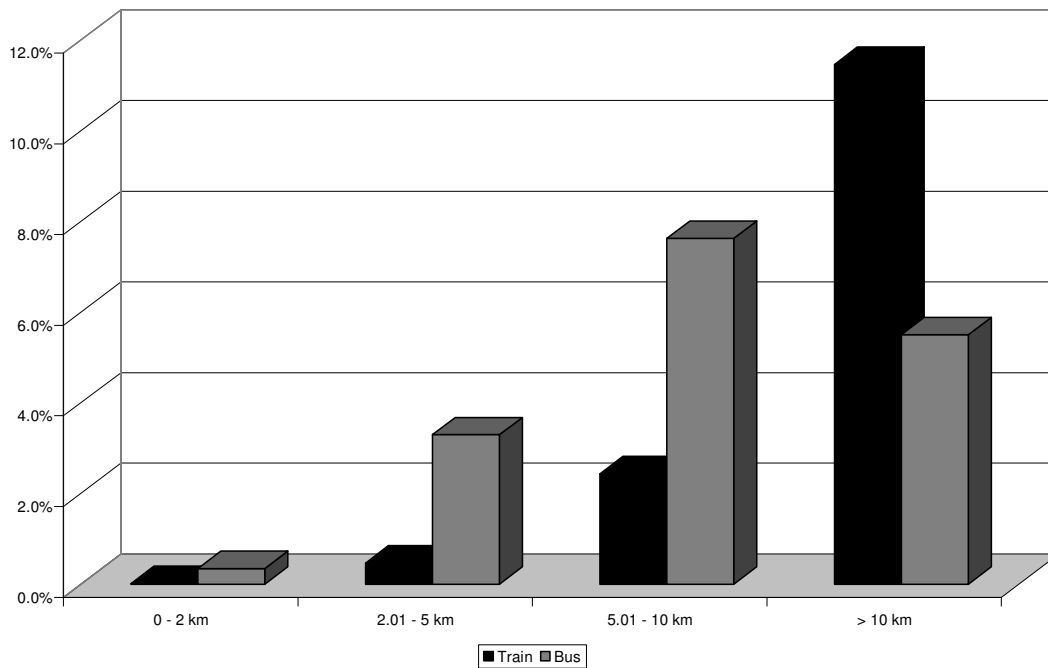


Figure 5.24: The proportion of trips for those who use a train or bus by distance traveled, Sydney, 2002



6. A MESO LEVEL MULTIVARIATE ANALYSIS OF TRAIN USE IN SYDNEY

6.1 Introduction

The preceding chapter began to assess the relationship between public transport and residential density at the macro level. It is evident from this macro analysis that individuals with certain socio-economic characteristics and who live in certain dwelling types are more likely to use public transport. This still does not, however, answer the question as to whether density is more important than socio-economic variables in explaining public transport use. This section builds upon the macro analysis above by examining the meso level relationship between socio-economic variables, density and public transport use (in this case train use) in Sydney through a series of multiple regression analyses.

6.2 Methodology

The multiple regression analyses presented are based on an exploration of three different data sets. Multiple regression analysis is used as it is a relatively simple statistical technique used to ‘un-pack’ or distil large data sets in order to obtain a smaller number of variables that explain a significant proportion of the variance within the data set (see Appendix 7). Multiple regression is also the most common technique used in land use and transport research in other countries (Stead 2001, Boarnet and Sarmiento 1998, Naess et al 1995, De Roo and Miller 2000) and provides the basis on which to assess the validity of this research against that from other countries.

6.3 The Data Sets Used for the Multiple Regression Analyses

The three data sets examined in this analysis are used to better understand the factors influencing train usage in Sydney. Trains are used in this thesis as a surrogate for public transport use. Buses and other modes of public transport (e.g. ferries) are excluded. As

we have already mentioned this is due to the lack of data and information available in Sydney for buses and the emphasis on rail stations as geographical concentrations for high density housing in previous and current planning policies in NSW.

The data sets are based on Census Collector Districts (CDs)¹¹. Other researchers have used CDs in the absence of household level information (e.g. Bunker et al 2005a and b), and in Australia are the lowest spatial level of data able to be extrapolated from the Census. Unfortunately, because Census data is used the analysis is limited to train usage for journey to work trips only, and therefore no analysis is conducted for non-work trips. Although, journey to work trips represent about one-fifth of all trips in Sydney, they comprise about half of train trips in Sydney, providing an adequate data base. Also, the link between homes, jobs and public transport is an explicit part of the Sydney Metropolitan Strategy's assumptions.

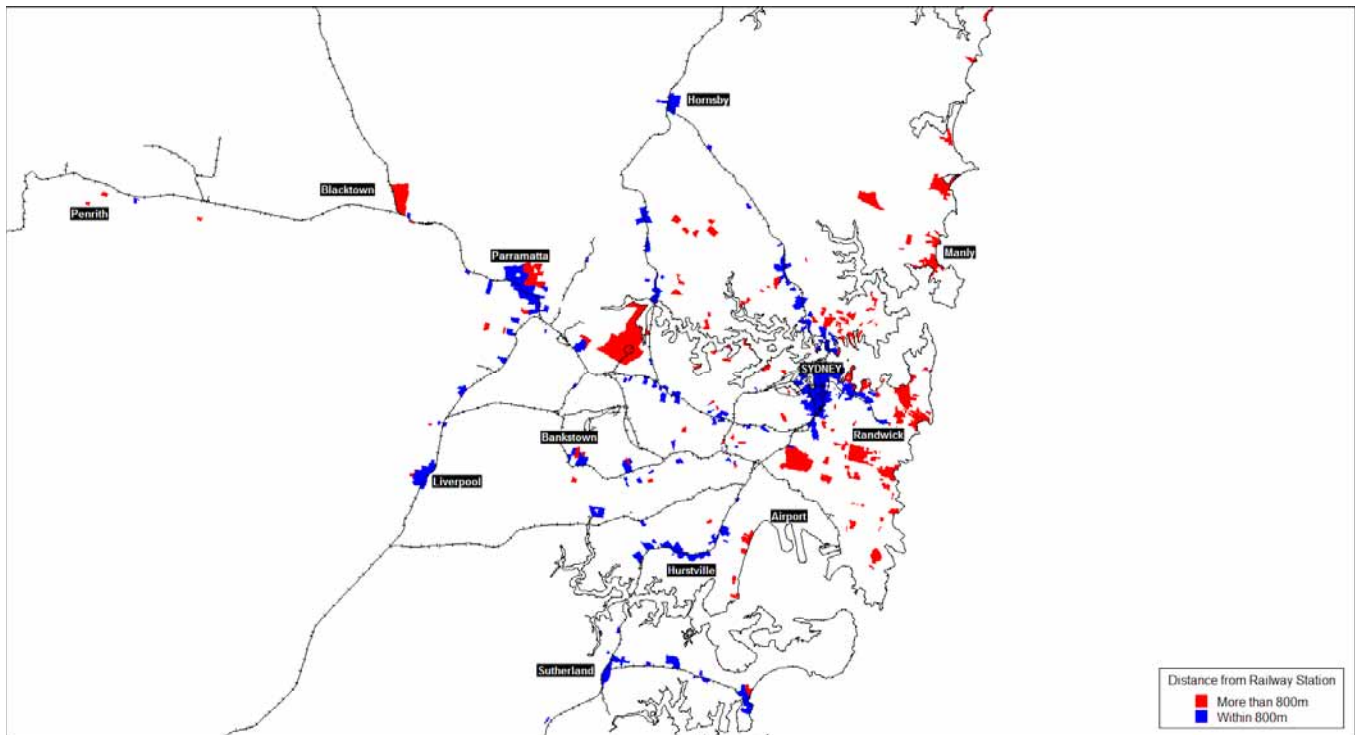
The first data set examined includes all CDs in the Sydney Statistical Division (SD), which encompasses the Sydney metropolitan area. This data set provides a base line from which to compare train usage in the other two sets at the intra-urban level. The second data set contains those CDs which are within 800 metres of a railway station and are predominantly higher density housing. Higher density housing CDs are defined after Bunker et al (2005a and b) and are a CD in which 80 per cent or more of the dwellings in the CD are flats. The figure of 800m is commonly used to denote the distance a person is likely to walk to a train station (see Department of Planning 2005). CDs were selected using the GIS software MapInfo.

The third data set includes all those CDs that are predominantly higher density housing but are greater than 800m from a railway station. These last two data sets will be used to compare whether distance from a railway station has any influence on train usage, and both will be compared to the results of data set No 1, for Sydney as a whole (Figure 6.1). Such a meso level analysis is also important given the introduction of sub-regional

¹¹ A Census Collector District has, on average, 250 households.

planning strategies in Sydney. A full list of the variables used in the regression analysis can also be found in Appendix 8.

Figure 6.1: Location of higher density CDs by distance from the nearest railway station, 2001



6.4 Profile of the Census Collector Districts in the Three Data Sets

In 2001 there were 6,590 CDs in Sydney SD (Data Set No 1). Some 8% of employed persons travelled to work by train, 5% by bus and 58% by car (Table 6.1). In contrast, there were 400 CDs in data set number two (CDs within 800 metres of a rail station and predominantly higher density housing). Nearly 24% of employed persons in these CDs travelled to work by train, 4% by bus and 38% by car. There were 362 CDs in the high density data set number three. Despite being predominately higher density housing, only 4% of employed persons in this data set traveled to work by train, however, 16% traveled to work by bus, significantly higher than the other two data sets. Further, in higher density CDs more than 800m from a railway station (Data Set No. 3), 20% of employed

persons travel to work by train or bus, much lower than in higher density CDs near a rail station (28%). This confirms that higher density dwellings away from public transport nodes are less likely to use public transport of any description.

At this stage it would be easy to argue that by building higher density housing near railway stations more individuals would use the train. However, this analysis does not answer the question as to whether density is the most important factor in influencing train use within these CDs.

Table 6.1: Number of CDs and transport use in the three data sets, 2001

	Number of CDs	Number of Households	Proportion of Employed Person who travel by Train	Proportion of Employed Person who travel by Bus	Proportion of Employed Person who travel by Car
1. All CDs in Sydney SD	6,590	1,438,411	8.0%	4.6%	57.7%
2. CDs of predominantly higher density housing and within 800m of a railway station	400	96,900	23.5%	4.1%	38.3%
3. CDs of predominantly higher density housing and further than 800m from a railway station	362	79,440	3.6%	16.1%	46.8%

(Source: ABS, CDATA2001)

6.5 What factors are influencing train usage in Sydney?

The three data sets (mentioned above) were subject to a multiple regression analysis to assess the influence of socio-economic variables and density on train use. In the three data sets examined using multiple regression analysis the variables included in each analysis from the Census explained between 49% and 68% of the variance. For all of the CDs in Sydney SD (Data Set No. 1), 25 variables explained 68% of the variance in train use, while 13 variables explained 63% of the variance in train use in higher density CDs within 800 metres from a railway station (Data Set No. 2). Some 10 variables explained

49% of the variance in train use in higher density CDs more than 800 metres away from a railway station (Data Set No. 3). These results are similar to that obtained by Stead (2001) at the local authority level in the UK, but higher than that found by Giuliano and Dargay (2006) in the US and Naess et al (1995) in Europe. Tables 6.2 and 6.3 below present the components that explained the variance within each of the three data sets in order of significance. The complete statistical output from the regression equations including the correlation coefficients is presented in Appendix 9.

In CDs in Sydney SD (Data Set No. 1) higher train use is associated with higher proportions of overseas born persons, those lacking fluency in English, households with no motor vehicle, owner-occupiers, one parent families and lone person households, renters and those aged 25-34 years. Higher train usage was also associated with areas of lower paying occupations and in areas with higher proportions of high income households confirming the findings of the Sydney Household Travel survey presented in Chapter 5. Conversely, lower train usage was associated with higher proportions of persons separated or divorced, and households with three or more motor vehicles.

Importantly, at the Sydney wide level higher train use was associated with CDs with higher proportions of flats. That is, persons in flats have a higher propensity to use the train, however, the juxtaposition to this is that CDs with higher dwelling densities per hectare in CDs across the Sydney metropolitan area actually recorded lower levels of train usage. This was also the case in higher density CDs within 800 metres from a railway station. Whether the significant proportion of higher density CDs in Sydney CBD impacted on this result cannot be ascertained. Nevertheless, this result runs counter to the proposition that increasing densities increases public transport use.

For those higher density CDs within 800 metres from a railway station (Data Set No. 2) lower levels of train usage were associated with higher proportions of persons who travel to work by bus or car, those who pay high rents, those aged 45-64 years and higher numbers of persons per household. Conversely, higher train use was associated with CDs which have higher proportions of overseas born persons, owner-occupiers, higher

proportions of persons not in the labour force, elementary and intermediate clerical workers and higher proportions of persons with university qualifications. Similar to Sydney as a whole (data set number one), higher dwelling densities per hectare were associated with lower train use in CDs in data set number two, although the variance explained by this variable is lower than the other variables previously mentioned.

In high density CDs more than 800 metres from a railway station (Data Set No. 3) a similar picture emerges to the other two data sets. Lower train use is associated with areas in which there is higher bus and car use, CDs with high proportions of multiple vehicles, and higher proportions of persons at the same address over a five year period. Conversely, higher train use in these CDs is associated with CDs with higher proportions of persons lacking fluency in English, low rent, purchasers and persons in lower paying occupations.

Overall, this meso level analysis using three different data sets has revealed some significant results. Higher train use is associated with lack of car ownership and use, and lower income households. This confirms work conducted in other countries (e.g. Stead 2001, Dieleman et al 2002). Interestingly, train use at the meso level in Sydney is influenced by the proportion of persons born overseas and those lacking fluency in English. At this stage of the analysis, this result confirms earlier investigations at the macro level, and given the recent work of Bunker et al (2005a and b) who identified a high density housing sub-market of low income migrants, and the results of the local transport survey in Fairfield presented above, this is perhaps not surprising. On saying this though, some of these overseas born households may be on lower incomes, however, this study has not been able to identify whether this is the case.

Importantly, this meso level analysis showed that train use in Sydney is affected by a number of variables which include factors associated with higher socio-economic status areas as well as those related to lower socio-economic areas. The proportion of variance explained by the multiple regression analysis for each of the three data sets suggests that there are factors that influence demand for trains in Sydney that are outside the variables

presented here that cannot be obtained from an analysis of Census data alone. There are other factors influenced by individual circumstances and behaviours that are also important in driving train usage that are beyond the scope of this study. Mees (2000), for example, implies that public transport use is higher in high value locations in inner Sydney because of the high quality of the system. This study found that high density CDs within 800 metres from a railway station and of higher incomes, and had access to a motor vehicle were more likely to use a train, lending support to suggesting Mees' comments. Further, it is evident from this analysis that socio-economic variables have a stronger association with train use in Sydney than does land use (i.e. dwelling density). This result confirms other work conducted by Stead (2001), Hanson (1982) and Giuliano and Dargay (2006) that density is not as important as other variables in influencing public transport use.

6.6 Where to from here?

The proportion of variance explained by the regression analyses ranged between one-half to approximately two-thirds, and showed that there is a multiplicity of factors that influence train use in Sydney, rather than density and transport availability per se. Nevertheless, in trying to more fully understand the influences of train use in Sydney a number of other variables, other than those included in the Census based analysis presented above are likely to be required (see also Stead and Marshall 2001, Yigitcanlar et al 2005). These might include measures that examine:

- The availability and cost of parking
- Distance of employment from a rail station
- The mix of uses in CDs
- Aesthetics of the neighbourhood, or neighbourhood type
- Urban design variables
- Levels of congestion
- Frequency of public transport services
- Proximity to local facilities
- Economic factors such as public transport fares, petrol prices, taxes, tolls etc

In some cases the exact measurement of these variables is still a matter of debate. Importantly, the influence of some of these variables listed above may vary between geographical scales, and thus it will be important to examine other variables between scales. Nonetheless, the factors listed above, along with socio-economic variables from the Census are important in identifying the influences of train usage at a local level. Even an early study in Perth (Newman and Kenworthy 1985), for example, noted that local level factors were important in influencing transport use, yet few have been conducted.

Table 6.2: Factors influencing train use in Sydney for the three data sets, 2001 (R Square values)

Sydney SD CDs		Higher Density CDs within 800m of a railway station		Higher Density CDs more than 800m from a railway station	
Variable	R Square	Variable	R Square	Variable	R Square
Travel to Work by Car	0.264	Travel to Work by Bus	0.225	Travel to Work by Bus	0.222
Overseas Born	0.187	Overseas Born	0.115	Lack Fluency in English	0.147
Travel to Work by Bus	0.137	Travel to Work by Car	0.097	Three or more Motor Vehicles	0.034
Three or more Motor Vehicles	0.020	Weekly Rent is \$400 or more per week	0.068	Weekly Rent is under \$200 per week	0.028
Intermediate Clerical, Sales and Service Workers	0.014	Owner-Occupier	0.046	Same Address at Previous Census	0.020
Lack Fluency in English	0.013	Household Income \$2,000 or more per week	0.020	Travel to Work by Car	0.016
Weekly Rent is \$400 or more per week	0.008	Not in the Labour Force	0.017	Household Income less than \$400 per week	0.016
University Qualifications	0.004	Intermediate Clerical, Sales and Service Workers	0.013	Elementary Clerical, Sales and Service Workers	0.009
Elementary Clerical, Sales and Service Workers	0.004	University Qualifications	0.012	Purchaser	0.008
Other Tenure	0.003	Person per Household	0.009	Other Tenure	0.007
No Motor Vehicles	0.003	Aged 45-64 years	0.006		
Purchaser	0.003	Dwelling Density per Hectare	0.005		
One Parent Family	0.003	Elementary Clerical, Sales and Service Workers	0.004		
Persons Separated or Divorced	0.002				
Owner-Occupier	0.002				
Flats	0.002				
Dwelling Density per Hectare	0.002				
Aged 25-34 years	0.002				
Rent from Public Landlord	0.002				
Household Income \$2,000 or more per week	0.001				
Lone Person Households	0.001				
Rent from Private Sources	0.001				
Household Income less than \$400 per week	0.001				
Labourers and Related Workers	0.001				
Total R Square	0.680 (68.0%)		0.637 (63.7%)		0.507 (50.7%)
Adjusted R Square	0.678 (67.8%)		0.628 (62.8%)		0.494 (49.4%)

Table 6.3: Factors influencing train use in Sydney for the three data Sets, 2001 (coefficients)

Sydney SD CDs		Higher Density CDs within 800m of a railway station		Higher Density CDs more than 800m from a railway station	
Variable	Coefficient	Variable	Coefficient	Variable	Coefficient
(Constant)	8.732	(Constant)	18.537	(Constant)	12.656
Travel to Work by Car	-0.393	Travel to Work by Bus	-1.027	Travel to Work by Bus	-0.287
Overseas Born	0.057	Overseas Born	0.139	Lack Fluency in English	0.283
Travel to Work by Bus	-0.834	Travel to Work by Car	-0.307	Three or more Motor Vehicles	-0.275
Three or more Motor Vehicles	-0.166	Weekly Rent is \$400 or more per week	-0.225	Weekly Rent is under \$200 per week	0.084
Intermediate Clerical, Sales and Service Workers	0.261	Owner-Occupier	0.136	Same Address at Previous Census	-0.064
Lack Fluency in English	0.34	Household Income \$2,000 or more per week	0.194	Travel to Work by Car	-0.114
Weekly Rent is \$400 or more per week	-0.057	Not in the Labour Force	0.244	Household Income less than \$400 per week	-0.131
University Qualifications	0.136	Intermediate Clerical, Sales and Service Workers	0.281	Elementary Clerical, Sales and Service Workers	0.107
Elementary Clerical, Sales and Service Workers	0.189	University Qualifications	0.245	Purchaser	0.109
Other Tenure	-0.079	Person per Household	-0.563	Other Tenure	0.226
No Motor Vehicles	0.035	Aged 45-64 years	-0.17		
Purchaser	0.158	Dwelling Density per Hectare	-0.006		
One Parent Family	0.095	Elementary Clerical, Sales and Service Workers	0.206		
Persons Separated or Divorced	-0.125				
Owner-Occupier	0.186				
Flats	0.033				
Dwelling Density per Hectare	-0.011				
Aged 25-34 years	0.048				
Rent from Public Landlord	0.119				
Household Income \$2,000 or more per week	0.072				
Lone Person Households	0.064				
Rent from Private Sources	0.111				
Household Income less than \$400 per week	-0.08				
Labourers and Related Workers	0.073				

7. A MICRO LEVEL ANALYSIS OF TRAIN USAGE IN COMMUNITIES OF HIGHER DENSITY HOUSING

7.1 Introduction

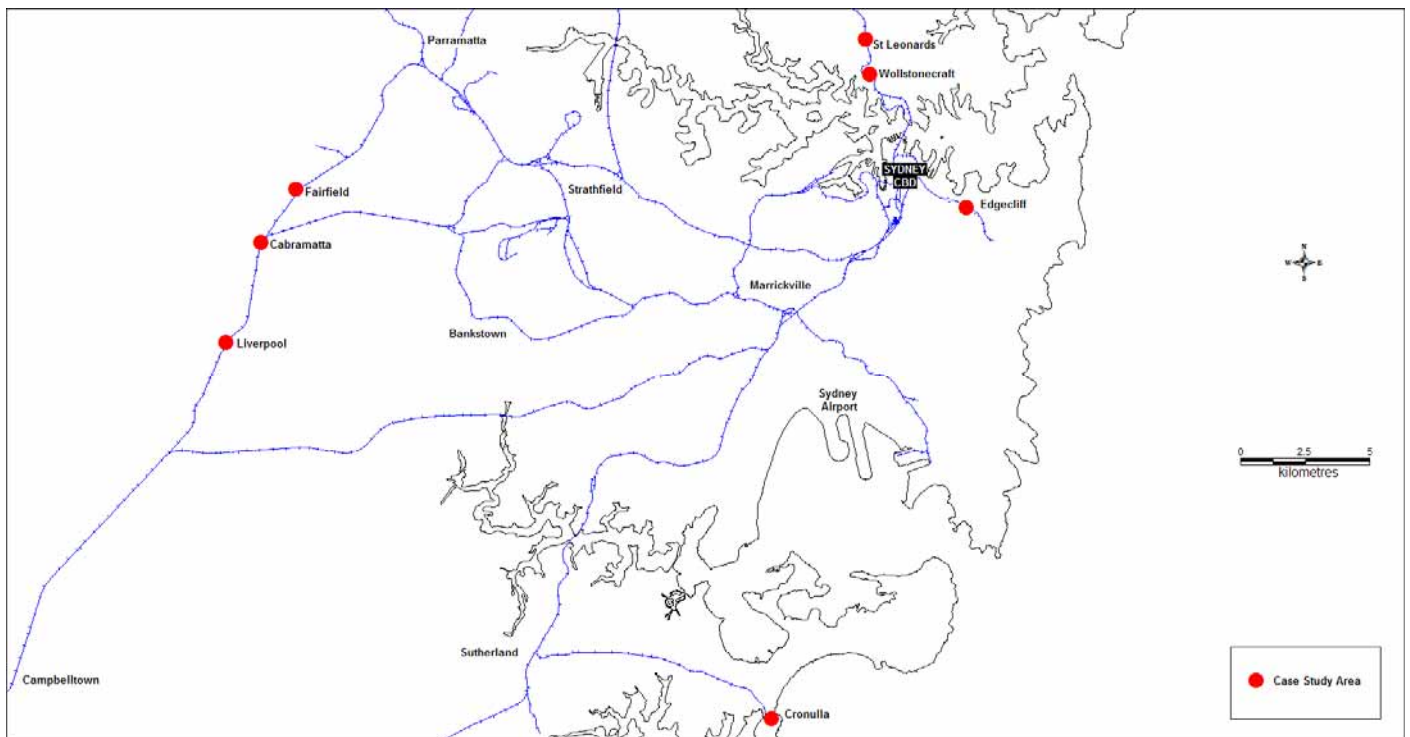
So far this study has examined the relationship between residential density and public transport use in Sydney at the macro and meso level. What it has failed to address, however, is whether the factors influencing train use at the macro level are also reflected in communities or neighbourhoods of higher density housing in different locations across the Sydney metropolitan area, or, alternatively, whether specific factors in different spatial locations are influencing train use. This is crucial given the diverse range of socio-economic factors that were found in Chapter 6 to influence train usage. A local level investigation is also important as it will distinguish whether the socio-economic variables presented in the regression analyses above are also present in different locations across Sydney or whether selected variables are important in certain geographical locations.

This chapter addresses this issue by examining train use in five selected case study areas across the Sydney metropolitan area. The five case study areas are a conglomeration of CDs which were selected on the basis of three criteria. The first was that they had to be predominantly higher density CDs as defined by Bunker et al (2005a and b). The second selection criteria were that the case study areas are within 800 metres of a railway station (i.e. transit node), which constitutes a target for urban consolidation policy in Sydney.

Thirdly, the case study areas had to represent the different spatial and socio-economic higher density housing sub-markets in the Sydney metropolitan area as identified by Bunker et al (2005a and b). The three criteria, therefore, allow the case studies to be both spatial and socially diverse. This also allows an analysis of different socio-economic variables within a different array of geographical locations. This is important for urban policy makers and social planners alike if different local areas will have different

variables which influence train use, and therefore an integrated approach is necessary to increase public transport use, and therefore reduce energy emissions. The five case study areas selected for further analysis were Liverpool and Fairfield/Cabramatta in Sydney's west, Edgecliff in the inner eastern suburbs, St Leonards/Wollstonecraft in northern Sydney, and Cronulla in Sydney's south (see Figure 7.1). A full list of the CDs in each of the case study areas is listed in Appendix 10.

Figure 7.1: Location of the Case Study Areas



7.2 Socio-Economic Profile of the Case Study Areas

The five case study areas selected represent different geographical locations across the Sydney metropolitan area as well as varying socially and economically. Fairfield/Cabramatta is the smallest of the case study areas with 1,165 households while Cronulla

is the largest with 2,598 households (Table 7.1). Approximately 90% or more the housing in the five case study areas are flats/units. Edgecliff has the lowest proportion of flats of the case study areas (89.7%), whereas, Cronulla has the highest proportion (94.5%). All five areas, though, have significantly higher proportions of flats/units than for Sydney as a whole (24%).

7.2.1 Cronulla

The Cronulla case study area is located to the south of the Sydney CBD in the Sutherland Shire. The area has a distinctive age profile with the highest proportion (along with St Leonards/Wollstonecraft) of persons aged 15-34 years, while it also has the second highest proportion of persons aged over 65, after Edgecliff. There are very few children in the Cronulla case study, at 8.6% it is less than half the Sydney average. The Cronulla case study area has the highest proportion of Australian born residents (72%) of all the case study areas, which is also significantly higher than the Sydney average. The unique age profile of the case study area means that it has the highest proportion of lone person households of the case study areas (41%) and couples without children (28%). The proportion of couple families with children is the lowest of the case study areas.

Nevertheless, 35% of households own their dwelling, the second highest of the case study areas, although 42% still rent privately, while only 12% are purchasing their dwelling, half of the Sydney average. Only 16% of households do not own a car, similar to the Sydney average, although only 23% have 2 or more vehicles, significantly lower than the Sydney average. Employed persons in the Cronulla case study area work in 'middle paying' occupations with higher than average proportions of Associate Professionals, Tradespersons, and Advanced and Intermediate Clerical workers. This is also reflected in the unemployment rate, which at 4.3% in 2001 was lower than the Sydney average. In general, the Cronulla case study area is a higher density area of young middle class professionals as well as an area for older middle income persons with few children.

7.2.2 Edgecliff

Edgecliff is located in the inner eastern suburbs of the Sydney metropolitan area. The case study area has a distinctive older population with 33% of persons aged over 55, the highest of all the case study areas, with very few younger persons. Some 54% of persons were born in Australia while a further 16% were born in Europe and the UK. With an older population the Edgecliff case study area has the highest proportion of lone person households after Cronulla. Similar to Cronulla and St Leonards/Wollstonecraft, the Edgecliff case study area has very few children. The older population in Edgecliff is reflected in the large proportion of dwellings that are full owned and very few purchasers. The Edgecliff case study area also has the lowest proportion of private renters (34%), although this is still higher than the Sydney average.

The lower proportion of purchasers in Edgecliff does not appear to be related to the income of the residents. Some 36% earn more than \$1,500 per week with only 12% earning less than \$500 per week. Interestingly, 4% have three or more motor vehicles, the highest of any case study area while a further 17% have two or more motor vehicles. Although the proportion of households with two or more vehicles is lower than the Sydney average those with one or no motor vehicle is above the Sydney average. Generally, the Edgecliff case study area is an advantaged area with low unemployment and a significant higher income professional workforce with 17% being employed as a Manager or Administrator, nearly twice the Sydney average.

7.2.3 Fairfield/Cabramatta

The Fairfield/Cabramatta case study area is the most disadvantaged of the case study areas. Along with Liverpool the Fairfield/Cabramatta case study area has a much younger age profile than the other three case study areas. Some 22% of persons are aged under 14 years while a further 31% are aged 15-34 years. Only 17% of persons are over 55 years of age, significantly lower than Cronulla, Edgecliff and St Leonards/Wollstonecraft, and the Sydney wide average.

The younger age profile means that 32% of households in the higher density Fairfield/Cabramatta case study area are couples with children, similar to the Sydney average but over three times that of Cronulla and Edgecliff. A further 17% are one parent families the highest of any case study area.

Importantly, only 17% of persons in the Fairfield/Cabramatta case study area were born in Australia, the lowest of all the case study areas. That is, 78% of persons in the case study area have recorded their birthplace as outside of Australia. Some 35% of persons are from the Middle East, over ten times the Sydney average (3%) while 20% were born in Asian countries, double the Sydney average.

The socio-economic disadvantage of the area is reflected in the fact that only 18% own their dwelling, the second lowest proportion after Liverpool, while only 8% are purchasing their dwelling, the lowest of all the case study areas. The majority of households in the Fairfield/Cabramatta case study area are in private rental. Some 65% of households in the case study area rent privately nearly three times the Sydney average. The proportion of households that own two or more vehicles is the lowest of the case study areas while 23% are employed as Labourers and related workers, nearly three times the Sydney average, and significantly higher than that recorded in the other case study areas. Only 1.5% are employed as Managers or Administrators, significantly lower than the Sydney average (9%) and the other case study areas.

Generally, the Fairfield/Cabramatta case study area represents the main higher density submarket identified by Bunker et al (2005a), that is, a low income migrant community in predominantly private rental.

7.2.4 Liverpool

The Liverpool case study area is also a disadvantaged area, although not to the same extent as the Fairfield/Cabramatta case study area. The Liverpool case study area has the

youngest age profile of the case study areas. Nearly 59% of persons in the Liverpool case study area are aged under 35 years significantly higher the Sydney average and the other case study areas whereas only 5% are aged over 65 years, the lowest of the case study areas. Not surprisingly then the Liverpool case study area has the highest proportion of couples with children (35%) while it also has the lowest proportion of couples without children (16%). The proportion of one parent families is also above the Sydney average.

Similar to the Fairfield/Cabramatta case study area a large proportion of persons were born overseas. Only 21% of persons in the Liverpool case study area were born in Australia. While larger proportions of persons in Liverpool were born in the Middle East (9%) and Asian countries (17%), the largest proportion were born in Europe (28%).

The Liverpool case study area has the lowest proportion of owner-occupiers (13%), although a larger proportion are purchasing their dwelling. However, 59% of persons in the Liverpool case study area are renting privately. The socio-economic disadvantage recorded in the Liverpool case study area is also reflected in the lower income profile of the case study area and the proportion of persons employed in lower paying occupations. Further, similar to Fairfield/Cabramatta, the unemployment rate in the Liverpool case study area is over three times the Sydney average. In general, the Liverpool case study area is a disadvantaged migrant community with high proportions of private rental. The disadvantage recorded in this case study area is not as high as that in Fairfield/Cabramatta, while the higher proportion of purchasers in this case study area distinguishes it from the Fairfield/Cabramatta case study area.

7.2.5 St Leonards/Wollstonecraft

The St Leonards/Wollstonecraft case study area is an interesting case study area. Although it is the most advantaged of all the case study areas it lies between the Cronulla and Edgecliff case study areas and Fairfield-Liverpool areas in a number of variables. The St Leonards/Wollstonecraft case study area is clearly the highest income area of all the case study areas. Some 42% of households earn more than \$1,500 per week,

significantly higher than the Sydney average, while it also has significantly low proportions of lower income households. Interestingly though, the case study area has a higher unemployment rate than Cronulla or Edgecliff.

The age profile of the St Leonards/Wollstonecraft case study area is older than in Cronulla and Edgecliff, but not as young as that in Fairfield/Cabramatta and Liverpool. Nearly 23% of persons are aged under 25 years while 26% are aged over 55 years. A further 26% are aged 25-34 years, significantly higher than the Sydney average. The case study area clearly has a young professional community with 29% of households being couples without children and 31% being lone person households. Similar to Cronulla and Edgecliff there are lower proportions of couples with children and one parent families.

The St Leonards/Wollstonecraft case study area has a large proportion of persons born in Asian countries (21%) while 49% were also born in Australia, slightly less than the Sydney average, although 7% were born in the UK/Ireland. The case study area also has an interesting tenure profile with 46% of households renting privately and 29% owning their dwelling. The St Leonards/Wollstonecraft case study area has the largest proportion of purchasers of all the case study areas (16%).

The socio-economic advantage recorded in this case study area is reflected in the very large proportions of persons employed in Professional and Managerial occupations, while St Leonards/Wollstonecraft has the lowest proportion of Tradespersons of all the case study areas. The case study area also has the largest proportion of households with two or more motor vehicles (24%). In general, the St Leonards/Wollstonecraft case study area has the highest income of all the case study areas with a large Managerial and Professional workforce, although a significant proportion of households rent privately it has the largest proportion of purchasers.

Table 7.1: Socio-Economic Profile of the Case Study Areas, 2001

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft	Sydney SD
Index of Disadvantage Score	1,062	1,124	703	855	1,135	1,017
Households	2,598	1,261	1,165	1,507	1,358	1,438,394
Persons	4,631	2,522	3,158	3,863	3,496	3,948,015
Dwelling Structure						
Separate Houses	1.3%	3.6%	1.2%	1.1%	4.2%	63.1%
Semi Detached Dwellings	1.9%	5.8%	8.3%	5.0%	3.3%	11.3%
Flats in a block of less than 4 storeys	62.8%	32.8%	66.0%	78.9%	11.0%	15.1%
Flats in a block of 4 or more storeys	31.7%	56.9%	24.2%	10.9%	81.0%	8.4%
Other	1.1%	0.2%	0.3%	2.9%	0.2%	1.2%
Not Stated	1.3%	0.7%	0.0%	1.2%	0.2%	0.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Age						
0-14	8.6%	8.6%	21.5%	21.6%	10.0%	20.2%
15-24	11.8%	10.5%	12.1%	15.4%	12.9%	14.0%
25-34	26.3%	20.9%	19.1%	22.2%	25.7%	16.0%
35-44	13.0%	13.8%	18.9%	19.1%	15.4%	15.7%
45-54	10.7%	13.5%	11.5%	11.3%	12.1%	13.4%
55-64	8.7%	10.3%	7.7%	5.5%	9.2%	8.8%
65+	21.0%	22.4%	9.2%	4.9%	14.8%	11.9%
Not Stated	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Birthplace						
Australia	72.4%	54.2%	17.2%	20.8%	48.7%	62.2%
Other Oceania	3.4%	3.7%	3.0%	8.5%	3.2%	3.2%
UK/Ireland	6.0%	7.0%	0.6%	1.0%	6.8%	5.0%
Other Europe	3.6%	8.9%	12.1%	28.2%	4.3%	6.7%
Asia	2.2%	5.3%	20.2%	17.3%	20.5%	10.6%
Middle East	0.3%	0.4%	34.5%	8.7%	0.8%	2.6%
Africa (Inc North Africa)	0.6%	3.8%	1.2%	2.7%	1.9%	1.5%
Americas	1.7%	2.5%	4.9%	4.2%	1.4%	1.5%
Other	0.1%	0.1%	0.5%	0.3%	0.0%	0.2%
Not stated	9.4%	13.0%	5.0%	8.4%	9.6%	6.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Household Type						
Couples with Children	6.9%	9.1%	32.2%	34.6%	14.5%	35.9%
Couples without Children	28.1%	23.3%	20.0%	16.0%	28.9%	23.1%
One Parent Family	7.5%	4.1%	17.1%	11.9%	5.7%	10.7%
Lone Persons Households	40.6%	37.9%	20.7%	24.9%	30.7%	21.3%
Group Households	7.1%	10.5%	4.4%	4.8%	9.5%	4.1%
Other Households	9.6%	15.1%	5.7%	7.9%	10.7%	4.9%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft	Sydney SD
Households	2,598	1,261	1,165	1,507	1,358	1,438,394
Persons	4,631	2,522	3,158	3,863	3,496	3,948,015
Tenure						
Fully Owned	34.6%	41.0%	17.9%	12.7%	28.9%	39.0%
Being Purchased	11.9%	7.9%	7.6%	15.1%	16.1%	23.7%
Rented from State Housing Authority	0.6%	0.0%	2.1%	1.9%	0.0%	5.1%
Rented from Other Sources	41.8%	34.1%	65.2%	59.1%	45.7%	23.6%
Other Tenure	1.6%	3.0%	1.8%	1.5%	2.2%	2.7%
Not Stated	9.2%	12.9%	5.2%	9.7%	5.5%	6.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Number of Motor Vehicles						
None	15.9%	17.9%	31.2%	25.1%	14.4%	13.1%
1 motor vehicle	49.9%	45.0%	50.0%	49.6%	52.7%	38.6%
2 motor vehicles	19.4%	17.1%	7.2%	10.2%	20.0%	29.5%
3 motor vehicles	3.4%	4.1%	2.1%	2.2%	4.0%	10.7%
Not stated	11.4%	15.9%	9.4%	12.9%	9.1%	8.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Occupation						
Managers and Administrators	9.8%	17.4%	1.5%	3.1%	16.0%	9.0%
Professionals	21.6%	33.5%	8.6%	13.1%	37.5%	21.2%
Associate Professionals	13.4%	14.4%	5.1%	7.7%	14.5%	11.8%
Tradespersons and Related Workers	12.5%	3.8%	17.5%	17.5%	2.7%	11.1%
Advanced Clerical and Service Workers	6.3%	6.8%	0.4%	1.6%	5.7%	4.5%
Intermediate Clerical, Sales and Service Workers	17.4%	11.5%	14.4%	14.3%	12.7%	17.2%
Intermediate Production and Transport Workers	4.4%	1.2%	16.2%	14.6%	0.7%	7.4%
Elementary Clerical, Sales and Service Workers	8.0%	5.1%	12.5%	10.0%	4.7%	9.1%
Labourers and Related Workers	6.0%	1.2%	23.3%	15.6%	1.8%	6.6%
Inadequately described	0.2%	4.4%	0.6%	0.8%	2.2%	0.9%
Not stated	0.4%	0.9%	0.0%	1.8%	1.7%	1.2%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Household Income						
Less than \$300 a week	10.7%	5.4%	14.2%	10.2%	3.5%	9.7%
\$300-\$399	6.0%	3.0%	16.8%	10.0%	2.4%	6.3%
\$400-\$499	5.9%	3.4%	9.4%	7.6%	3.2%	5.4%
\$500-\$599	4.5%	2.5%	7.4%	8.2%	3.8%	4.1%
\$600-\$699	4.5%	3.1%	8.7%	7.6%	2.7%	4.8%
\$700-\$799	5.2%	2.9%	4.6%	6.3%	3.5%	4.0%
\$800-\$999	8.7%	6.9%	8.4%	11.7%	6.2%	8.0%
\$1,000-\$1,199	10.1%	9.1%	5.2%	6.6%	9.9%	8.0%
\$1,200-\$1,499	6.1%	4.0%	4.5%	7.2%	4.5%	7.8%
\$1,500-\$1,999	12.2%	16.7%	3.2%	4.2%	18.9%	12.6%
\$2,000 or more	8.7%	19.0%	2.1%	2.1%	22.8%	13.1%
Not Stated	17.4%	24.0%	15.5%	18.4%	18.8%	16.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft	Sydney SD
Households	2,598	1,261	1,165	1,507	1,358	1,438,394
Persons	4,631	2,522	3,158	3,863	3,496	3,948,015
Gender						
Male	49.1%	43.8%	50.2%	53.3%	47.7%	49.2%
Female	50.9%	56.2%	49.8%	46.7%	52.3%	50.8%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Labour Force Status						
Employed	95.7%	95.6%	72.9%	79.3%	96.2%	93.9%
Unemployed	4.3%	4.4%	27.1%	20.7%	3.8%	6.1%
Labour Force	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Not in the Labour Force	27.0%	26.3%	38.3%	28.6%	25.1%	26.6%

(source: CDATE 2001)

7.3 Train Use in the Case Study Areas

This section presents a profile of train users from the Census journey to work data in the five case study areas to examine the factors that influence train usage in different higher density areas in Sydney. The results are presented in Tables 7.2 and 7.3, and in Figures 7.2 to 7.17.

Figures 7.2 and 7.3 show that in all the case study areas, except Liverpool, there is a tendency for females to use the train more than males. Once account is taken of the population of males and females (Figure 7.3) this holds true for all the case study areas. That is, in all the case study areas females are more likely to use the train than males. This is different to the analysis presented in Chapter 5 from the Sydney Household Travel Survey where males were more likely to use a train. This difference is most probably due to the fact that non-work trips are included in the Sydney Household Travel Survey.

As other research has also shown, there is a greater tendency for younger persons to use the train in the case study areas. The largest proportion of train users in all the case study areas were aged 25-34 years. Larger proportions of persons aged 35-44 years used the train in Fairfield/Cabramatta, Liverpool and St Leonards/Wollstonecraft. The proportion of train users declined with age from 45 years onwards, with the lowest proportion of users aged over 65 years. Interestingly, once the number of persons in each age group was taken into account (Figure 7.5) some significant results emerge. Although a

significant proportion of persons aged under 34 years are more likely than older persons to use the train, in Fairfield/Cabramatta the proportion of persons aged over 55 and in particular over 65 years, that use the train is much larger than for the other case study areas.

The majority of train users in the case study areas of Cronulla, Edgecliff and St Leonards/Wollstonecraft are Australian born residents, whereas in Fairfield/Cabramatta the major proportion of train users are from Asia and the Middle East. In Liverpool a larger proportion of train users were born in Europe and Asia. These results are not surprising given the birthplace of residents in these case study areas, however, once account is taken of the populations in these case study areas it is evident that persons from overseas countries are more likely than Australian born residents to use a train (Figure 7.7). This also confirms the findings of the multiple regression analysis presented above. In the Cronulla, Edgecliff and St Leonards/Wollstonecraft case study areas migrants, including those from Oceania, UK/Ireland, Asia and the Middle East (in Cronulla) are more likely to use a train. In Fairfield/Cabramatta and Liverpool those from predominantly non-English speaking countries are more likely to use a train.

In Fairfield/Cabramatta and Liverpool there are a large proportion of persons on higher incomes who use public transport. In fact in all the case study areas a significant proportion of higher income persons use the train to get to work (Figure 7.8). Once the population in each of the different income groups in the case study areas is taken into account an interesting picture emerges (Figure 7.9). The profile of persons who use a train to get to work in Liverpool and to a lesser extent in Fairfield/Cabramatta is quite polarised. It is clear that those on both lower and higher incomes are more likely than middle income households to use the train to get to work. The occupational profile of both these lower and higher income households is an issue that needs further research. Nevertheless, in Cronulla and Edgecliff those on higher incomes are more likely to use the train to get to work, while those on middle and upper incomes are more likely to use the train in St Leonards/Wollstonecraft.

In the case study areas the proportion of train users by household type differs between areas (Figure 7.10). In Edgecliff couple households and group households are, proportionately, the highest users. In Cronulla single person households provide the largest proportion of users while in St Leonards/Wollstonecraft couples and group households are the largest users of the train. Similarly, in Liverpool couples and group households are the largest users of trains to go to work, while in Fairfield/Cabramatta one parent families provide the largest proportion of train users followed by lone person households. Once account is taken of the population in each case study area it is evident that group households, one parent families and couples without children are more likely to use a train to go to work (Figure 7.11). As other studies (e.g. Dieleman et al 2002) have found in the case study areas households with children are the least likely to use the train.

Throughout the analysis it is evident that a large proportion of households in the case study areas are private renters. As Figures 7.12 and 7.13 show, the largest proportion of employed persons who use the train to go to work are private renters. Even when the population of each tenure group is taken into account private renters are the cohort most likely to use the train. In Liverpool the train is an important transport mode for public housing tenants as well.

Not surprisingly, those households with no motor vehicles are more likely to use a train to go to work than households with a motor vehicle, confirming research (e.g. Dieleman et al 2002) presented elsewhere (Figure 7.15). Interestingly though, those households with only one motor vehicle make up the majority of train users, suggesting that there are maybe some females in households with one vehicle who use the train to go to work (Figure 7.14). This is also evidenced by the fact that clerical sales and services workers provide a significant proportion of journey to work trips by train (Figure 7.16). As we have already seen lower and higher income groups both use the train to go to work in the case study areas. This is confirmed through an analysis of the journey to work for train user by occupation. The largest users of the train in Edgecliff, and St Leonards/Wollstonecraft are Managers, Administrators and Professional workers while there is also

a significant proportion of these workers in the Cronulla case study area. In Cronulla, Liverpool and Fairfield/Cabramatta the largest users are employed as Clerical, Sales and Service workers. In Fairfield/Cabramatta and Liverpool there is also a significant proportion of Labourers. Even when the proportion of workers for each occupation is taken into account Managers, Administrators and Professional workers and Clerical workers are more likely to use the train to go to work (Figure 7.17). A significant proportion of Labourers in the case study areas are also likely to use the train to go to work.

7.4 Overview

The analysis of train use for employed persons in the five case study areas confirms the findings of other research in that females, and younger persons are more likely to use the train, although the train is an important mode for older persons in Fairfield/Cabramatta and Liverpool. Further, the findings above also support other research (e.g. Dieleman et al 2002) which suggests that households with children are less likely to use a train and utilise other modes of transport.

Although Australian born residents are a larger proportion of train users in the case study areas those from overseas have a higher propensity than Australian born persons to use the train. This confirms the results presented in the regression analysis above but also suggests that future research endeavours will need to explore the influence of this variable on train use in Sydney.

The results also present some interesting findings in relation to income. Some overseas research has contended that public transport is used by individuals on lower incomes and who do not own a motor vehicle (e.g. Lu and Pas 1999), and thus have no alternative but to use a train (or bus). This research has shown that in Sydney higher income households are a very significant proportion of train users, particularly for work journeys. In the three socio-economic advantaged areas of Cronulla, Edgecliff and St Leonards/Wollstonecraft higher income households did use the train. In the more disadvantaged

areas of Fairfield/Cabramatta and Liverpool both higher and lower income households used the train. This is also confirmed through an analysis of the occupations of train users, which shows that significant proportions of train users are Managers and Professional Workers and as well Clerical and Sales Workers and Labourers. That is, the income and occupational profile of train users in the case study areas was polarised.

Perhaps more surprising though was that in the case study areas there is a clear reliance by private renters on the train to get to work. Whether these private renters are making a choice to catch a train for economic reasons or convenience can only be speculated upon. Importantly, such questions cannot be answered without larger scale surveys in different locations with different socio-economic groups.

Nevertheless, this analysis has shown that there are many factors outside of dwelling density that are important in influencing train use in Sydney. Such results confirm the findings of researchers such as Stead (2001), Hodgetts (2003), Giuliano and Dargay (2006) that the notion of increasing densities increases public transport use is an oversimplification of the relationship between land use and public transport use. This is the case particularly at the micro level in the small area case studies presented here. It further emphasises the point that at the macro level the link between density and public transport use, and its articulation in urban consolidation policies in Sydney, is plausible but nonetheless this theory is contestable at the micro level.

Table 7.2: Socio-Economic Profile of Employed Persons Who Use a Train to Go to Work, 2001 (proportion of train users)

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft
Persons Who Use a Train	538	352	199	373	556
Age					
15-24	19.1%	14.8%	16.6%	21.7%	15.6%
25-34	44.2%	45.2%	30.2%	34.3%	46.8%
35-44	14.9%	15.6%	27.1%	26.3%	20.9%
45-54	13.0%	12.5%	16.1%	13.7%	11.0%
55-64	7.2%	7.4%	7.0%	3.2%	3.2%
65+	1.5%	3.4%	3.0%	0.8%	1.4%
Not Stated	0.0%	1.1%	0.0%	0.0%	1.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Birthplace					
Australia	75.7%	60.2%	9.0%	18.2%	48.9%
Other Oceania	6.3%	6.5%	7.5%	11.5%	7.2%
UK/Ireland	6.9%	12.2%	1.5%	0.8%	7.4%
Other Europe	2.4%	5.4%	15.6%	23.9%	4.0%
Asia	2.6%	7.7%	38.2%	30.6%	26.4%
Middle East	1.1%	0.0%	17.1%	3.2%	0.5%
Africa (Inc North Africa)	0.6%	2.0%	0.0%	4.3%	2.7%
Americas	2.6%	3.7%	6.5%	4.0%	1.6%
Other	0.0%	0.0%	1.5%	0.8%	0.0%
Not stated	1.9%	2.3%	3.0%	2.7%	1.3%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Household Type					
Couples with Children	5.6%	8.8%	29.1%	34.0%	11.5%
Couples without Children	42.9%	32.1%	28.6%	19.8%	39.7%
One Parent Family	8.7%	4.0%	15.1%	9.7%	4.9%
Lone Persons Households	23.4%	18.5%	9.0%	15.5%	17.6%
Group Households	15.2%	25.6%	10.1%	11.0%	19.2%
Other Households	4.1%	11.1%	8.0%	9.9%	7.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Tenure					
Fully Owned	17.1%	21.0%	15.6%	12.1%	18.9%
Being Purchased	12.8%	8.5%	7.5%	19.6%	14.9%
Rented from State Housing Authority	0.0%	0.0%	1.5%	1.6%	0.0%
Rented from Other Sources	67.5%	61.4%	68.8%	62.2%	60.6%
Other Tenure	1.9%	2.3%	1.5%	0.0%	3.1%
Not Stated	0.7%	6.8%	5.0%	4.6%	2.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Number of Motor Vehicles					
None	25.5%	27.8%	30.7%	27.6%	17.3%
1 motor vehicle	53.5%	43.8%	56.8%	50.9%	54.9%
2 motor vehicles	15.6%	14.5%	7.0%	9.4%	17.4%
3 motor vehicles	2.2%	2.8%	0.0%	2.4%	3.2%
4 motor vehicles or more	0.0%	1.7%	1.5%	0.8%	0.5%

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft
Number of Motor Vehicles					
Not stated	3.2%	9.4%	4.0%	8.8%	6.7%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Occupation					
Managers and Administrators	6.9%	12.8%	0.0%	1.6%	12.4%
Professionals	21.7%	38.4%	14.1%	17.2%	40.6%
Associate Professionals	12.5%	14.5%	8.5%	5.1%	14.6%
Tradespersons and Related Workers	6.3%	0.9%	7.0%	12.1%	0.5%
Advanced Clerical and Service Workers	11.0%	8.8%	1.5%	3.5%	8.3%
Intermediate Clerical, Sales and Service Workers	20.4%	13.6%	23.1%	20.1%	15.1%
Intermediate Production and Transport Workers	4.1%	0.9%	7.5%	8.8%	0.0%
Elementary Clerical, Sales and Service Workers	9.9%	4.8%	12.6%	13.7%	4.7%
Labourers and Related Workers	5.8%	2.0%	20.6%	17.2%	1.4%
Inadequately described	0.9%	0.9%	0.0%	0.8%	0.7%
Not stated	0.6%	2.6%	5.0%	0.0%	1.6%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Household Income					
Less than \$300 a week	1.1%	0.0%	0.0%	1.6%	0.5%
\$300-\$399	0.6%	0.0%	7.5%	2.9%	0.5%
\$400-\$499	2.0%	1.7%	3.0%	7.5%	1.1%
\$500-\$599	4.1%	2.0%	8.5%	5.1%	3.2%
\$600-\$699	3.0%	0.9%	7.0%	7.0%	1.6%
\$700-\$799	5.0%	1.1%	4.5%	6.4%	3.2%
\$800-\$999	12.3%	6.3%	8.0%	14.7%	6.5%
\$1,000-\$1,199	11.5%	6.0%	9.5%	11.3%	7.9%
\$1,200-\$1,499	14.7%	6.5%	16.1%	18.5%	4.7%
\$1,500-\$1,999	21.6%	22.2%	14.1%	6.7%	21.9%
\$2,000 or more	16.9%	38.6%	12.1%	5.6%	40.6%
Not Stated	7.2%	14.8%	9.5%	12.6%	8.1%
Total	100.0%	100.0%	100.0%	100.0%	100.0%
Gender					
Male	45.9%	49.7%	43.7%	54.4%	47.5%
Female	54.1%	50.3%	56.3%	45.6%	52.5%
Total	100.0%	100.0%	100.0%	100.0%	100.0%

(source: ABS Special Request Matrix)

Table 7.3: Socio-Economic Profile of Employed Persons Who Use a Train to Go to Work, 2001 (proportion of employed persons)

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft
Employed Persons	2,551	1,302	825	1,344	1,845
Age					
15-24	26.9%	35.1%	29.2%	33.2%	35.5%
25-34	23.4%	38.9%	23.3%	28.5%	37.0%
35-44	17.4%	22.6%	20.7%	24.9%	30.9%
45-54	18.3%	18.2%	23.5%	26.3%	20.5%
55-64	16.2%	16.7%	29.2%	22.6%	10.4%
65+	11.6%	12.8%	60.0%	27.3%	19.0%
Not Stated	0.0%	40.0%	0.0%	0.0%	60.0%
Birthplace					
Australia	20.6%	26.6%	24.3%	24.2%	27.4%
Other Oceania	26.4%	33.8%	41.7%	28.9%	43.0%
UK/Ireland	22.6%	33.6%	42.9%	13.0%	24.6%
Other Europe	15.9%	18.6%	25.6%	25.9%	22.7%
Asia	25.0%	33.8%	30.9%	34.3%	38.7%
Middle East	66.7%	0.0%	13.2%	18.8%	20.0%
Africa (Inc North Africa)	12.5%	11.7%	0.0%	40.0%	38.5%
Americas	23.3%	46.4%	22.4%	21.4%	26.5%
Other	0.0%	0.0%	100.0%	50.0%	0.0%
Not stated	20.8%	27.6%	33.3%	27.8%	30.4%
Household Type					
Couples with Children	13.3%	19.1%	21.2%	26.8%	22.0%
Couples without Children	22.3%	26.1%	23.8%	24.0%	33.3%
One Parent Family	20.9%	24.1%	27.0%	28.8%	32.1%
Lone Persons Households	20.7%	24.9%	18.9%	23.9%	33.3%
Group Households	23.2%	34.2%	37.0%	42.3%	39.9%
Other Households	21.2%	31.2%	30.8%	38.1%	15.9%
Tenure					
Fully Owned	18.6%	20.1%	22.5%	26.2%	30.7%
Being Purchased	14.7%	21.6%	14.6%	24.9%	26.9%
Rented from State Housing Authority	0.0%	0.0%	25.0%	66.7%	0.0%
Rented from Other Sources	24.4%	32.3%	25.5%	29.6%	34.6%
Other Tenure	31.3%	19.0%	13.0%	0.0%	51.5%
Not Stated	6.3%	28.6%	90.9%	27.9%	7.5%
Number of Motor Vehicles					
None	55.7%	50.0%	43.6%	52.8%	49.0%
1 motor vehicle	24.0%	27.8%	22.1%	25.0%	35.1%
2 motor vehicles	10.0%	14.6%	11.2%	13.8%	21.7%
3 motor vehicles	11.0%	14.3%	0.0%	34.6%	22.8%
4 motor vehicles or more	0.0%	20.0%	37.5%	21.4%	12.0%
Not stated	14.9%	32.0%	36.4%	34.7%	16.2%

	Cronulla	Edgecliff	Fairfield/Cabramatta	Liverpool	St Leonards/Wollstonecraft
Occupation					
Managers and Administrators	14.2%	19.7%	0.0%	17.6%	22.7%
Professionals	22.0%	30.5%	40.0%	36.2%	32.8%
Associate Professionals	19.4%	26.0%	34.7%	20.2%	29.9%
Tradespersons and Related Workers	10.9%	7.3%	10.3%	20.3%	6.5%
Advanced Clerical and Service Workers	36.9%	36.5%	33.3%	48.1%	44.2%
Intermediate Clerical, Sales and Service Workers	23.9%	30.6%	40.7%	36.6%	37.2%
Intermediate Production and Transport Workers	18.0%	16.7%	10.9%	16.5%	0.0%
Elementary Clerical, Sales and Service Workers	26.2%	20.2%	26.6%	38.9%	27.7%
Labourers and Related Workers	24.2%	43.8%	21.1%	30.8%	25.0%
Inadequately described	22.7%	15.0%	0.0%	25.0%	21.1%
Not stated	75.0%	69.2%	333.3%	0.0%	24.3%
Household Income					
Less than \$300 a week	14.3%	0.0%	0.0%	40.0%	20.0%
\$300-\$399	12.0%	0.0%	38.5%	37.9%	33.3%
\$400-\$499	15.7%	21.4%	14.6%	41.8%	33.3%
\$500-\$599	21.6%	29.2%	24.6%	21.1%	35.3%
\$600-\$699	17.0%	9.7%	16.1%	24.3%	29.0%
\$700-\$799	21.1%	13.3%	13.6%	23.8%	39.1%
\$800-\$999	27.5%	29.3%	13.0%	24.3%	42.4%
\$1,000-\$1,199	19.1%	19.3%	20.0%	28.4%	27.3%
\$1,200-\$1,499	28.5%	27.4%	32.7%	34.0%	22.8%
\$1,500-\$1,999	21.5%	30.5%	37.3%	21.6%	33.2%
\$2,000 or more	18.5%	28.5%	36.4%	35.6%	35.0%
Not Stated	18.1%	31.0%	35.8%	25.7%	14.9%
Gender					
Male	17.4%	26.4%	16.6%	24.1%	27.7%
Female	25.6%	27.7%	37.3%	33.9%	32.7%

(source: ABS Special Request Matrix)

Figure 7.2: The Proportion of Train Users who are Males and Females in the Case Study Areas, 2001

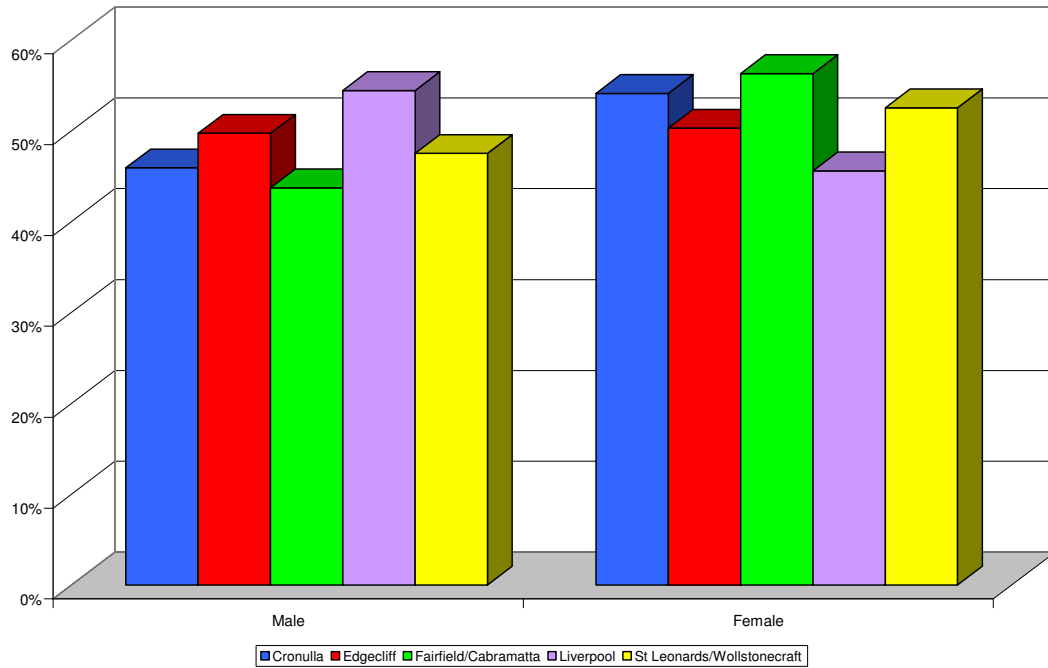


Figure 7.3: The Proportion of Employed Males and Females Who Commute to Work by Train in the Case Study Areas, 2001

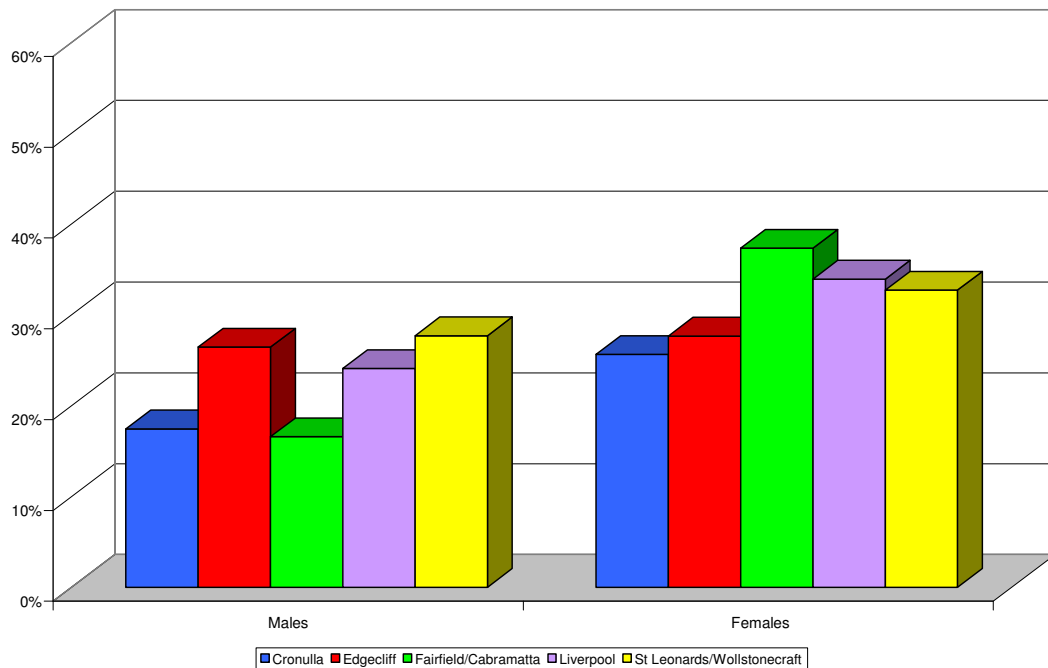


Figure 7.4: The Proportion of Train Users by Age Group in the Case Study Areas, 2001

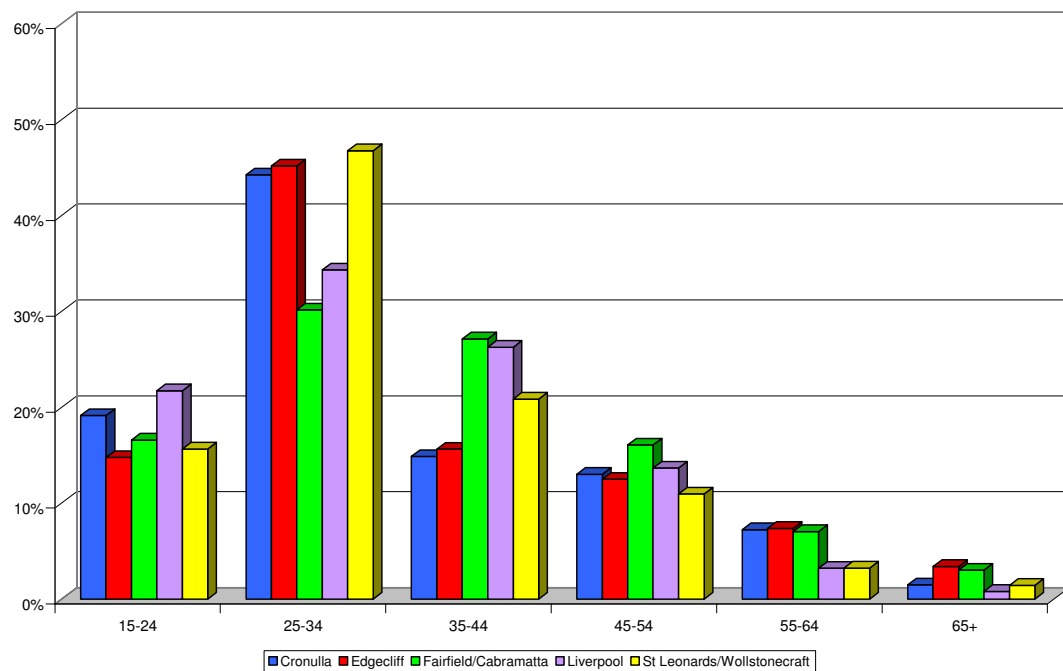


Figure 7.5: The Proportion of Employed Persons Who Commute to Work by Train by Age Group in the Case Study Areas, 2001

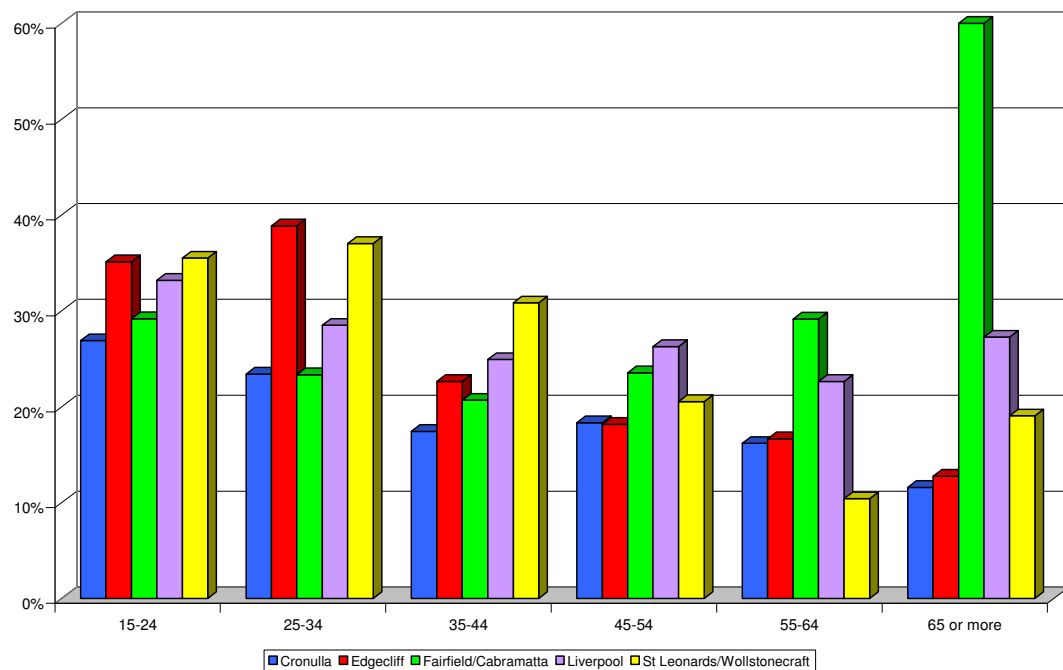


Figure 7.6: The Proportion of Train Users by Birthplace in the Case Study Areas, 2001

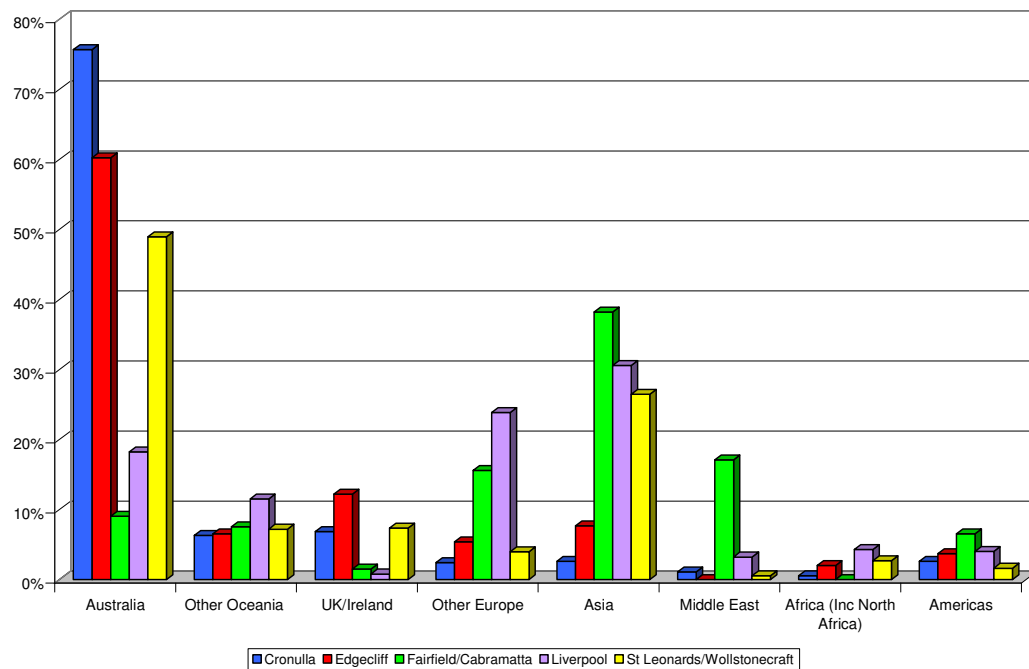


Figure 7.7: The Proportion of Employed Persons Who Commute to Work by Train by Birthplace in the Case Study Areas, 2001

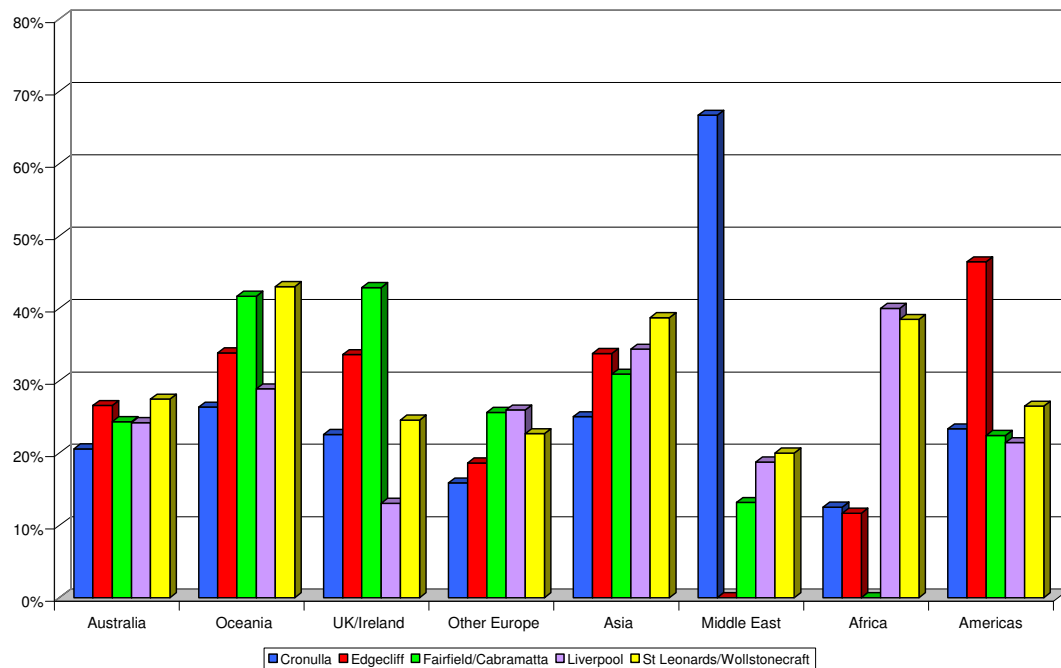


Figure 7.8: The Proportion of Train Users by Household Income in the Case Study Areas, 2001

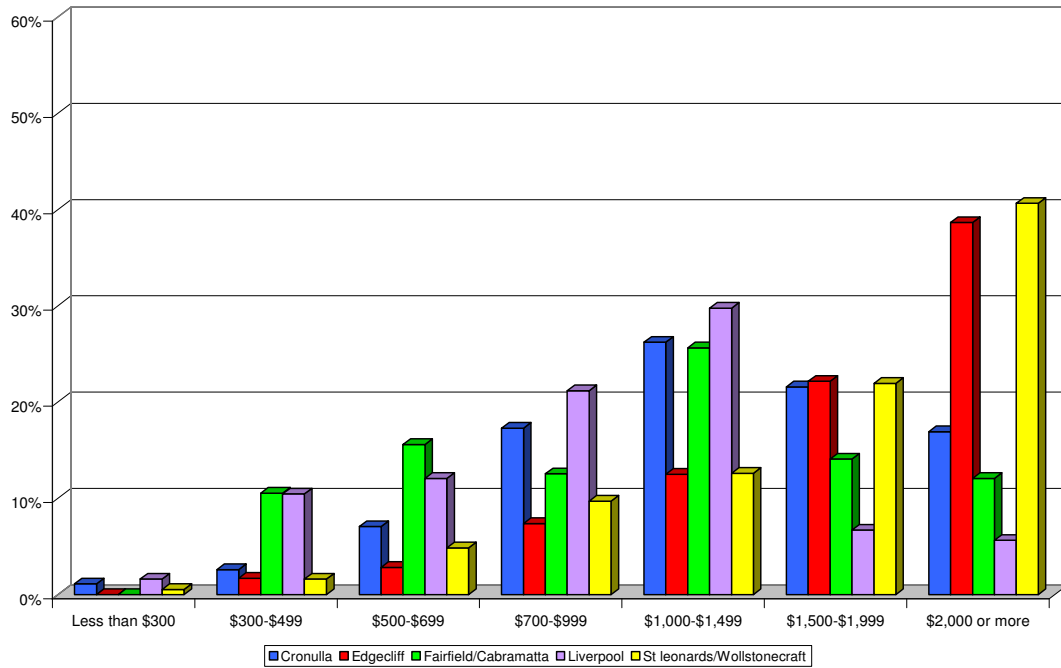


Figure 7.9: The Proportion of Employed Persons Who Commute to Work by Train by Household Income in the Case Study Areas, 2001

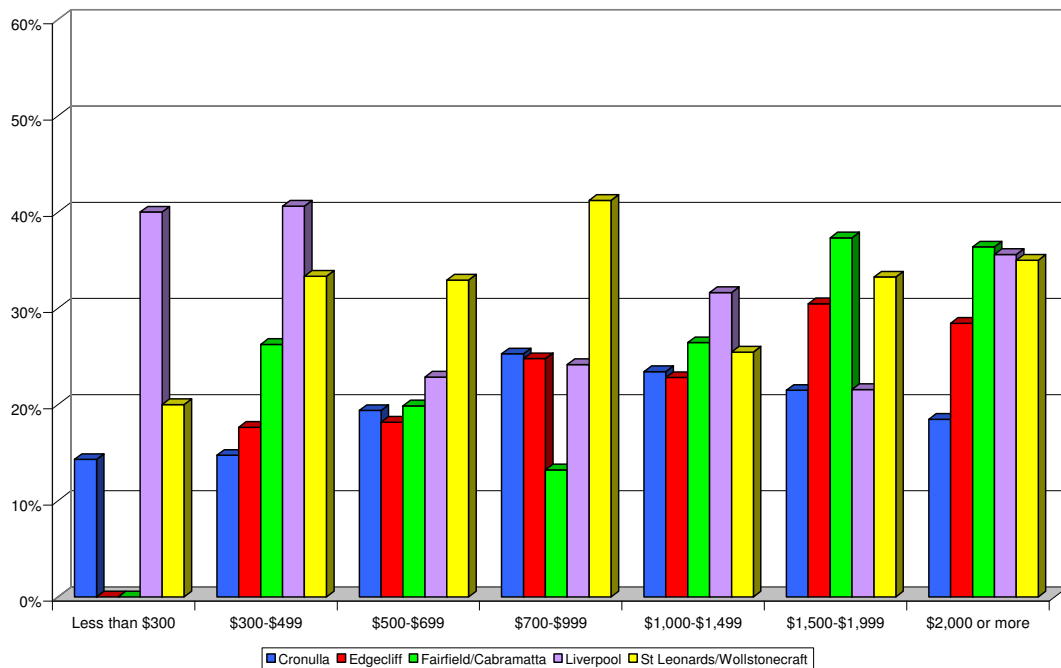


Figure 7.10: The Proportion of Train Users by Household Type in the Case Study Areas, 2001

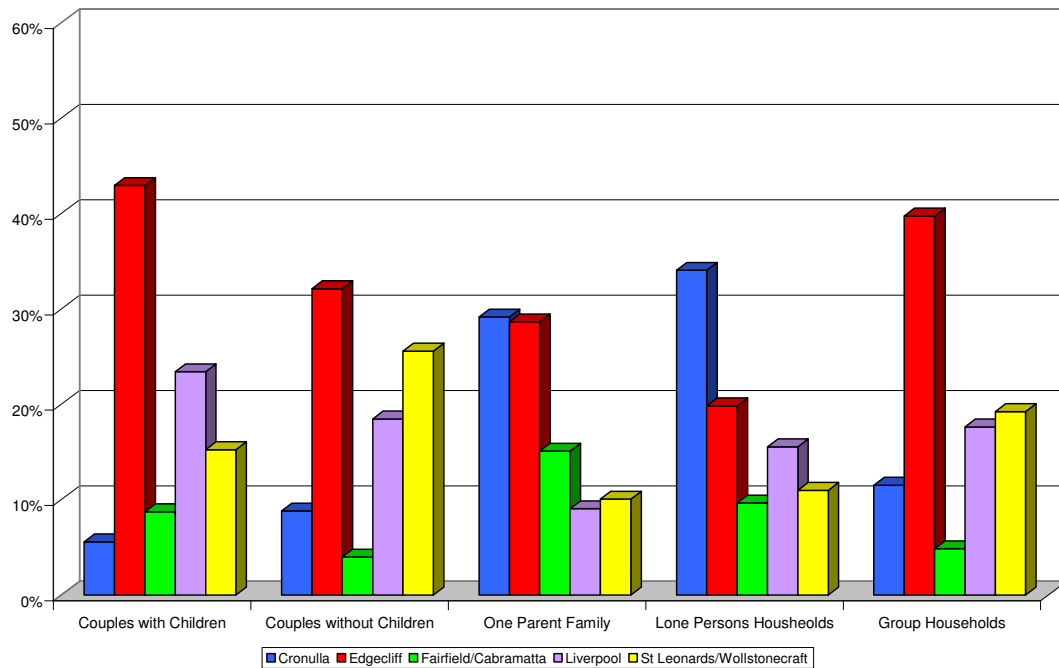


Figure 7.11: The Proportion of Employed Persons Who Commute to Work by Train by Household Type in the Case Study Areas, 2001

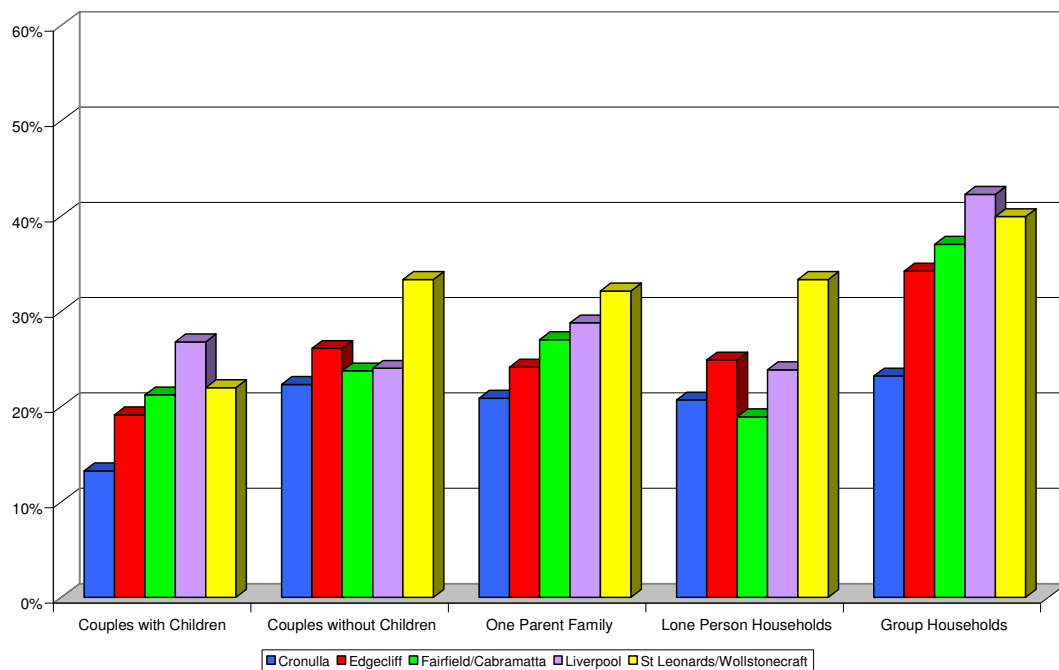


Figure 7.12: The Proportion of Train Users by Tenure in the Case Study Areas, 2001

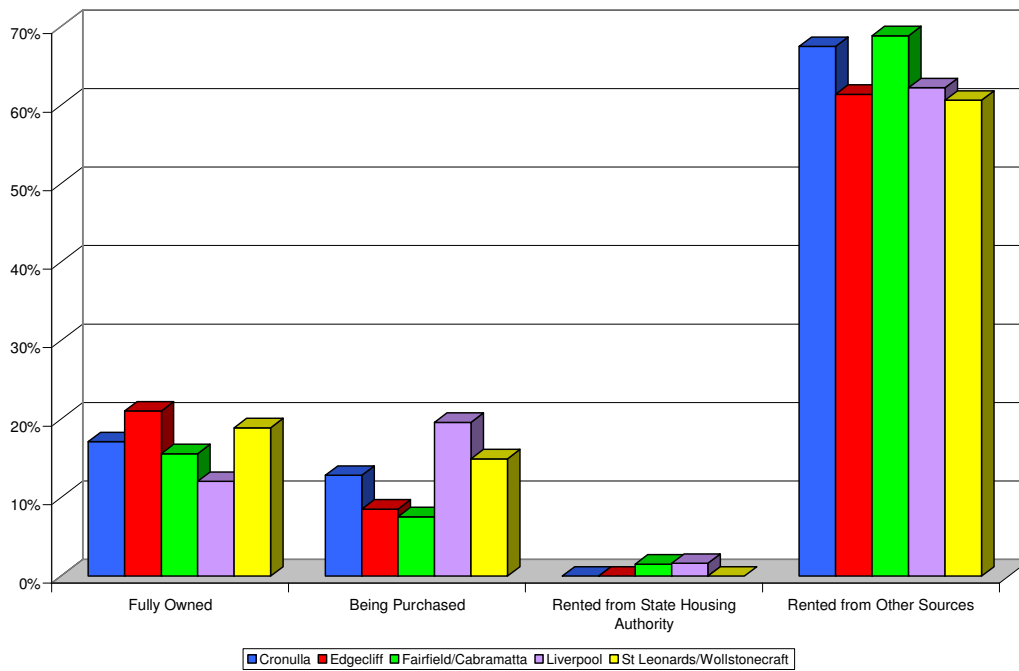


Figure 7.13: The Proportion of Employed Persons Who Commute to Work by Train by Tenure in the Case Study Areas, 2001

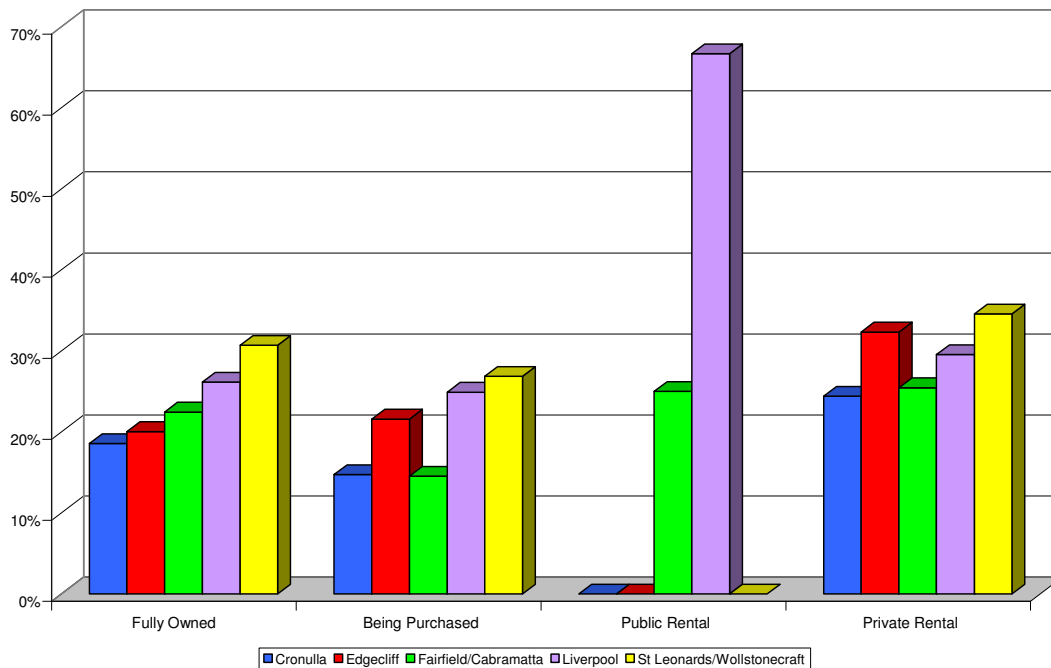


Figure 7.14: The Proportion of Train Users by Motor Vehicle Ownership in the Case Study Areas, 2001

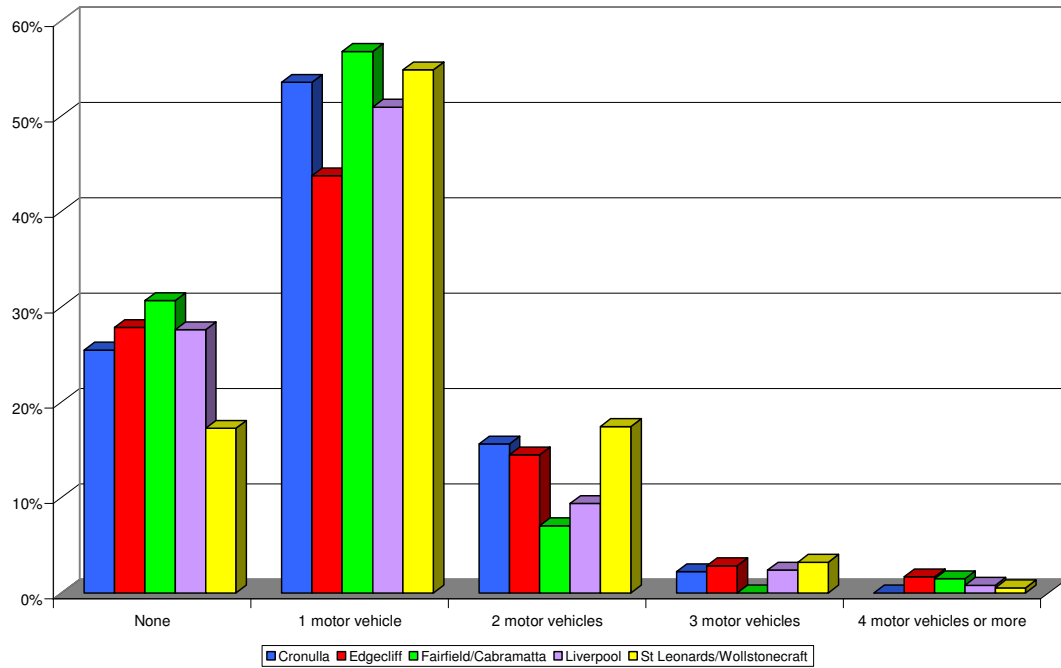


Figure 7.15: The Proportion of Employed Persons Who Commute to Work by Train by Motor Vehicle Ownership in the Case Study Areas, 2001

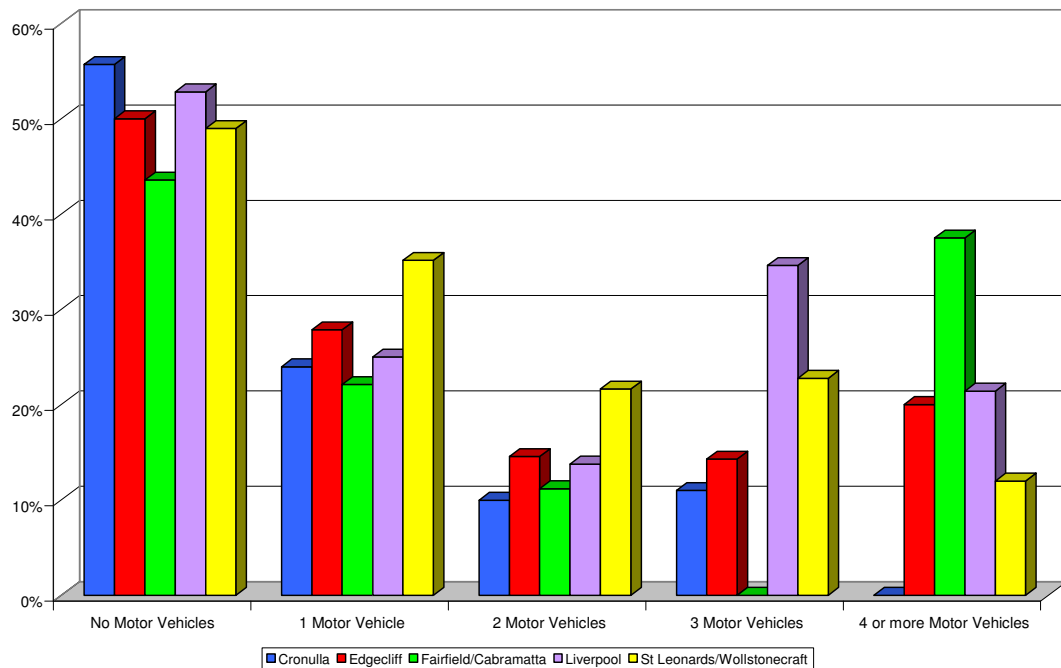


Figure 7.16: The Proportion of Train Users by Occupation in the Case Study Areas, 2001

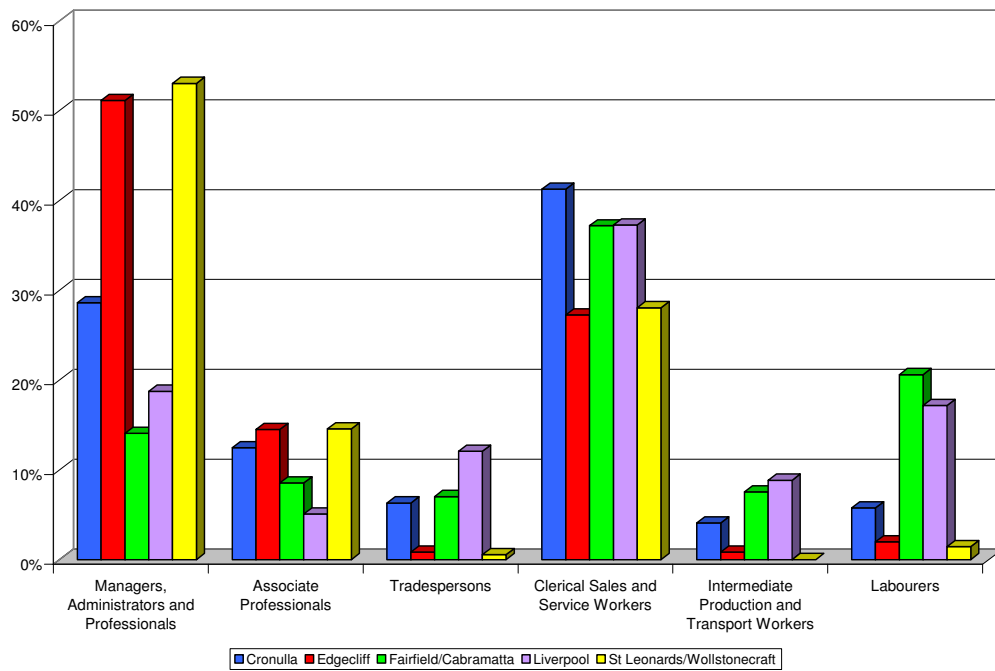
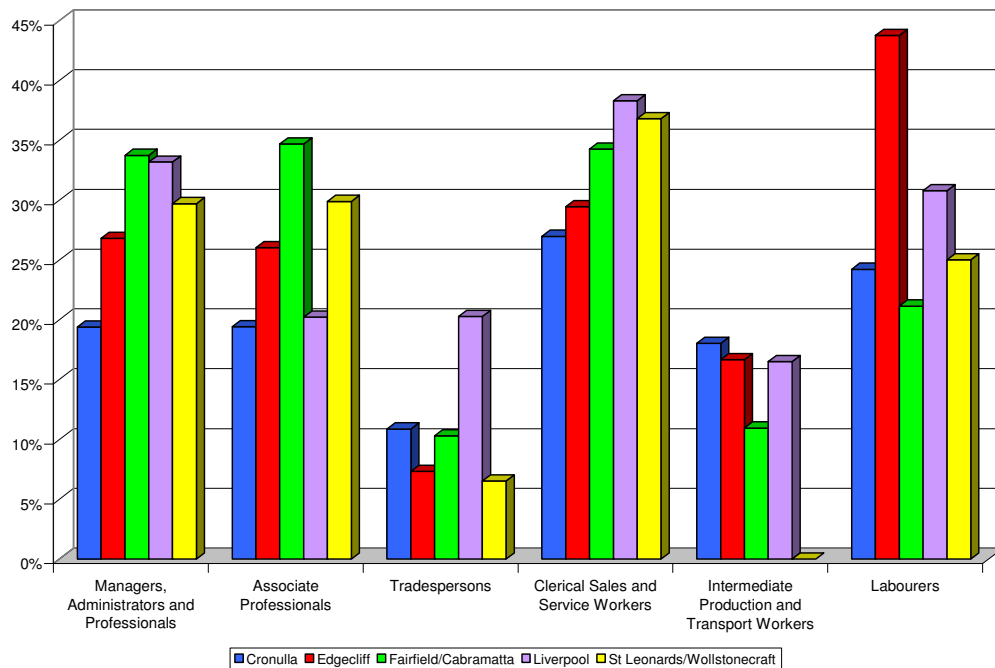


Figure 7.17: The Proportion of Employed Persons Who Commute to Work by Train by Occupation in the Case Study Areas, 2001



PART 4: CONCLUSIONS AND IMPLICATIONS

8. CONCLUSION

8.1 Introduction

At the beginning of this thesis a number of objectives were outlined in an attempt to assess the relationship between urban residential density and public transport use in Sydney. In particular, the study aimed to

- Evaluate the validity of the notion linking residential densities to public transport, specifically train, use;
- Assess the macro level relationship between public transport usage, housing and the socio-economic characteristics of individuals in the Sydney metropolitan area;
- Assess the meso level relationship between train use, residential density and the socio-economic characteristics of individuals who live in higher density housing in Sydney;
- Examine the micro level influences of public transport usage in higher density housing in different geographical localities in the Sydney metropolitan area; and
- Assess the implications of these results for urban consolidation policies in Sydney.

This chapter collates the main findings of the thesis and the results obtained for each of the study aims. The results are also assessed against other studies, and the implications for urban growth management policies are identified.

8.2 An Assessment of the Link Between Residential Densities and Public Transport Use

The research presented in this study clearly shows that, in Sydney, urban residential densities do not have a significant association with public transport use. The concept of increasing public transport use through increased urban densities appears to be an over-

simplification of the factors that influence public transport use. Importantly, the explanatory power of the hypothesis varies with geographical scale, as also noted by Geurs and van Wee (2006). This finding has implications for planning and public policies which is discussed below.

The analysis presented in Chapter 5 at the macro level gives a level of support to the notion that increasing densities increases public transport use, although there is enough evidence even at this level to suggest density is not the only factor influencing public transport use. Chapters 6 and 7 delved into more detail by assessing the relationship between density and public transport use at the meso and micro level. At these levels, the results showed that density has declining influence on one form of public transport use, namely train use, in Sydney as scale declines. The results also concur with the recent work of researchers such as Stead (2001) and Giuliano and Dargay (2006) that socio-economic factors are more important in influencing public transport use than density.

The lack of meso and micro level investigations into the relationship between density and public transport use has much to do with the unavailability of quality data at this level. Nevertheless, other elements such as economic restraints (e.g. parking policies, tolls, etc) and the promotion of mixed use development warrant further research in Sydney to evaluate their implications. The overwhelming conclusion though, is that the use of the promotion of higher density development around railway stations as a means to increase public transport use needs to be re-evaluated. Transport patterns are complex, and this needs to be reflected in policies.

8.3 A Macro Level Analysis of Public Transport Usage, Housing and the Socio-Economic Characteristics of Individuals in the Sydney Metropolitan area

The analysis presented in Chapter 5 concluded that in 2002 the percentage of train trips for those in flats (9%) was three times that for houses (3%) lending some weight at this macro level to the notion that density influences train use. Nevertheless, even at this

scale there are indications which suggest that other factors are important in explaining train use in Sydney.

An examination of the Sydney Household Travel Survey (HTS) showed that there are a number of socio-economic variables that may be influencing train use other than density. For example, private renters and public housing tenants are higher users of public transport in Sydney. The latter suggests that income may be a factor in influencing public transport use, however, public transport use is not dissimilar for low earners as it is for high income earners. Given this result, Mees' (2000) contention that if a reliable, integrated public transport system is present then individuals will use it appears to be a feasible assertion in Sydney. The wealthier inner Sydney areas have excellent public transport services, and higher frequency services, compared with other areas in Sydney, and this seems to reflect the high proportion of higher income persons using public transport.

Like many overseas studies the macro analysis of the HTS also showed that the more motor vehicles there are in a household, the less likely individuals are to use public transport. It is difficult at this stage to ascertain whether this factor is influenced by household income levels or geographical location, or a combination of both.

At the Sydney wide level, males and females use public transport at relatively similar levels. Males are more likely to use a train than females, and trains are generally used for longer trips. We cannot say for certain, but this result implies that females have a higher propensity to take shorter trips. This supports the work of Schwanen et al (2002) and Hanson and Pratt (1995). Overseas research suggests this is predominantly a result of shopping, and school trips which tend to be shorter. In addition, the implication of this result is that bus feeder services as promoted by the current metropolitan strategy may be appropriate policy response. On the other hand, it also questions whether the extensive bus networks as envisaged for Western Sydney will be used for long trips and/or a substitute for the train.

Perhaps the most interesting finding from the analysis of the Sydney HTS is the fact that overseas born persons have a higher propensity to use public transport than Australian born residents. This was also the finding from the local transport survey in Fairfield local government area in Sydney (see Chapter 5). The result implies that the relationship between migrants, train use and higher density housing in Sydney (see also Bunker et al 2005a and b) is an important component of the debate in urban growth management and transport policies in Sydney. The reason for this result cannot be definitively ascertained from the analysis presented here, however, it is possible that there are a number of factors and geographical variables impacting on this result. It may be due to the employment location characteristics of overseas born persons, lower car ownership and/or lower income. As Bunker et al (2005a and b) showed low income, overseas born persons are located in higher density housing in western Sydney. It is highly likely that this result is due to a combination of factors. This is an intriguing result nonetheless.

The findings of the analysis of the Sydney Household Travel Survey imply that even at this macro level while there may be a relationship between residential density and public transport use in Sydney other factors also have a significant relationship with public transport use.

8.4 A Meso Level Analysis of the Relationship Between Train Use, Residential Density and the Socio-Economic Characteristics of Individuals in Higher Density Housing in Sydney

Three multiple regression analyses were conducted on three different data sets to assess the relationship between density, train use and socio-economic variables at the meso (intra-urban) level. The results of the multiple regression analyses showed that in the first data set (Sydney SD) 25 variables explained 68% of the variance. In data sets two (higher density areas within 800 metres from a railway station) and three (higher density areas greater than 800 metres from a railway station) 13 and 10 variables explained 63% and 49% of the variance within the data. These results are similar to that presented by Stead (2001), but higher than those presented by Giuliano and Dargay (2006).

At the Sydney wide level the regression analysis found a higher proportion of flats was associated with higher levels of train usage. However, residential density was not a factor when higher density CDs were analysed separately and geographical location was considered.

Two of the most important factors from this analysis were bus and car use. Individuals who catch a bus and drive a car are less likely to use a train. The next most significant factor in explaining train use, and in the three data sets, was birthplace. In a confirmation of the macro analysis of the Sydney HTS, overseas born persons and those from non-English speaking background have higher propensities to use a train. This factor was more important than other socio-economic variables.

The multiple regression analyses also confirmed the analysis of the broader Sydney HTS in terms of income. That is, this study has found no significant direct relationship between income and train use in Sydney. This is not to say that income may be indirectly influencing public transport use in Sydney, but this study has not been able to deduce that income plays a significant independent role at either the macro or meso level. This result for income is similar to that identified by Schwanen et al (2002).

The multiple regression analyses confirmed that the larger the number of cars in a household the lower the train use. This confirms other research from Schwanen et al (2002), Dieleman et al (2002) and Lu and Pas (1999), and that of the macro level analysis presented earlier.

Importantly, the three multiple regression analyses presented in this study reveal that residential density is not as important in explaining train use as socio-economic factors, and that the factors influencing train use are complex.

In addition, it is evident from the meso level analyses that there are variables other than that obtained from the Census that are important influences on train use in Sydney. The

state of the transport system, including the density and frequency itself and its linkages to employment opportunities are potentially other factors which may influence the levels of public transport use.

8.5 A Micro Level Analysis of Public Transport Usage of Individuals in Higher Density Housing in Sydney

In all five selected case study areas in Sydney the largest users of the train were younger persons confirming the research findings of Hanson (1982). This result also concurs with the macro level analysis of the Sydney HTS presented in Chapter 5. Nonetheless, when the number of persons in each age group in each case study area was taken into account a similar picture emerged in four of the case study areas, except in the Fairfield/Cabramatta area, where older persons had a higher propensity to use the train than younger persons. This reveals that the influence of age is important but its influence is different in separate geographical localities across the Sydney metropolitan area.

In the Edgecliff, Cronulla and St Leonards/Wollstonecraft case study areas the largest number of train users were Australian born residents while in Fairfield/Cabramatta and Liverpool the largest number of train users were born overseas. However, once account was taken of the birthplace characteristics within each case study area it is evident that overseas born persons have higher propensities to use the train. This confirms the findings of the macro and meso level analyses presented in Chapters 5 and 6.

The local level analysis also showed that higher income households do use the train to go to work in all the case study areas. In the more advantaged areas of Cronulla and Edgecliff higher income households had higher propensities to use the train, whereas in Fairfield/Cabramatta and Liverpool both higher and lower income households used the train. This finding concurs with the multiple regression analyses and the assessment of the Sydney HTS in that the role of income in directly influencing train use in Sydney seems not to be significant. The Census employment profile of workers in Fairfield/Cabramatta and Liverpool strongly suggests that the location of employment and type of

employment is important in influencing train use, confirming the work presented in Melbourne by Hodgetts (2003).

The findings of this thesis clearly show that in Sydney income is not a factor in directly influencing train use. Others may argue differently, and the results from the Liverpool case study suggest income may be a factor in this locality. Nevertheless, there are also wealthy individuals who use the train in Sydney. That is, train use for journey to work trips is polarised in the sense that both low and high income individuals use the train at not dissimilar levels. The implication of this is that higher frequency services, or density of services, as evidenced in the higher income inner city and north shore areas of Sydney are important in influencing train use.

Private renters were more likely than owners and purchasers to use a train. Although only the amount of rent payments revealed any level of significance in the multiple regression analyses, both the macro level Sydney HTS and case study area analysis suggest that private renters have higher propensities use the train in Sydney. In the Liverpool case study area the train is an important mode for public housing tenants, although this was not the case in the other case study area which contained public housing - Fairfield/Cabramatta. This implies that while income may be a factor in influencing train use (in Liverpool) there are individuals who are choosing to use the train for journeys to work for other reasons suggesting that other lifestyle factors are also influencing train use.

In the case study areas households with children used the train less than other household types confirming the findings of Dieleman et al (2002). Also confirming the findings of Dieleman et al (2002) and Lu and Pas (1999), households with no motor vehicle were more likely to use the train, although the largest group of train users came from households with one motor vehicle.

Importantly, females were more likely than males to use trains in the case study areas, which is opposite to the findings of the macro level HTS analysis. As the HTS contains

non-work trip information this confirms the work of Boarnet and Sarmiento (1998) in that the influence of non-work trips is important in understanding the factors that influence public transport.

Overall, the micro level case study area analysis revealed that a number of variables influence train use at the local level in Sydney. This confirms similar findings from the meso and macro level analyses, which questions the validity of the notion that increasing residential densities increases public transport.

8.6 Implications for Urban Consolidation Policy

At the sub-metropolitan level this study contends that there is little evidence in Sydney that density is the main driver of public transport use. This, therefore, questions the emphases on urban consolidation policies not only in Sydney, but also in other cities, on linking higher density development to public transport use. For example, the analyses presented above showed that a number of socio-economic variables, including housing tenure and birthplace, are associated with an increased propensity to use the train. As residential density is clearly not the main driver in influencing train use in Sydney then there needs to be an evaluation as to why a policy of increased densities around public transport nodes is being promoted. This is not to say that increasing densities in appropriate locations, nor the provision of public transport use is important, but that the relationship between the two is not necessarily a positive correlation.

This also raises the issue that if density is not the key driver of public transport use than urban policy makers will be limited in their capacity to increase public transport use. That is, if socio-economic variables (and other variables) are more important than density in influencing public transport use then there needs to be a whole of government public policy approach, as planners will have limited tools to significantly increase public transport use, if increasing residential densities is not the key factor. At an even broader level, public policy responses will be important across a range of portfolios if public transport use is to increase, and therefore reduce emissions.

Evidence from other researchers suggests that the co-location of residential development, employment and retail facilities and services is important in reducing car use. This was implied in the findings of the Victorian Greenhouse Neighbourhood project. The results of this study suggest that, from the limited results available, this seems to be an issue worthy of further exploration in Sydney. The linking of trips, and increasingly walking trips, through co-locating land uses is evident in the literature. The Sydney Metropolitan Strategy has identified the significant proportion of short trips in Sydney by car. To reduce this it would seem a more appropriate policy response to examine mixed land use settings rather than rely on residential density alone.

It should also be noted that planning authorities in Sydney, and across the country, are limited in their capacity to increase public transport use. Nonetheless, there is little evidence from this study that much can be gained from promoting a significant relationship between density and public transport use per se. The outcome of these findings is that planners need to base growth management policies based on evidence, rather than deterministic notions which are under-researched.

This is not to say that such a policy should not be part of the suite of growth management initiatives. However, density does not seem to determine the propensity to travel in Sydney. Travel patterns are complex, and change over time, and if an increase in public transport is the required outcome, then policies need to reflect this complexity.

8.7 Further Research

It is evident that there is still further work to be done to contribute to a better understanding of the relationship between residential density and public transport use. This is, particularly, the case at the local level, and the need to articulate this evidence in urban growth management and transport policies.

One of the most significant findings of the research is the lack of local level data on the behaviour and attitudes of residents in higher density dwellings and their transport preferences in Sydney, or other Australian cities. In Australia, the Census provides a valuable resource for examining journey to work data for small areas, however, it lacks information on non-work trips. The Sydney HTS provides a range of information on the transport patterns and socio-demographic characteristics of individuals, but it is mainly used for Sydney wide analyses. In between these two data sets there remains a missing data set that could further contribute to our knowledge on this issue. The availability of data on non-work trips will also be important for investigating the effects of mixed land uses on reducing car use.

Clearly, there is a need to have another or alternative data set. One which not only includes non-work trips but tries to identify whether other factors, such as parking policies, petrol prices, tolls, taxes and charges, or traffic calming measures also influence public transport use. Moreover, further research should be conducted in Sydney, as well as in other cities, as to the influences of employment opportunities and the public transport system on patronage levels. Obviously, all this needs to occur at different spatial levels to better inform urban planning policies given their spatial impacts. That is, scale is important and this needs to be reflected in urban and government policies regarding public transport use. The affect of scale is also important as different variables (e.g. dwellings per hectare or population per hectare) may have different effects at different geographical scales, and between cities.

Information about urban structure or design may also be incorporated as part of the assessment (see Meurs and Haaijer 2001). How such information may be incorporated into further research work along with already available data from other sources such as the Census needs to be defined. Geurs and van Wee (2006) have suggested that multilevel regression models and structural equation models offer much better opportunities to analyse such complex relationships that exist between land use and travel behaviour. Nevertheless, in achieving a better understanding of such relationships household surveys should be explored as a first step. Household surveys have the ability

to provide both qualitative and quantitative information that cannot be obtained from existing data sets. Sufficient sample sizes also have the ability to be analysed in more detail and possibly at different spatial scales. That is, household surveys which examine more variables than the Sydney HTS will provide a significant contribution to this debate.

There are a number of issues that were raised during this research that also warrant further investigation. Firstly, a better understanding of the relationship between private rental tenure and public transport use is crucial for future urban growth management policies. Such a finding is influenced by the state of the housing market at a certain time, and admittedly this is a market whose actions are outside the control of planners. Whether this is indirectly a result of income or other factors should also be explored.

However, and secondly, it is evident from this study that income does not seem to directly influence train use in Sydney, at either of the three analyses (macro, meso and micro) investigated here. Both high and low income households use the train in Sydney at not dissimilar levels, and this was generally evident at all spatial scales. Other research, and anecdotal evidence, suggests that income is a factor that distinguishes different higher density housing markets in Sydney (Bunker et al 2005a and b). This is clearly an issue that warrants further research.

Thirdly, and without a doubt though, one of the most intriguing findings of the research presented here was the influence of birthplace on train use. Overseas born residents, particularly those from a non-English speaking background, had higher propensities to use a train to travel to work than Australian born residents, at all spatial levels. This study could not determine whether there were other variables (e.g. income) that indirectly influence this result. Again this is an issue that is worthy of further research.

8.8 Concluding Remarks

The research presented in this thesis has attempted to add to our knowledge surrounding the concept of density as a mechanism to increase public transport use in Sydney. This

thesis also set out to assess the concept at a more localised level than has been conducted previously.

The implications of the findings from this study suggest that there are many factors, in particular, socio-economic factors, that influence public transport use in Sydney. At the local level the situation is more complex. Although there are certain factors that are common across local areas, there are a number of factors that influenced train use that were particular to each case study area. At the macro level it may seem that individuals who live in higher density developments near railway stations use trains more, but this is not necessarily the case. The results revealed that density was not the most influential factor in increasing train use in Sydney. This thesis has not been able to include all the variables that should be considered when trying to assess why individuals use public transport. There is still much research to be conducted. In particular, the role of birthplace and tenure need to be more fully evaluated, and how these factors interrelate with other variables.

This thesis also concludes that planning policies and strategies should re-assess promoting any simple relationship between residential density and public transport use. While overseas research has revealed that mixed use development has potential in reducing car trips and therefore emissions, however, its potential in Sydney needs to be assessed. Importantly, the minimal amount of research on this topic to date in Sydney may need to be supplemented by a household survey which encapsulates the factors influencing public transport use in Sydney and includes questions which cannot be obtained from the Census or the Sydney Household Travel Survey. Until such research is conducted debate will still continue about the benefits of promoting increasing residential densities as the major driver of increasing public transport use. Debate will also continue into the use of the density – public transport relationship in urban consolidation policy and whether such a policy is the most appropriate in achieving a more sustainable urban form in Sydney.

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APPENDIX 1: DEFINITIONS OF DIFFERENT DWELLING TYPES

(source: Urban Frontiers Program 2001, p. 6; Bunker et al 2002, p. 146; Australian Bureau of Statistics 2001)

Dual occupancy is defined as two independent buildings on a single allotment. The allotment may be subdivided if it is large enough. The dwellings may be in the form of an extended single house under one roof, two separate dwellings, two new attached dwellings or one dwelling above another.

Townhouses and villa homes are self contained dwellings with open space, attached one to another in groups or in clusters. Villas are generally single storey, and townhouses usually of two or (more rarely) three storeys. This type often takes the form of semi-detached dwellings (shared common wall but separate lot and facilities), or row or terraced houses (three or more attached houses sharing common walls but with separate lots).

Semi detached dwellings are dwellings which are attached, but have their own private grounds with no other dwelling above or below them. Semi detached dwellings can refer to duplexes, villas, townhouses, row and terrace housing.

Flats and units consist of attached dwellings in various configurations of height and number within an individual building. They share some common arrangements of access, facilities and open space. In this study, low rise flats refer to a flat or unit in a block of less than 4 storeys. High rise flats refer to a flat or unit in a block of 4 or more storeys.

APPENDIX 2: CHRONOLOGY OF URBAN CONSOLIDATION POLICIES IN SYDNEY 1980-2007

1980	Sydney Regional Environmental Plan No. 1 – Dual Occupancy Allowed attached dual occupancies on lots bigger than 400m ² and detached dual occupancies on lots greater than 600m ² . Local authorities could demand that the owner had to occupy one of the dwellings.
	Establishment of the Urban Development Program Managed the release and development of land in Sydney. This was mainly greenfields development on the fringe. It was also used to introduce informal targets for multi-unit developments. The initial target was for 12,000 units a year between 1981 and 1986.
1981	Sydney Regional Environmental Plan No. 2 – Dual Occupancy The original dual occupancy REP (No.1) only applied to 26 local councils in Sydney. Under this new REP another 9 councils were added to the provisions of the dual occupancy policy.
	State Environmental Planning Policy No. 5 – Housing for Aged and Disabled Persons All housing for aged and disabled persons in most residential zones in Sydney and allowed development to occur at densities that were higher than otherwise permitted.
1983	State Environmental Planning Policy No. 8 – Surplus Public Land Allowed surplus government land to be (re)developed at high densities in existing areas.
1986	Sydney Regional Environmental Plan No. 7 – Multi-Unit Housing: Surplus Government Sites Made available government land in residential areas to be developed for multi-unit housing in which there was a lack of suitable sites for such development. It also enabled the state government to develop and demonstrate good examples of multi-unit housing.
	State Environmental Planning Policy No. 20 – Minimum Standards for Residential Flat Development This policy replaced the planning controls for flat development in Schedule 7 of the Local Government Act.

1987	State Environmental Planning Policy No. 25 – Residential Allotment Sizes Allowed small lots by reducing the minimum plot size for single dwellings to 450m ² and integrated housing developments (subdivisions of 5 or more on small lots).
	Sydney Regional Environmental Plan No. 12 – Dual Occupancy Provided uniform controls for dual occupancy across the Sydney region; permitted a single house to be converted into 2 dwellings; permitted the erection of a building containing 2 dwellings; permitted the erection of a second dwelling on land in residential areas and in non-urban areas under certain conditions; and permitted any persons to occupy a dwelling created under this plan.
1988	Sydney into its Third Century A document released by the State government to guide future development. Its objectives were to provide a variety of housing types and tenure and increase the supply of multi-unit housing. It aimed for 6,000 multi-unit dwelling starts in a year in established areas. The strategy also aimed to increase public transport use, target growth in centres and increase densities along rail lines and in corridors.
1989	Inquiry into urban consolidation policies - The Simpson Report Inquiry into the impact and affects SEPP 5, SEPP 25 and REP 12 were having in the community.
	State Environmental Planning Policy No. 28 – Town Houses and Villa Houses This policy allowed town house and villa units to be built in all residential areas in Sydney. Councils could be exempt as long as they could prove they had adopted measures themselves to implement such developments.
1990	State Environmental Planning Policy No. 32 – Urban Consolidation (Redevelopment of Urban Land) Allowed redevelopment of sites for medium density housing on non-residential sites which was no longer used for its original purpose.
1991-1992	State Environmental Planning Policy No. 25 – Residential Allotment Sizes (Amendments) <ul style="list-style-type: none"> • Removed the requirement for integrated developments that land could not be subdivided prior to the completion of the development. • Allowed the subdivision of dual occupancy developments. • Allowed for increased parking provisions for large dual occupancy developments and sought to prevent sequential dual occupancy development on the same lot.

1993	<p>Sydney's Future – A Discussion Paper</p> <p>A paper released from the State government attempting to increase the proportion of multi-unit dwellings from 40% to 65% of all starts by 2011</p>
1995	<p>Cities for the 21st Century – Sydney Metropolitan Strategy</p> <p>A focus of future development in major centres and along rail lines. Multi-unit dwellings to be 65% of all new starts and 15 dwellings per hectare in new release areas.</p> <p>Residential Strategies: Residential Development Strategies for Local Governments in the Greater Metropolitan Region</p> <p>This policy from the State government required local councils to Residential Development Strategies.</p>
1997	<p>Framework for Growth and Change: The Review of Strategic Planning for the Greater Metropolitan Area</p> <p>Set out the need to review population forecasts which, in turn, have implication for urban consolidation targets.</p> <p>NSW Model Code: A Model Code for Performance Based Multi-Unit Housing Codes</p> <p>This document set out performance criteria for multi-unit housing and suggested design responses for a number of issues/concerns associated with such developments.</p> <p>State Environmental Planning Policy No. 53 – Metropolitan Residential Development</p> <p>This policy aimed to bring together all the existing urban consolidation policies into one document. Councils could be exempt from this SEPP if their local Residential Strategies reflected the aims of this SEPP.</p>
1998-1999	<p>Review of State Environmental Planning Policy No 5 – Housing for Older People or People with a Disability</p> <p>Aimed to review aspects of the policy itself but also in particular concerns over the policy being used as a 'back door' mechanism for developers to build multi-unit housing and override local controls.</p>
2000	<p>Premier's Design Forum</p> <p>Urban Design Charter Launched</p> <p>Land and Environment Court review initiated</p>
2001	<p>Integrating Land Use and Transport (ILUT)</p> <p>A formalized policy from the state government attempting to better integrate land use and transport planning. The policy was developed through draft SEPP 66. Parts of the policy have been subsumed into the 2005 Metropolitan Strategy while provisions for zoning of retail and commercial space are articulated in a new Section 117 Ministerial Direction to guide LEP development in local councils.</p>

2003-2004	Review of State Environmental Planning Policy No. 5 and replacement with a new Seniors Living State Environmental Planning Policy (updated in 2007)
2004	<p>Commencement of New Metropolitan Strategy for Sydney Ministerial Directions Paper</p> <p>A paper released by the Minister outlining where the government was heading in terms of the new metropolitan strategy. Some 60-70% of all new development would be in existing areas, particularly concentrated in existing town centres and in corridors. This would increase public transport usage. Also encouragement of mixed use centres and initiatives to reduce energy and water consumption.</p>
2004	<p>Growth Centres or City Centres Policy</p> <p>A document released by the government confirming that future development in Sydney would be directed to existing town centres. Seven town centres in Western Sydney allocated funding to develop plans despite the Metropolitan Strategy not being officially released.</p>
2005	<p>Sydney Metropolitan Strategy</p> <p>The current metropolitan strategy for Sydney to guide development until 2031. Still a focus on concentrating development around rail stations and high frequency bus services in centres and along major transport corridors. Some 66% (420,000) of future residential development to be in the existing urban area of higher density with 34% (220,000) in new Greenfield sites. The Strategy articulates concentrations around existing transport rather than building new infrastructure. The strategy establishes dwelling targets at a sub-regional level to be implemented by local councils on a new sub-regional planning basis.</p>

APPENDIX 3: THE SYDNEY HOUSEHOLD TRAVEL SURVEY

(Source: Transport and Population Data Centre, NSW Department of Infrastructure, Planning and Natural Resources)

The Sydney Household Travel Survey (HTS) is a survey of personal travel behaviour conducted in the Sydney Metropolitan Area (SMA). The SMA includes the Sydney metropolitan area itself, the Blue Mountains, Central Coast, Lower Hunter and the Illawarra.

The HTS is a continuous or rolling survey with an annual sample size of about 5,000 households. This has been the case since 1997. A face-to-face survey is conducted with all members of a randomly selected household within the SMA. Each household provides travel details for an allocated travel day. Data is collected for all days of the week throughout the year.

All members of the selected household are asked about the details of their travel over a 24 hour period. Data collected includes demographic data about the household and each person in it, including those who did not make a trip that day, plus details of each individual trip.

Each annual sample or 'wave' consists of approximately 5,000 households or 9,000 individuals. A response rate of 60%-70% is achieved for each wave. The sampling methodology for the HTS was designed by the Australian Bureau of Statistics (ABS) and is designed to provide the best estimate of travel at a point in time by pooling 3 annual waves of data. With all 3 waves combined the sample size is similar to that achieved in the 1991/92 Household Interview Survey (HIS). The HIS was the precursor to the HTS. The sample is also designed to achieve a relative standard error for total trips of about 10% at the 95% confidence level for each statistical local area (SLA) after three years.

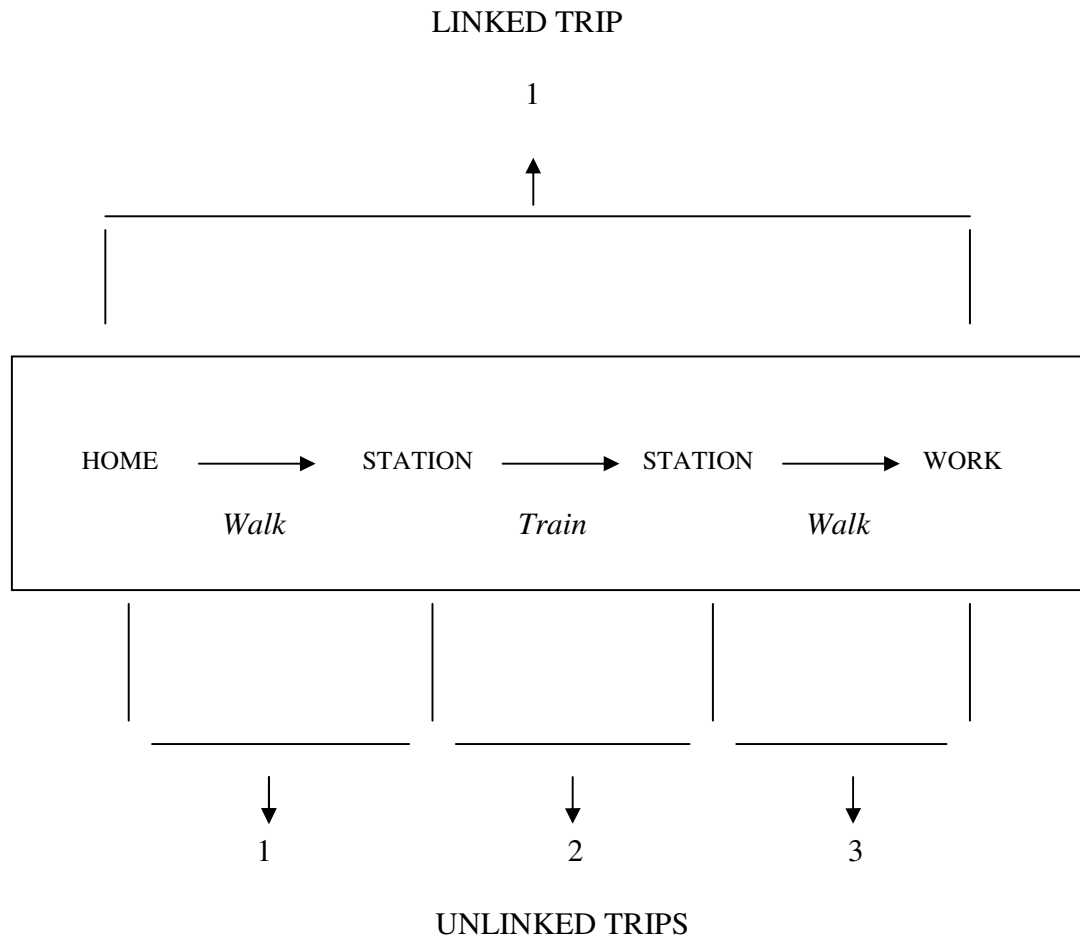
The sample data from the HTS is also expanded (or weighted) to represent travel patterns of the whole population in the survey area using information on households and

individuals from the ABS, including the 1996 Census of Population and Housing. The weightings are devised by the ABS and implemented by the Transport and Population Data Centre (TDPC). The data is weighted to represent the estimated resident population as at June 30 of the most recent year. For example, data collected over 2000/01, 2001/02 and 2002/03 is weighted based on the estimated resident population at 30 June 2002. The data therefore represents the year 2002, and is referred to as such.

It should be noted that while total trip estimates from the HTS for travel in each SLA have acceptable relative standard errors (RSEs), breaking the data down further produces higher RSEs. Caution is therefore advised when using HTS estimates based on fine cross-tabulations or detailed geographic areas. Similarly, SLA estimates of trip growth across survey years also have higher RSEs than trip estimates for a specific year. As such, great caution should be used when interpreting trend data.

APPENDIX 4: LINKED AND UNLINKED TRIPS

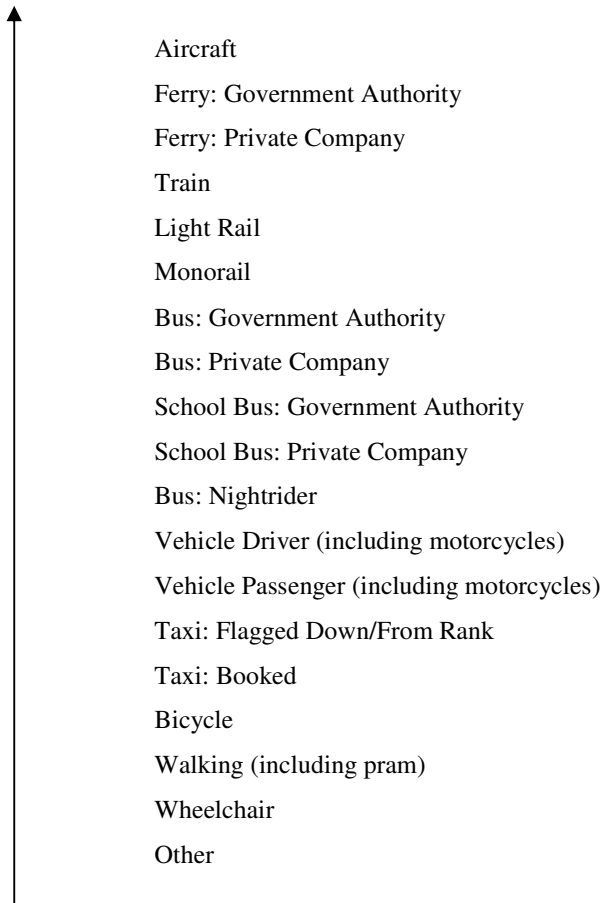
(Source: Transport and Population Data Centre 2003)



APPENDIX 5: PRIORITY MODE HIERARCHY

(Source: Transport and Population Data Centre 2003)

Highest Priority



Lowest Priority

APPENDIX 6: OUTPUT FROM THE SYDNEY HOUSEHOLD TRAVEL SURVEY, 2002

Household Travel Survey Unweighted Numbers

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
Trip Purpose						
Childcare	177	0	13	54	4	248
Education	1,468	216	590	596	30	2,900
Employers Business	3,926	98	37	322	70	4,453
Home	16,789	1,086	1,242	3,539	316	22,972
Other	2,808	35	46	500	8	3,397
Personal Business	2,503	144	119	815	38	3,619
Serve passenger	4,667	31	29	315	23	5,065
Shop	4,584	194	276	2,172	46	7,272
Social/Recreation	6,259	235	313	2,960	188	9,955
Work	4,068	723	339	1,217	93	6,440
Total	47,249	2,762	3,004	12,490	816	66,321
Dwelling Structure						
Separate house	40,519	1,806	2,046	7,971	488	52,830
Semi detached	3,557	296	349	1,794	82	6,078
Flat under 4 storeys	2,603	533	461	2,035	172	5,804
Flats 4 or more storeys	482	118	143	664	74	1,481
Other	88	9	5	26	0	128
Total	47,249	2,762	3,004	12,490	816	66,321
Tenure						
Owned	22,429	1,043	1,238	4,981	273	29,964
Being Purchased	15,797	706	752	2,999	216	20,470
Rent Publicly	1,279	116	191	805	50	2,441
Rent Privately	7,231	875	780	3,595	261	12,742
Other Tenure	513	22	43	110	16	704
Total	47,249	2,762	3,004	12,490	816	66,321
Household Type						
Person living alone	2,525	248	344	1,466	116	4,699
Couple only	8,302	563	394	2,391	221	11,871
Couple living with children	27,906	1,181	1,432	5,178	248	35,945
One person living with children	3,181	220	333	1,267	65	5,066
Other	5,335	550	501	2,188	166	8,740
Total	47,249	2,762	3,004	12,490	816	66,321
Age						
0 - 14 years	8,268	210	945	2,437	115	11,975
15-24 years	5,296	715	658	1,761	111	8,541
25-34 years	6,792	619	338	2,083	212	10,044
35-44 years	10,103	477	291	1,934	122	12,927
45-54 years	8,238	353	218	1,512	95	10,416
55-64 years	4,770	188	193	1,230	64	6,445
65+ years	3,782	200	361	1,533	97	5,973
Total	47,249	2,762	3,004	12,490	816	66,321

	Vehicle	Train	Bus	Walking/Cycling	Other	Total
Gender						
Male	23,381	1,376	1,369	5,707	441	32,274
Female	23,868	1,386	1,635	6,783	375	34,047
Total	47,249	2,762	3,004	12,490	816	66,321
Birthplace						
Australia	35,582	1,657	2,172	8,868	595	48,874
Overseas	11,667	1,105	832	3,622	221	17,447
Total	47,249	2,762	3,004	12,490	816	66,321
Household Income						
Less than \$200	1,956	165	224	1,080	48	3,473
\$200-\$399	3,578	220	356	1,504	70	5,728
\$400-\$599	4,169	224	310	1,344	62	6,109
\$600-\$799	4,535	172	275	1,108	45	6,135
\$800-\$999	4,189	246	284	1,024	49	5,792
\$1,000-\$1,199	5,349	244	288	1,233	56	7,170
\$1,200-\$1,499	4,748	296	240	994	31	6,309
\$1,500-\$1,999	5,774	368	360	1,160	95	7,757
\$2,000 or more	12,951	827	667	3,043	360	17,848
Total	47,249	2,762	3,004	12,490	816	66,321
Labour Force Status						
Employed	26,311	1,737	907	5,456	481	34,892
Unemployed	931	49	40	338	11	1,369
Studying	7,995	628	1,461	2,878	146	13,108
Retired	5,492	285	488	2,249	126	8,640
Keeping House	3,270	46	66	805	33	4,220
Other	3,250	17	42	764	19	4,092
Total	47,249	2,762	3,004	12,490	816	66,321
Occupation						
Managers and Administrators	2,583	105	54	449	67	3,258
Professionals	6,859	604	314	2,092	222	10,091
Associate Professionals	2,526	197	118	535	68	3,444
Tradespersons and Related Workers	4,041	110	42	320	18	4,531
Advanced Clerical and Service Workers	697	82	42	210	16	1,047
Intermediate Clerical, Sales and Service Workers	6,067	495	283	1,504	87	8,436
Intermediate Production and Transport Workers	2,134	41	22	167	4	2,368
Elementary Clerical, Sales and Service Workers	2,129	147	186	557	13	3,032
Labourers and Related Workers	1,661	126	93	344	27	2,251
Not Stated	29	10	1	0	1	41
Total	28,726	1,917	1,155	6,178	523	38,499
Distance Traveled						
0 - 2 km	7,859	2	60	9,015	133	17,069
2.01 - 5 km	12,314	83	563	2,843	212	16,015
5.01 - 10 km	11,739	378	1,174	508	183	13,982
Greater than 10 km	15,337	2,299	1,207	124	288	19,255
Total	47,249	2,762	3,004	12,490	816	66,321

(Source: Sydney Household Travel Survey)

APPENDIX 7: WHAT IS A MULTIPLE REGRESSION ANALYSIS

The general purpose of multiple regression is to learn more about the relationship between several independent variables (such as the number or proportion (%) of different household types, people in age categories and in different tenures) and a dependent variable (in this case train use). By analysing the relationship between these independent variables and the dependent variable in a series of settings (in this case higher density CDs) it is possible to establish which variables are significant predictors and what the statistical relationship looks like. This is a more sophisticated model than one that simply looks at the relationship between two variables (e.g. between the number of lone person households and the demand for trains). Multiple regression attempts to combine all the relevant factors into a single equation to examine which independent variables best predict the dependent variable.

Some forty six variables selected from the 2001 census were used to examine the factors that most influence train use. Not all variables influencing train use can be predicted from the Census, however, the large number of variables – both socio-economic and land use – that were included in the regression provide a useful starting point for a more detailed examination of train usage. The variables were collated for all census collector districts (CDs) in Sydney and analysed in a statistical software package (SPSS). The GIS software MapInfo was also used to extract CDs of higher density housing both within 800 metres of a railway station and beyond 800 metres from a rail station. CDs are not the ideal units to use in such an analysis as CDs are not homogeneous units. However, in the absence of unit or individual records they are commonly used in urban geography for this type of analysis.

From the forty six variables initially selected, a number were eliminated on the basis that they were unrelated to the dependant variable or because they were too closely related to one of the other independent variables (one that proved to be a better predictor).

The multiple regression analysis used a technique called stepwise regression to obtain a list of the factors influencing train use. Stepwise regression, finds the variable with the highest correlation to the dependent variable (in this case train use) and builds an equation. It then finds the next variable with the most significant partial correlation and adds it to the equation. This continues until there are no variables left that have a partial coefficient of 95%.

APPENDIX 8: LIST OF VARIABLES USED IN THE MULTIPLE REGRESSION ANALYSIS

Proportion of Persons Born Overseas
Proportion of Persons aged 5 and over who Lack Fluency in English
Proportion of Employed Persons Who Travel to Work by Bus
Proportion of Employed Persons Who Travel to Work by Car
Proportion of Households with No Vehicles
Proportion of Households who Own a Vehicle
Proportion of Households with Three or More Vehicles
Proportion of Employed Persons who are Managers, Administrators or Professional Workers
Proportion of Employed Persons who are Associate Professional Workers
Proportion of Employed Persons who are Advanced Clerical, Sales and Service Workers
Proportion of Employed Persons who are Tradespersons and Related Workers
Proportion of Employed Persons who are Intermediate Production or Transport Workers
Proportion of Employed Persons who are Intermediate Clerical, Sales and Service Workers
Proportion of Employed Persons who are Elementary Clerical, Sales and Service Workers
Proportion of Persons who are Labourers and Related Workers
Proportion of persons aged 15 and over with University Qualifications
Proportion of Households who are Owner-Occupiers
Proportion of Households who are Purchasing their dwelling
Proportion of Households who Rent from Private Sources
Proportion of Households who Rent from a Public Landlord
Proportion of Households with 'Other Tenure'
Proportion of Persons Aged over 15 who are Separated or Divorced
Proportion of Flats
Proportion of Households who are Couples with Children
Proportion of Households who are Couples without Children
Proportion of Households who are Lone Person Households
Proportion of Households who are One Parent Families
Proportion of Households who earn less than \$400 per week
Proportion of Households who earn more than \$2000 per week
Proportion of Persons aged 0-14 years
Proportion of Persons aged 15-24 years
Proportion of Persons aged 25-34 years
Proportion of Persons aged 35-44 years
Proportion of Persons aged 45-64 years
Proportion of Persons aged 65 years or more
Proportion of Unemployed Persons
Proportion of Persons Not in the Labour Force
Proportion of Persons of Indigenous origin
Proportion of Renters who pay less than \$200 per week in rent
Proportion of Renters who pay more than \$400 per week in rent
Proportion of Purchasers who pay less than \$400 per month in repayments
Proportion of Purchasers who pay more than \$1600 per month in repayments
Persons per Household
Population Density per Hectare
Dwelling Density per Hectare
Distance to CBD

APPENDIX 9: DETAILED OUTPUT FROM THE MULTIPLE REGRESSION ANALYSES

Sydney SD CDs

Variable	R Square	Significant F Change
Overseas Born	.187	0.000
Travel to Work by Bus	.137	0.000
Travel to Work by Car	.264	0.000
Three or more Motor Vehicles	.020	0.000
Intermediate Clerical, Sales and Service Workers	.014	0.000
University Qualifications	.004	0.000
Lack Fluency in English	.013	0.000
Weekly Rent is \$400 or more per week	.008	0.000
Elementary Clerical, Sales and Service Workers	.004	0.000
Other Tenure	.003	0.000
Persons Separated or Divorced	.002	0.000
No Motor Vehicles	.003	0.000
Owner-Occupier	.002	0.000
Flats	.002	0.000
Purchaser	.003	0.000
One Parent Family	.003	0.000
Dwelling Density per Hectare	.002	0.000
Aged 25-34 years	.002	0.000
Household Income \$2,000 or more per week	.001	0.000
Lone Person Households	.001	0.000
Rent from Private Sources	.001	0.000
Rent from Public Landlord	.002	0.000
Household Income less than \$400 per week	.001	0.000
Labourers and Related Workers	.001	0.000
Aged 45-64 years	.000	0.005
Total R Square	0.680	
Adjusted R Square	0.678	

Correlation matrix (cells coloured gray are not significant at p=0.05)

	Proportion of Employed Persons who use a train	Proportion of Employed Persons who use a bus	Proportion of Employed Persons who use a car	Dwellings per hectare	Proportion of flats
Proportion of Employed Persons who use a train	1.000	-0.296	-0.426	0.148	0.315
Proportion of Employed Persons who use a bus	-0.296	1.000	-0.443	0.275	0.429
Proportion of Employed Persons who use a car	-0.426	-0.443	1.000	-0.403	-0.619
Dwellings per hectare	0.148	0.275	-0.403	1.000	0.483
Proportion of flats	0.315	0.429	-0.619	0.483	1.000
Proportion of couples without children	-0.168	-0.033	0.133	-0.112	-0.159
Proportion of one parent families	0.030	-0.191	0.270	-0.138	-0.201
Proportion of lone person households	0.198	0.379	-0.560	0.354	0.640
Proportion of persons aged 0-14 years	-0.154	-0.453	0.617	-0.348	-0.580
Proportion of persons aged 15-24 years	0.093	-0.024	-0.069	0.013	0.008
Proportion of persons aged 25-34 years	0.205	0.405	-0.504	0.372	0.630
Proportion of persons aged 35-44 years	0.086	0.077	-0.088	0.063	0.109
Proportion of persons aged 45-64 years	-0.207	-0.097	0.170	-0.142	-0.295
Proportion of persons aged 65 years or more	-0.011	0.058	-0.077	0.010	0.051
Proportion of households earning less than \$400 per week	0.147	0.006	-0.099	0.080	0.146
Proportion of households earning more than \$2000 per week	-0.203	0.149	-0.003	-0.074	-0.148
Proportion of Associate Professional workers	-0.098	0.181	-0.135	0.069	0.120
Proportion of Intermediate Clerical, Sales and Service workers	0.064	-0.052	0.150	-0.008	-0.056
Proportion of Elementary Clerical, Sales and Service workers	0.099	-0.034	0.076	0.022	-0.041
Proportion of Labourers and Related workers	0.145	-0.238	0.194	-0.059	-0.070
Unemployment rate	-0.070	-0.058	0.086	-0.037	-0.060
Proportion of persons not in the labour force	0.107	-0.089	0.040	-0.046	-0.045
Proportion of households with three or more motor vehicles	-0.345	-0.363	0.564	-0.327	-0.596
Proportion of Indigenous persons	-0.044	-0.042	0.034	-0.036	-0.094
Proportion of owner occupiers	-0.213	-0.249	0.422	-0.317	-0.567
Proportion of households purchasing a dwelling	-0.234	-0.321	0.531	-0.265	-0.545
Proportion of households who rent from a public authority	0.015	0.082	-0.052	0.082	0.068
Proportion of households who rent from other sources	0.341	0.358	-0.600	0.354	0.775
Proportion of households classified as having 'other tenure'	-0.030	-0.032	-0.045	-0.031	0.009
Proportion of persons separated and divorced	0.079	0.137	-0.232	0.177	0.366
Proportion of persons born overseas	0.432	0.161	-0.301	0.237	0.453
Proportion of persons lacking fluency in English	0.398	-0.035	-0.090	0.111	0.228
Proportion of renters paying less than \$200 per week	0.098	-0.262	0.141	-0.071	-0.099
Proportion of renters paying more than \$400 per week	-0.167	0.215	-0.164	0.051	0.046
Proportion of purchasers paying less \$400 per month	0.007	-0.067	0.045	-0.032	-0.038
Proportion of purchasers paying more than \$1600 per month	-0.136	0.324	-0.228	0.060	0.105
Proportion of persons with university qualifications	0.095	0.410	-0.509	0.216	0.377
Proportion of households with no motor vehicle	0.345	0.297	-0.547	0.419	0.587

	Proportion of couples without children	Proportion of one parent families	Proportion of lone person households	Proportion of persons aged 0-14 years	Proportion of persons aged 15-24 years
Proportion of Employed Persons who use a train	-0.168	0.030	0.198	-0.154	0.093
Proportion of Employed Persons who use a bus	-0.033	-0.191	0.379	-0.453	-0.024
Proportion of Employed Persons who use a car	0.133	0.270	-0.560	0.617	-0.069
Dwellings per hectare	-0.112	-0.138	0.354	-0.348	0.013
Proportion of flats	-0.159	-0.201	0.640	-0.580	0.008
Proportion of couples without children	1.000	-0.305	-0.135	-0.207	-0.269
Proportion of one parent families	-0.305	1.000	-0.163	0.437	0.089
Proportion of lone person households	-0.135	-0.163	1.000	-0.650	-0.237
Proportion of persons aged 0-14 years	-0.207	0.437	-0.650	1.000	0.002
Proportion of persons aged 15-24 years	-0.269	0.089	-0.237	0.002	1.000
Proportion of persons aged 25-34 years	-0.028	-0.206	0.395	-0.463	0.041
Proportion of persons aged 35-44 years	-0.121	-0.091	-0.077	0.166	-0.122
Proportion of persons aged 45-64 years	0.295	-0.114	-0.182	-0.094	-0.105
Proportion of persons aged 65 years or more	0.184	-0.094	0.454	-0.362	-0.393
Proportion of households earning less than \$400 per week	-0.285	0.414	0.523	-0.077	-0.128
Proportion of households earning more than \$2000 per week	0.342	-0.446	-0.296	-0.100	-0.004
Proportion of Associate Professional workers	0.230	-0.363	0.091	-0.258	-0.073
Proportion of Intermediate Clerical, Sales and Service workers	-0.150	0.204	-0.012	0.121	0.123
Proportion of Elementary Clerical, Sales and Service workers	-0.240	0.301	0.004	0.152	0.138
Proportion of Labourers and Related workers	-0.338	0.511	-0.038	0.317	0.070
Unemployment rate	0.053	0.005	-0.028	0.069	-0.043
Proportion of persons not in the labour force	-0.082	0.292	0.283	-0.088	-0.112
Proportion of households with three or more motor vehicles	0.189	-0.086	-0.638	0.380	0.140
Proportion of Indigenous persons	-0.206	0.435	0.038	0.180	0.058
Proportion of owner occupiers	0.421	-0.178	-0.392	0.107	-0.138
Proportion of households purchasing a dwelling	0.114	0.003	-0.592	0.587	0.010
Proportion of households who rent from a public authority	-0.376	0.554	0.212	0.120	0.016
Proportion of households who rent from other sources	-0.110	-0.174	0.544	-0.500	0.076
Proportion of households classified as having 'other tenure'	0.007	-0.120	0.172	-0.120	-0.060
Proportion of persons separated and divorced	-0.174	0.292	0.531	-0.168	-0.199
Proportion of persons born overseas	-0.304	0.041	0.111	-0.171	0.181
Proportion of persons lacking fluency in English	-0.321	0.250	0.006	0.038	0.098
Proportion of renters paying less than \$200 per week	-0.294	0.505	0.149	0.276	-0.020
Proportion of renters paying more than \$400 per week	0.203	-0.326	-0.068	-0.185	-0.043
Proportion of purchasers paying less \$400 per month	-0.078	0.175	0.052	0.061	-0.010
Proportion of purchasers paying more than \$1600 per month	0.269	-0.444	0.005	-0.316	-0.092
Proportion of persons with university qualifications	0.218	-0.514	0.212	-0.455	-0.056
Proportion of households with no motor vehicle	-0.308	0.088	0.636	-0.408	0.012

	Proportion of persons aged 25-34 years	Proportion of persons aged 35-44 years	Proportion of persons aged 45-64 years	Proportion of persons aged 65 years or more	Proportion of households earning less than \$400 per week
Proportion of Employed Persons who use a train	0.205	0.086	-0.207	-0.011	0.147
Proportion of Employed Persons who use a bus	0.405	0.077	-0.097	0.058	0.006
Proportion of Employed Persons who use a car	-0.504	-0.088	0.170	-0.077	-0.099
Dwellings per hectare	0.372	0.063	-0.142	0.010	0.080
Proportion of flats	0.630	0.109	-0.295	0.051	0.146
Proportion of couples without children	-0.028	-0.121	0.295	0.184	-0.285
Proportion of one parent families	-0.206	-0.091	-0.114	-0.094	0.414
Proportion of lone person households	0.395	-0.077	-0.182	0.454	0.523
Proportion of persons aged 0-14 years	-0.463	0.166	-0.094	-0.362	-0.077
Proportion of persons aged 15-24 years	0.041	-0.122	-0.105	-0.393	-0.128
Proportion of persons aged 25-34 years	1.000	0.220	-0.450	-0.308	-0.141
Proportion of persons aged 35-44 years	0.220	1.000	-0.233	-0.461	-0.261
Proportion of persons aged 45-64 years	-0.450	-0.233	1.000	0.041	-0.142
Proportion of persons aged 65 years or more	-0.308	-0.461	0.041	1.000	0.474
Proportion of households earning less than \$400 per week	-0.141	-0.261	-0.142	0.474	1.000
Proportion of households earning more than \$2000 per week	-0.079	0.080	0.364	-0.121	-0.645
Proportion of Associate Professional workers	0.163	0.041	0.080	0.028	-0.295
Proportion of Intermediate Clerical, Sales and Service workers	-0.004	-0.028	-0.144	-0.029	0.164
Proportion of Elementary Clerical, Sales and Service workers	-0.173	-0.127	-0.104	0.104	0.373
Proportion of Labourers and Related workers	-0.143	-0.065	-0.188	-0.008	0.493
Unemployment rate	-0.045	-0.008	0.013	-0.001	0.034
Proportion of persons not in the labour force	-0.427	-0.463	0.009	0.704	0.739
Proportion of households with three or more motor vehicles	-0.525	-0.128	0.461	-0.164	-0.386
Proportion of Indigenous persons	-0.049	-0.081	-0.066	-0.051	0.311
Proportion of owner occupiers	-0.610	-0.258	0.529	0.296	-0.224
Proportion of households purchasing a dwelling	-0.199	0.250	0.017	-0.416	-0.458
Proportion of households who rent from a public authority	-0.110	-0.144	-0.042	0.087	0.623
Proportion of households who rent from other sources	0.739	0.209	-0.427	-0.101	0.031
Proportion of households classified as having 'other tenure'	-0.118	-0.208	-0.100	0.358	0.152
Proportion of persons separated and divorced	0.238	0.016	-0.157	0.069	0.468
Proportion of persons born overseas	0.269	0.143	-0.245	-0.095	0.144
Proportion of persons lacking fluency in English	0.043	0.077	-0.203	-0.013	0.346
Proportion of renters paying less than \$200 per week	-0.192	-0.100	-0.124	0.089	0.605
Proportion of renters paying more than \$400 per week	-0.048	0.006	0.250	0.044	-0.374
Proportion of purchasers paying less \$400 per month	-0.107	-0.090	0.040	0.069	0.222
Proportion of purchasers paying more than \$1600 per month	0.109	0.057	0.202	0.058	-0.424
Proportion of persons with university qualifications	0.371	0.213	0.059	-0.091	-0.452
Proportion of households with no motor vehicle	0.345	-0.049	-0.309	0.249	0.541

	Proportion of households earning more than \$2000 per week	Proportion of Associate Professional workers	Proportion of Intermediate Clerical, Sales and Service workers	Proportion of Elementary Clerical, Sales and Service workers	Proportion of Labourers and Related workers
Proportion of Employed Persons who use a train	-0.203	-0.098	0.064	0.099	0.145
Proportion of Employed Persons who use a bus	0.149	0.181	-0.052	-0.034	-0.238
Proportion of Employed Persons who use a car	-0.003	-0.135	0.150	0.076	0.194
Dwellings per hectare	-0.074	0.069	-0.008	0.022	-0.059
Proportion of flats	-0.148	0.120	-0.056	-0.041	-0.070
Proportion of couples without children	0.342	0.230	-0.150	-0.240	-0.338
Proportion of one parent families	-0.446	-0.363	0.204	0.301	0.511
Proportion of lone person households	-0.296	0.091	-0.012	0.004	-0.038
Proportion of persons aged 0-14 years	-0.100	-0.258	0.121	0.152	0.317
Proportion of persons aged 15-24 years	-0.004	-0.073	0.123	0.138	0.070
Proportion of persons aged 25-34 years	-0.079	0.163	-0.004	-0.173	-0.143
Proportion of persons aged 35-44 years	0.080	0.041	-0.028	-0.127	-0.065
Proportion of persons aged 45-64 years	0.364	0.080	-0.144	-0.104	-0.188
Proportion of persons aged 65 years or more	-0.121	0.028	-0.029	0.104	-0.008
Proportion of households earning less than \$400 per week	-0.645	-0.295	0.164	0.373	0.493
Proportion of households earning more than \$2000 per week	1.000	0.364	-0.315	-0.385	-0.627
Proportion of Associate Professional workers	0.364	1.000	-0.191	-0.271	-0.431
Proportion of Intermediate Clerical, Sales and Service workers	-0.315	-0.191	1.000	0.261	0.120
Proportion of Elementary Clerical, Sales and Service workers	-0.385	-0.271	0.261	1.000	0.336
Proportion of Labourers and Related workers	-0.627	-0.431	0.120	0.336	1.000
Unemployment rate	-0.061	-0.016	-0.023	-0.037	0.054
Proportion of persons not in the labour force	-0.406	-0.248	0.068	0.338	0.384
Proportion of households with three or more motor vehicles	0.396	-0.014	-0.048	-0.085	-0.098
Proportion of Indigenous persons	-0.292	-0.172	0.158	0.187	0.297
Proportion of owner occupiers	0.410	0.088	-0.144	-0.098	-0.192
Proportion of households purchasing a dwelling	0.185	-0.011	0.178	-0.047	-0.074
Proportion of households who rent from a public authority	-0.333	-0.254	0.155	0.270	0.330
Proportion of households who rent from other sources	-0.207	0.116	-0.072	-0.070	-0.007
Proportion of households classified as having 'other tenure'	-0.055	-0.030	-0.043	0.036	0.013
Proportion of persons separated and divorced	-0.468	-0.126	0.077	0.104	0.231
Proportion of persons born overseas	-0.173	-0.161	-0.045	0.128	0.252
Proportion of persons lacking fluency in English	-0.368	-0.315	-0.029	0.234	0.497
Proportion of renters paying less than \$200 per week	-0.643	-0.378	0.175	0.311	0.567
Proportion of renters paying more than \$400 per week	0.674	0.298	-0.347	-0.272	-0.445
Proportion of purchasers paying less \$400 per month	-0.167	-0.113	0.040	0.079	0.188
Proportion of purchasers paying more than \$1600 per month	0.703	0.381	-0.318	-0.357	-0.564
Proportion of persons with university qualifications	0.673	0.398	-0.368	-0.408	-0.630
Proportion of households with no motor vehicle	-0.383	-0.089	0.074	0.156	0.170

	Unemployment rate	Proportion of persons not in the labour force	Proportion of households with three or more motor vehicles	Proportion of Indigenous persons	Proportion of owner occupiers
Proportion of Employed Persons who use a train	-0.070	0.107	-0.345	-0.044	-0.213
Proportion of Employed Persons who use a bus	-0.058	-0.089	-0.363	-0.042	-0.249
Proportion of Employed Persons who use a car	0.086	0.040	0.564	0.034	0.422
Dwellings per hectare	-0.037	-0.046	-0.327	-0.036	-0.317
Proportion of flats	-0.060	-0.045	-0.596	-0.094	-0.567
Proportion of couples without children	0.053	-0.082	0.189	-0.206	0.421
Proportion of one parent families	0.005	0.292	-0.086	0.435	-0.178
Proportion of lone person households	-0.028	0.283	-0.638	0.038	-0.392
Proportion of persons aged 0-14 years	0.069	-0.088	0.380	0.180	0.107
Proportion of persons aged 15-24 years	-0.043	-0.112	0.140	0.058	-0.138
Proportion of persons aged 25-34 years	-0.045	-0.427	-0.525	-0.049	-0.610
Proportion of persons aged 35-44 years	-0.008	-0.463	-0.128	-0.081	-0.258
Proportion of persons aged 45-64 years	0.013	0.009	0.461	-0.066	0.529
Proportion of persons aged 65 years or more	-0.001	0.704	-0.164	-0.051	0.296
Proportion of households earning less than \$400 per week	0.034	0.739	-0.386	0.311	-0.224
Proportion of households earning more than \$2000 per week	-0.061	-0.406	0.396	-0.292	0.410
Proportion of Associate Professional workers	-0.016	-0.248	-0.014	-0.172	0.088
Proportion of Intermediate Clerical, Sales and Service workers	-0.023	0.068	-0.048	0.158	-0.144
Proportion of Elementary Clerical, Sales and Service workers	-0.037	0.338	-0.085	0.187	-0.098
Proportion of Labourers and Related workers	0.054	0.384	-0.098	0.297	-0.192
Unemployment rate	1.000	0.025	0.075	0.043	0.018
Proportion of persons not in the labour force	0.025	1.000	-0.161	0.161	0.184
Proportion of households with three or more motor vehicles	0.075	-0.161	1.000	-0.103	0.578
Proportion of Indigenous persons	0.043	0.161	-0.103	1.000	-0.255
Proportion of owner occupiers	0.018	0.184	0.578	-0.255	1.000
Proportion of households purchasing a dwelling	0.073	-0.436	0.448	-0.013	0.085
Proportion of households who rent from a public authority	-0.029	0.402	-0.213	0.449	-0.395
Proportion of households who rent from other sources	-0.048	-0.175	-0.621	-0.086	-0.594
Proportion of households classified as having 'other tenure'	0.019	0.262	0.020	-0.051	0.012
Proportion of persons separated and divorced	0.019	0.163	-0.495	0.244	-0.505
Proportion of persons born overseas	-0.117	0.181	-0.346	-0.175	-0.236
Proportion of persons lacking fluency in English	-0.064	0.366	-0.231	-0.059	-0.143
Proportion of renters paying less than \$200 per week	0.116	0.414	-0.134	0.361	-0.279
Proportion of renters paying more than \$400 per week	-0.050	-0.176	0.123	-0.195	0.264
Proportion of purchasers paying less \$400 per month	0.025	0.171	-0.028	0.124	-0.038
Proportion of purchasers paying more than \$1600 per month	-0.071	-0.256	0.095	-0.281	0.236
Proportion of persons with university qualifications	-0.090	-0.390	-0.195	-0.301	-0.020
Proportion of households with no motor vehicle	-0.058	0.312	-0.599	0.124	-0.511

	Proportion of households purchasing a dwelling	Proportion of households who rent from a public authority	Proportion of households who rent from other sources	Proportion of households classified as having 'other tenure'	Proportion of persons separated and divorced
Proportion of Employed Persons who use a train	-0.234	0.015	0.341	-0.030	0.079
Proportion of Employed Persons who use a bus	-0.321	0.082	0.358	-0.032	0.137
Proportion of Employed Persons who use a car	0.531	-0.052	-0.600	-0.045	-0.232
Dwellings per hectare	-0.265	0.082	0.354	-0.031	0.177
Proportion of flats	-0.545	0.068	0.775	0.009	0.366
Proportion of couples without children	0.114	-0.376	-0.110	0.007	-0.174
Proportion of one parent families	0.003	0.554	-0.174	-0.120	0.292
Proportion of lone person households	-0.592	0.212	0.544	0.172	0.531
Proportion of persons aged 0-14 years	0.587	0.120	-0.500	-0.120	-0.168
Proportion of persons aged 15-24 years	0.010	0.016	0.076	-0.060	-0.199
Proportion of persons aged 25-34 years	-0.199	-0.110	0.739	-0.118	0.238
Proportion of persons aged 35-44 years	0.250	-0.144	0.209	-0.208	0.016
Proportion of persons aged 45-64 years	0.017	-0.042	-0.427	-0.100	-0.157
Proportion of persons aged 65 years or more	-0.416	0.087	-0.101	0.358	0.069
Proportion of households earning less than \$400 per week	-0.458	0.623	0.031	0.152	0.468
Proportion of households earning more than \$2000 per week	0.185	-0.333	-0.207	-0.055	-0.468
Proportion of Associate Professional workers	-0.011	-0.254	0.116	-0.030	-0.126
Proportion of Intermediate Clerical, Sales and Service workers	0.178	0.155	-0.072	-0.043	0.077
Proportion of Elementary Clerical, Sales and Service workers	-0.047	0.270	-0.070	0.036	0.104
Proportion of Labourers and Related workers	-0.074	0.330	-0.007	0.013	0.231
Unemployment rate	0.073	-0.029	-0.048	0.019	0.019
Proportion of persons not in the labour force	-0.436	0.402	-0.175	0.262	0.163
Proportion of households with three or more motor vehicles	0.448	-0.213	-0.621	0.020	-0.495
Proportion of Indigenous persons	-0.013	0.449	-0.086	-0.051	0.244
Proportion of owner occupiers	0.085	-0.395	-0.594	0.012	-0.505
Proportion of households purchasing a dwelling	1.000	-0.263	-0.474	-0.133	-0.282
Proportion of households who rent from a public authority	-0.263	1.000	-0.192	-0.058	0.385
Proportion of households who rent from other sources	-0.474	-0.192	1.000	-0.047	0.357
Proportion of households classified as having 'other tenure'	-0.133	-0.058	-0.047	1.000	-0.056
Proportion of persons separated and divorced	-0.282	0.385	0.357	-0.056	1.000
Proportion of persons born overseas	-0.382	0.054	0.422	-0.024	0.002
Proportion of persons lacking fluency in English	-0.324	0.182	0.209	-0.003	0.054
Proportion of renters paying less than \$200 per week	-0.051	0.455	-0.042	0.035	0.407
Proportion of renters paying more than \$400 per week	-0.101	-0.186	-0.049	-0.029	-0.233
Proportion of purchasers paying less \$400 per month	-0.058	0.211	-0.073	-0.026	0.111
Proportion of purchasers paying more than \$1600 per month	-0.127	-0.230	0.023	0.005	-0.287
Proportion of persons with university qualifications	-0.187	-0.290	0.362	-0.063	-0.122
Proportion of households with no motor vehicle	-0.547	0.395	0.472	0.140	0.392

	Proportion of persons born overseas	Proportion of persons lacking fluency in English	Proportion of renters paying less than \$200 per week	Proportion of renters paying more than \$400 per week	Proportion of purchasers paying less \$400 per month
Proportion of Employed Persons who use a train	0.432	0.398	0.098	-0.167	0.007
Proportion of Employed Persons who use a bus	0.161	-0.035	-0.262	0.215	-0.067
Proportion of Employed Persons who use a car	-0.301	-0.090	0.141	-0.164	0.045
Dwellings per hectare	0.237	0.111	-0.071	0.051	-0.032
Proportion of flats	0.453	0.228	-0.099	0.046	-0.038
Proportion of couples without children	-0.304	-0.321	-0.294	0.203	-0.078
Proportion of one parent families	0.041	0.250	0.505	-0.326	0.175
Proportion of lone person households	0.111	0.006	0.149	-0.068	0.052
Proportion of persons aged 0-14 years	-0.171	0.038	0.276	-0.185	0.061
Proportion of persons aged 15-24 years	0.181	0.098	-0.020	-0.043	-0.010
Proportion of persons aged 25-34 years	0.269	0.043	-0.192	-0.048	-0.107
Proportion of persons aged 35-44 years	0.143	0.077	-0.100	0.006	-0.090
Proportion of persons aged 45-64 years	-0.245	-0.203	-0.124	0.250	0.040
Proportion of persons aged 65 years or more	-0.095	-0.013	0.089	0.044	0.069
Proportion of households earning less than \$400 per week	0.144	0.346	0.605	-0.374	0.222
Proportion of households earning more than \$2000 per week	-0.173	-0.368	-0.643	0.674	-0.167
Proportion of Associate Professional workers	-0.161	-0.315	-0.378	0.298	-0.113
Proportion of Intermediate Clerical, Sales and Service workers	-0.045	-0.029	0.175	-0.347	0.040
Proportion of Elementary Clerical, Sales and Service workers	0.128	0.234	0.311	-0.272	0.079
Proportion of Labourers and Related workers	0.252	0.497	0.567	-0.445	0.188
Unemployment rate	-0.117	-0.064	0.116	-0.050	0.025
Proportion of persons not in the labour force	0.181	0.366	0.414	-0.176	0.171
Proportion of households with three or more motor vehicles	-0.346	-0.231	-0.134	0.123	-0.028
Proportion of Indigenous persons	-0.175	-0.059	0.361	-0.195	0.124
Proportion of owner occupiers	-0.236	-0.143	-0.279	0.264	-0.038
Proportion of households purchasing a dwelling	-0.382	-0.324	-0.051	-0.101	-0.058
Proportion of households who rent from a public authority	0.054	0.182	0.455	-0.186	0.211
Proportion of households who rent from other sources	0.422	0.209	-0.042	-0.049	-0.073
Proportion of households classified as having 'other tenure'	-0.024	-0.003	0.035	-0.029	-0.026
Proportion of persons separated and divorced	0.002	0.054	0.407	-0.233	0.111
Proportion of persons born overseas	1.000	0.802	-0.040	-0.037	-0.032
Proportion of persons lacking fluency in English	0.802	1.000	0.229	-0.237	0.050
Proportion of renters paying less than \$200 per week	-0.040	0.229	1.000	-0.476	0.216
Proportion of renters paying more than \$400 per week	-0.037	-0.237	-0.476	1.000	-0.109
Proportion of purchasers paying less \$400 per month	-0.032	0.050	0.216	-0.109	1.000
Proportion of purchasers paying more than \$1600 per month	-0.025	-0.243	-0.604	0.598	-0.187
Proportion of persons with university qualifications	0.133	-0.219	-0.580	0.580	-0.168
Proportion of households with no motor vehicle	0.373	0.310	0.230	-0.133	0.097

	Proportion of purchasers paying more than \$1600 per month	Proportion of persons with university qualifications	Proportion of households with no motor vehicle
Proportion of Employed Persons who use a train	-0.136	0.095	0.345
Proportion of Employed Persons who use a bus	0.324	0.410	0.297
Proportion of Employed Persons who use a car	-0.228	-0.509	-0.547
Dwellings per hectare	0.060	0.216	0.419
Proportion of flats	0.105	0.377	0.587
Proportion of couples without children	0.269	0.218	-0.308
Proportion of one parent families	-0.444	-0.514	0.088
Proportion of lone person households	0.005	0.212	0.636
Proportion of persons aged 0-14 years	-0.316	-0.455	-0.408
Proportion of persons aged 15-24 years	-0.092	-0.056	0.012
Proportion of persons aged 25-34 years	0.109	0.371	0.345
Proportion of persons aged 35-44 years	0.057	0.213	-0.049
Proportion of persons aged 45-64 years	0.202	0.059	-0.309
Proportion of persons aged 65 years or more	0.058	-0.091	0.249
Proportion of households earning less than \$400 per week	-0.424	-0.452	0.541
Proportion of households earning more than \$2000 per week	0.703	0.673	-0.383
Proportion of Associate Professional workers	0.381	0.398	-0.089
Proportion of Intermediate Clerical, Sales and Service workers	-0.318	-0.368	0.074
Proportion of Elementary Clerical, Sales and Service workers	-0.357	-0.408	0.156
Proportion of Labourers and Related workers	-0.564	-0.630	0.170
Unemployment rate	-0.071	-0.090	-0.058
Proportion of persons not in the labour force	-0.256	-0.390	0.312
Proportion of households with three or more motor vehicles	0.095	-0.195	-0.599
Proportion of Indigenous persons	-0.281	-0.301	0.124
Proportion of owner occupiers	0.236	-0.020	-0.511
Proportion of households purchasing a dwelling	-0.127	-0.187	-0.547
Proportion of households who rent from a public authority	-0.230	-0.290	0.395
Proportion of households who rent from other sources	0.023	0.362	0.472
Proportion of households classified as having 'other tenure'	0.005	-0.063	0.140
Proportion of persons separated and divorced	-0.287	-0.122	0.392
Proportion of persons born overseas	-0.025	0.133	0.373
Proportion of persons lacking fluency in English	-0.243	-0.219	0.310
Proportion of renters paying less than \$200 per week	-0.604	-0.580	0.230
Proportion of renters paying more than \$400 per week	0.598	0.580	-0.133
Proportion of purchasers paying less \$400 per month	-0.187	-0.168	0.097
Proportion of purchasers paying more than \$1600 per month	1.000	0.646	-0.099
Proportion of persons with university qualifications	0.646	1.000	0.046
Proportion of households with no motor vehicle	-0.099	0.046	1.000

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	361937.038	25	14477.482	555.313	.000
Residual	170894.520	6555	26.071		
Total	532831.558	6580			

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-Order	Partial	Part	Tolerance	VIF
(Constant)	8.732	1.333		6.551	.000	6.119	11.345					
Overseas born (%)	.057	.010	.087	5.603	.000	.037	.077	.432	.069	.039	.204	4.899
Bus users (%)	-.834	.011	-.660	-75.274	.000	-.856	-.812	-.296	-.681	-.527	.637	1.570
Car users (%)	-.393	.009	-.551	-45.050	.000	-.410	-.376	-.426	-.486	-.315	.327	3.055
More than 3 vehicles (%)	-.166	.015	-.146	-11.287	.000	-.195	-.137	-.345	-.138	-.079	.292	3.427
Intermediate clerical workers (%)	.261	.017	.127	15.280	.000	.228	.295	.064	.185	.107	.703	1.422
Person with University qualifications (%)	.136	.015	.165	9.060	.000	.106	.165	.095	.111	.063	.147	6.797
Lacking fluency in English (%)	.340	.024	.222	14.391	.000	.294	.387	.398	.175	.101	.205	4.867
Weekly rent over \$400 (%)	-.057	.005	-.128	-12.186	.000	-.066	-.048	-.167	-.149	-.085	.443	2.259
Elementary clerical workers (%)	.189	.019	.081	9.785	.000	.152	.227	.099	.120	.068	.709	1.411
Other Tenure (%)	-.079	.026	-.026	-3.006	.003	-.131	-.028	-.030	-.037	-.021	.634	1.576
Person separated and divorced (%)	-.125	.021	-.064	-6.029	.000	-.166	-.084	.079	-.074	-.042	.439	2.278
No motor vehicles(%)	.035	.004	.100	8.278	.000	.026	.043	.345	.102	.058	.336	2.974
Owner-Occupiers (%)	.186	.014	.330	13.547	.000	.160	.213	-.213	.165	.095	.082	12.135
Flats (%)	.033	.004	.118	7.997	.000	.025	.041	.315	.098	.056	.223	4.487
Purchasers (%)	.158	.014	.217	11.436	.000	.131	.185	-.234	.140	.080	.136	7.374
One parent families (%)	.095	.018	.061	5.418	.000	.061	.130	.030	.067	.038	.381	2.622
Dwelling density (ha)	-.011	.002	-.049	-5.849	.000	-.015	-.007	.148	-.072	-.041	.693	1.443
Aged 25-34 (%)	.048	.017	.038	2.883	.004	.015	.081	.205	.036	.020	.286	3.493
Household income over \$2000 week (%)	.072	.018	.072	4.009	.000	.037	.107	-.203	.049	.028	.153	6.555
Lone person households (%)	.064	.013	.082	4.873	.000	.038	.090	.198	.060	.034	.173	5.788
Private renters (%)	.111	.015	.197	7.492	.000	.082	.140	.341	.092	.052	.071	14.168
Public renters (%)	.119	.016	.167	7.539	.000	.088	.151	.015	.093	.053	.100	10.032
Household income less than \$400 per week (%)	-.080	.016	-.085	-4.924	.000	-.112	-.048	.147	-.061	-.034	.165	6.050
Labourers (%)	.073	.020	.041	3.629	.000	.033	.112	.145	.045	.025	.386	2.591
Aged 45-64 (%)	-.047	.017	-.027	-2.834	.005	-.080	-.015	-.207	-.035	-.020	.520	1.924

Dependent Variable: train users (%)

Higher Density CDs within 800m of a rail station

Variable	R Square	Significant F Change
Travel to Work by Bus	.225	.000
Overseas Born	.115	.000
Weekly Rent is \$400 or more per week	.068	.000
Travel to Work by Car	.097	.000
Owner-Occupier	.046	.000
Household Income \$2,000 or more per week	.020	.000
Not in the Labour Force	.017	.000
Intermediate Clerical, Sales and Service Workers	.013	.000
University Qualifications	.012	.000
Person per Household	.009	.002
Aged 45-64 years	.006	.010
Elementary Clerical, Sales and Service Workers	.004	.034
Dwelling Density per Hectare	.005	.022
Total R Square	0.640	
Adjusted R Square	0.628	

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	27875.493	13	2144.269	52.583	.000
Residual	15699.763	385	40.779		
Total	43575.256	398			

Correlation matrix (cells coloured gray are not significant at p=0.05)

	Proportion of Employed Persons who use a train	Persons per Household	Proportion of couples without children	Proportion of one parent families
Proportion of Employed Persons who use a train	1.000	-0.144	0.021	0.150
Persons per Household	-0.144	1.000	0.193	-0.049
Proportion of couples without children	0.021	0.193	1.000	-0.187
Proportion of one parent families	0.150	-0.049	-0.187	1.000
Proportion of lone person households	-0.068	0.054	-0.151	-0.209
Proportion of persons aged 0-14 years	0.212	0.093	-0.248	0.618
Proportion of persons aged 15-24 years	-0.007	-0.017	0.015	-0.066
Proportion of persons aged 25-34 years	0.007	-0.135	0.405	-0.474
Proportion of persons aged 35-44 years	0.161	0.104	-0.156	-0.012
Proportion of persons aged 45-64 years	-0.292	0.073	-0.084	-0.009
Proportion of persons aged 65 years or more	-0.033	-0.071	-0.070	0.033
Proportion of households earning less than \$400 per week	0.016	-0.107	-0.476	0.571
Proportion of households earning more than \$2000 per week	-0.132	-0.088	0.578	-0.453
Proportion of Associate Professional workers	-0.159	-0.033	0.223	-0.464
Proportion of Tradespersons and Related Workers	0.119	-0.025	-0.075	0.494
Proportion of Advanced Clerical and Service Workers	-0.008	-0.140	0.277	-0.153
Proportion of Intermediate Clerical, Sales and Service workers	0.153	-0.011	-0.134	0.211
Proportion of Intermediate Production and Transport Workers	0.151	0.005	-0.267	0.576
Proportion of Elementary Clerical, Sales and Service workers	0.050	-0.037	-0.394	0.366
Proportion of Labourers and Related Workers	0.142	0.034	-0.343	0.558
Proportion of Persons not in the Labour Force	0.136	-0.101	-0.313	0.526
Proportion of Households with Three or More Vehicles	0.152	-0.063	0.167	0.228
Proportion of Indigenous Persons	-0.136	-0.044	-0.248	0.320
Proportion of Owner-occupiers	0.211	-0.123	0.338	-0.114
Proportion of Purchasers	0.123	-0.106	0.291	-0.051
Proportion of Households who Rent from State Housing Authority	-0.157	-0.073	-0.329	0.488
Proportion of Households who Rent from Other Sources	0.228	0.231	0.264	-0.250
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.027	-0.037	-0.074	-0.097
Proportion of Persons Separated or Divorced	-0.170	0.047	-0.201	0.353
Proportion of Persons Born Overseas	0.370	-0.062	-0.211	0.360
Proportion of Renters who pay less than \$200 per week	0.058	0.017	-0.473	0.569
Proportion of Renters who pay more than \$400 per month	-0.403	0.035	0.217	-0.421
Proportion of Purchasers who pay less than \$400 per month	-0.008	-0.038	-0.192	0.045
Proportion of Purchasers who pay more than \$1600 per month	-0.254	-0.085	0.314	-0.453
Proportion of Persons with University Qualifications	0.082	-0.053	0.373	-0.573
Proportion of persons at the same address five years earlier	0.129	-0.070	-0.255	0.445
Persons per Hectare	-0.158	-0.028	-0.131	-0.125
Dwellings per Hectare	-0.148	-0.106	-0.126	-0.162
Proportion of persons who travel to work by bus	-0.475	-0.084	-0.256	-0.116
Proportion of persons who travel to work by car	0.102	-0.007	0.177	0.522
Proportion of Unemployed Persons	-0.022	-0.034	-0.446	0.540

	Proportion of lone person households	Proportion of persons aged 0-14 years	Proportion of persons aged 15-24 years	Proportion of persons aged 25-34 years
Proportion of Employed Persons who use a train	-0.068	0.212	-0.007	0.007
Persons per Household	0.054	0.093	-0.017	-0.135
Proportion of couples without children	-0.151	-0.248	0.015	0.405
Proportion of one parent families	-0.209	0.618	-0.066	-0.474
Proportion of lone person households	1.000	-0.513	-0.412	-0.009
Proportion of persons aged 0-14 years	-0.513	1.000	-0.025	-0.417
Proportion of persons aged 15-24 years	-0.412	-0.025	1.000	0.246
Proportion of persons aged 25-34 years	-0.009	-0.417	0.246	1.000
Proportion of persons aged 35-44 years	-0.136	0.294	-0.219	-0.017
Proportion of persons aged 45-64 years	0.352	-0.278	-0.456	-0.389
Proportion of persons aged 65 years or more	0.490	-0.277	-0.410	-0.473
Proportion of households earning less than \$400 per week	0.283	0.271	-0.220	-0.623
Proportion of households earning more than \$2000 per week	-0.078	-0.524	0.074	0.474
Proportion of Associate Professional workers	0.074	-0.483	0.185	0.407
Proportion of Tradespersons and Related Workers	-0.169	0.531	-0.106	-0.228
Proportion of Advanced Clerical and Service Workers	0.137	-0.257	-0.105	0.145
Proportion of Intermediate Clerical, Sales and Service workers	0.101	0.092	0.123	-0.010
Proportion of Intermediate Production and Transport Workers	-0.284	0.712	-0.104	-0.390
Proportion of Elementary Clerical, Sales and Service workers	-0.033	0.321	0.082	-0.356
Proportion of Labourers and Related Workers	-0.212	0.646	-0.067	-0.456
Proportion of Persons not in the Labour Force	0.121	0.264	-0.159	-0.705
Proportion of Households with Three or More Vehicles	-0.060	0.144	-0.134	-0.149
Proportion of Indigenous Persons	0.208	0.019	-0.061	-0.221
Proportion of Owner-occupiers	-0.025	-0.081	-0.184	-0.075
Proportion of Purchasers	-0.192	0.094	0.110	0.317
Proportion of Households who Rent from State Housing Authority	0.319	0.061	-0.220	-0.475
Proportion of Households who Rent from Other Sources	-0.234	0.085	0.249	0.519
Proportion of Households who are Categorised as Having 'Other Tenure'	0.180	-0.129	-0.080	-0.173
Proportion of Persons Separated or Divorced	0.482	-0.016	-0.415	-0.356
Proportion of Persons Born Overseas	-0.441	0.580	0.158	-0.287
Proportion of Renters who pay less than \$200 per week	0.134	0.529	-0.270	-0.472
Proportion of Renters who pay more than \$400 per week	-0.182	-0.401	0.226	0.150
Proportion of Purchasers who pay less than \$400 per month	0.176	0.030	-0.085	-0.172
Proportion of Purchasers who pay more than \$1600 per month	-0.021	-0.511	0.123	0.359
Proportion of Persons with University Qualifications	0.095	-0.507	0.041	0.550
Proportion of persons at the same address five years earlier	0.373	0.192	-0.552	-0.592
Persons per Hectare	0.024	-0.133	0.144	0.012
Dwellings per Hectare	0.164	-0.225	0.022	0.052
Proportion of persons who travel to work by bus	0.245	-0.304	0.087	-0.064
Proportion of persons who travel to work by car	-0.232	0.548	-0.186	-0.204
Proportion of Unemployed Persons	-0.036	0.476	-0.072	-0.526

	Proportion of persons aged 35-44 years	Proportion of persons aged 45-64 years	Proportion of persons aged 65 years or more	Proportion of households earning less than \$400 per week
Proportion of Employed Persons who use a train	0.161	-0.292	-0.033	0.016
Persons per Household	0.104	0.073	-0.071	-0.107
Proportion of couples without children	-0.156	-0.084	-0.070	-0.476
Proportion of one parent families	-0.012	-0.009	0.033	0.571
Proportion of lone person households	-0.136	0.352	0.490	0.283
Proportion of persons aged 0-14 years	0.294	-0.278	-0.277	0.271
Proportion of persons aged 15-24 years	-0.219	-0.456	-0.410	-0.220
Proportion of persons aged 25-34 years	-0.017	-0.389	-0.473	-0.623
Proportion of persons aged 35-44 years	1.000	-0.081	-0.458	-0.203
Proportion of persons aged 45-64 years	-0.081	1.000	0.323	0.251
Proportion of persons aged 65 years or more	-0.458	0.323	1.000	0.470
Proportion of households earning less than \$400 per week	-0.203	0.251	0.470	1.000
Proportion of households earning more than \$2000 per week	-0.173	0.101	-0.070	-0.585
Proportion of Associate Professional workers	-0.003	-0.019	-0.099	-0.465
Proportion of Tradespersons and Related Workers	0.103	-0.146	-0.083	0.292
Proportion of Advanced Clerical and Service Workers	-0.106	0.028	0.141	-0.273
Proportion of Intermediate Clerical, Sales and Service workers	0.040	-0.152	-0.008	0.188
Proportion of Intermediate Production and Transport Workers	0.143	-0.116	-0.126	0.436
Proportion of Elementary Clerical, Sales and Service workers	-0.065	-0.033	0.128	0.518
Proportion of Labourers and Related Workers	0.147	-0.102	-0.060	0.521
Proportion of Persons not in the Labour Force	-0.311	0.171	0.617	0.832
Proportion of Households with Three or More Vehicles	-0.155	0.030	0.119	-0.002
Proportion of Indigenous Persons	-0.097	0.246	0.137	0.408
Proportion of Owner-occupiers	-0.005	0.034	0.204	-0.324
Proportion of Purchasers	0.187	-0.284	-0.346	-0.426
Proportion of Households who Rent from State Housing Authority	-0.295	0.398	0.425	0.832
Proportion of Households who Rent from Other Sources	0.353	-0.464	-0.563	-0.561
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.142	0.016	0.368	0.076
Proportion of Persons Separated or Divorced	-0.152	0.402	0.347	0.561
Proportion of Persons Born Overseas	0.258	-0.246	-0.222	0.297
Proportion of Renters who pay less than \$200 per week	0.097	0.124	0.088	0.683
Proportion of Renters who pay more than \$400 per week	-0.169	0.246	-0.053	-0.399
Proportion of Purchasers who pay less than \$400 per month	-0.101	0.075	0.228	0.306
Proportion of Purchasers who pay more than \$1600 per month	-0.158	0.112	-0.011	-0.493
Proportion of Persons with University Qualifications	0.107	-0.040	-0.207	-0.613
Proportion of persons at the same address five years earlier	-0.053	0.380	0.521	0.646
Persons per Hectare	-0.093	-0.002	0.038	0.042
Dwellings per Hectare	-0.093	0.054	0.109	0.067
Proportion of persons who travel to work by bus	-0.224	0.204	0.220	0.281
Proportion of persons who travel to work by car	0.031	-0.153	-0.063	0.131
Proportion of Unemployed Persons	-0.108	0.080	0.168	0.768

	Proportion of households earning more than \$2000 per week	Proportion of Associate Professional workers	Proportion of Tradespersons and Related Workers	Proportion of Advanced Clerical and Service Workers
Proportion of Employed Persons who use a train	-0.132	-0.159	0.119	-0.008
Persons per Household	-0.088	-0.033	-0.025	-0.140
Proportion of couples without children	0.578	0.223	-0.075	0.277
Proportion of one parent families	-0.453	-0.464	0.494	-0.153
Proportion of lone person households	-0.078	0.074	-0.169	0.137
Proportion of persons aged 0-14 years	-0.524	-0.483	0.531	-0.257
Proportion of persons aged 15-24 years	0.074	0.185	-0.106	-0.105
Proportion of persons aged 25-34 years	0.474	0.407	-0.228	0.145
Proportion of persons aged 35-44 years	-0.173	-0.003	0.103	-0.106
Proportion of persons aged 45-64 years	0.101	-0.019	-0.146	0.028
Proportion of persons aged 65 years or more	-0.070	-0.099	-0.083	0.141
Proportion of households earning less than \$400 per week	-0.585	-0.465	0.292	-0.273
Proportion of households earning more than \$2000 per week	1.000	0.484	-0.530	0.323
Proportion of Associate Professional workers	0.484	1.000	-0.435	0.201
Proportion of Tradespersons and Related Workers	-0.530	-0.435	1.000	-0.158
Proportion of Advanced Clerical and Service Workers	0.323	0.201	-0.158	1.000
Proportion of Intermediate Clerical, Sales and Service workers	-0.342	-0.041	0.118	-0.057
Proportion of Intermediate Production and Transport Workers	-0.601	-0.605	0.626	-0.291
Proportion of Elementary Clerical, Sales and Service workers	-0.514	-0.407	0.212	-0.281
Proportion of Labourers and Related Workers	-0.641	-0.559	0.546	-0.327
Proportion of Persons not in the Labour Force	-0.431	-0.466	0.231	-0.204
Proportion of Households with Three or More Vehicles	0.091	-0.163	0.193	0.121
Proportion of Indigenous Persons	-0.224	-0.095	0.011	-0.050
Proportion of Owner-occupiers	0.312	0.123	0.019	0.312
Proportion of Purchasers	0.143	0.102	0.210	0.200
Proportion of Households who Rent from State Housing Authority	-0.303	-0.272	0.057	-0.159
Proportion of Households who Rent from Other Sources	0.092	0.089	0.055	-0.065
Proportion of Households who are Categorised as Having 'Other Tenure'	0.024	0.054	-0.137	0.104
Proportion of Persons Separated or Divorced	-0.276	-0.220	0.217	-0.012
Proportion of Persons Born Overseas	-0.366	-0.465	0.266	-0.332
Proportion of Renters who pay less than \$200 per week	-0.692	-0.597	0.554	-0.318
Proportion of Renters who pay more than \$400 per week	0.666	0.377	-0.520	0.140
Proportion of Purchasers who pay less than \$400 per month	-0.158	-0.103	-0.020	-0.070
Proportion of Purchasers who pay more than \$1600 per month	0.734	0.498	-0.543	0.273
Proportion of Persons with University Qualifications	0.700	0.451	-0.647	0.237
Proportion of persons at the same address five years earlier	-0.378	-0.411	0.268	-0.026
Persons per Hectare	-0.024	0.072	-0.106	-0.084
Dwellings per Hectare	0.002	0.080	-0.118	-0.046
Proportion of persons who travel to work by bus	-0.015	0.047	-0.329	-0.035
Proportion of persons who travel to work by car	-0.249	-0.320	0.648	0.004
Proportion of Unemployed Persons	-0.557	-0.558	0.371	-0.387

	Proportion of Intermediate Clerical, Sales and Service workers	Proportion of Intermediate Production and Transport Workers	Proportion of Elementary Clerical, Sales and Service workers	Proportion of Labourers and Related Workers
Proportion of Employed Persons who use a train	0.153	0.151	0.050	0.142
Persons per Household	-0.011	0.005	-0.037	0.034
Proportion of couples without children	-0.134	-0.267	-0.394	-0.343
Proportion of one parent families	0.211	0.576	0.366	0.558
Proportion of lone person households	0.101	-0.284	-0.033	-0.212
Proportion of persons aged 0-14 years	0.092	0.712	0.321	0.646
Proportion of persons aged 15-24 years	0.123	-0.104	0.082	-0.067
Proportion of persons aged 25-34 years	-0.010	-0.390	-0.356	-0.456
Proportion of persons aged 35-44 years	0.040	0.143	-0.065	0.147
Proportion of persons aged 45-64 years	-0.152	-0.116	-0.033	-0.102
Proportion of persons aged 65 years or more	-0.008	-0.126	0.128	-0.060
Proportion of households earning less than \$400 per week	0.188	0.436	0.518	0.521
Proportion of households earning more than \$2000 per week	-0.342	-0.601	-0.514	-0.641
Proportion of Associate Professional workers	-0.041	-0.605	-0.407	-0.559
Proportion of Tradespersons and Related Workers	0.118	0.626	0.212	0.546
Proportion of Advanced Clerical and Service Workers	-0.057	-0.291	-0.281	-0.327
Proportion of Intermediate Clerical, Sales and Service workers	1.000	0.151	0.143	0.084
Proportion of Intermediate Production and Transport Workers	0.151	1.000	0.371	0.740
Proportion of Elementary Clerical, Sales and Service workers	0.143	0.371	1.000	0.395
Proportion of Labourers and Related Workers	0.084	0.740	0.395	1.000
Proportion of Persons not in the Labour Force	0.094	0.409	0.478	0.490
Proportion of Households with Three or More Vehicles	-0.033	0.170	-0.076	0.066
Proportion of Indigenous Persons	0.213	0.176	0.323	0.259
Proportion of Owner-occupiers	-0.150	-0.130	-0.303	-0.204
Proportion of Purchasers	0.110	0.004	-0.152	-0.156
Proportion of Households who Rent from State Housing Authority	0.189	0.204	0.390	0.281
Proportion of Households who Rent from Other Sources	-0.105	0.008	-0.198	-0.021
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.072	-0.132	-0.121	-0.081
Proportion of Persons Separated or Divorced	0.137	0.201	0.167	0.184
Proportion of Persons Born Overseas	-0.004	0.532	0.345	0.549
Proportion of Renters who pay less than \$200 per week	0.162	0.715	0.450	0.698
Proportion of Renters who pay more than \$400 per week	-0.361	-0.472	-0.315	-0.461
Proportion of Purchasers who pay less than \$400 per month	-0.031	0.051	0.176	0.072
Proportion of Purchasers who pay more than \$1600 per month	-0.227	-0.588	-0.418	-0.603
Proportion of Persons with University Qualifications	-0.247	-0.643	-0.482	-0.634
Proportion of persons at the same address five years earlier	0.147	0.374	0.253	0.376
Persons per Hectare	0.046	-0.066	0.148	0.004
Dwellings per Hectare	0.022	-0.102	0.122	-0.042
Proportion of persons who travel to work by bus	0.066	-0.178	0.284	-0.065
Proportion of persons who travel to work by car	0.049	0.525	0.013	0.388
Proportion of Unemployed Persons	0.037	0.604	0.530	0.675

	Proportion of Persons not in the Labour Force	Proportion of Households with Three or More Vehicles	Proportion of Indigenous Persons	Proportion of Owner-occupiers
Proportion of Employed Persons who use a train	0.136	0.152	-0.136	0.211
Persons per Household	-0.101	-0.063	-0.044	-0.123
Proportion of couples without children	-0.313	0.167	-0.248	0.338
Proportion of one parent families	0.526	0.228	0.320	-0.114
Proportion of lone person households	0.121	-0.060	0.208	-0.025
Proportion of persons aged 0-14 years	0.264	0.144	0.019	-0.081
Proportion of persons aged 15-24 years	-0.159	-0.134	-0.061	-0.184
Proportion of persons aged 25-34 years	-0.705	-0.149	-0.221	-0.075
Proportion of persons aged 35-44 years	-0.311	-0.155	-0.097	-0.005
Proportion of persons aged 45-64 years	0.171	0.030	0.246	0.034
Proportion of persons aged 65 years or more	0.617	0.119	0.137	0.204
Proportion of households earning less than \$400 per week	0.832	-0.002	0.408	-0.324
Proportion of households earning more than \$2000 per week	-0.431	0.091	-0.224	0.312
Proportion of Associate Professional workers	-0.466	-0.163	-0.095	0.123
Proportion of Tradespersons and Related Workers	0.231	0.193	0.011	0.019
Proportion of Advanced Clerical and Service Workers	-0.204	0.121	-0.050	0.312
Proportion of Intermediate Clerical, Sales and Service workers	0.094	-0.033	0.213	-0.150
Proportion of Intermediate Production and Transport Workers	0.409	0.170	0.176	-0.130
Proportion of Elementary Clerical, Sales and Service workers	0.478	-0.076	0.323	-0.303
Proportion of Labourers and Related Workers	0.490	0.066	0.259	-0.204
Proportion of Persons not in the Labour Force	1.000	0.162	0.325	-0.041
Proportion of Households with Three or More Vehicles	0.162	1.000	-0.090	0.441
Proportion of Indigenous Persons	0.325	-0.090	1.000	-0.291
Proportion of Owner-occupiers	-0.041	0.441	-0.291	1.000
Proportion of Purchasers	-0.388	0.183	-0.182	0.283
Proportion of Households who Rent from State Housing Authority	0.665	-0.057	0.533	-0.472
Proportion of Households who Rent from Other Sources	-0.518	-0.079	-0.384	-0.002
Proportion of Households who are Categorised as Having 'Other Tenure'	0.178	0.111	-0.053	0.124
Proportion of Persons Separated or Divorced	0.347	0.054	0.342	-0.176
Proportion of Persons Born Overseas	0.407	0.021	-0.111	-0.127
Proportion of Renters who pay less than \$200 per week	0.524	0.058	0.299	-0.345
Proportion of Renters who pay more than \$400 per week	-0.287	-0.080	-0.140	0.110
Proportion of Purchasers who pay less than \$400 per month	0.245	-0.015	0.010	-0.150
Proportion of Purchasers who pay more than \$1600 per month	-0.371	-0.002	-0.153	0.238
Proportion of Persons with University Qualifications	-0.527	-0.067	-0.304	0.197
Proportion of persons at the same address five years earlier	0.659	0.248	0.271	0.173
Persons per Hectare	0.021	-0.202	-0.021	-0.151
Dwellings per Hectare	0.026	-0.212	0.000	-0.167
Proportion of persons who travel to work by bus	0.216	-0.282	0.348	-0.373
Proportion of persons who travel to work by car	0.173	0.420	-0.036	0.293
Proportion of Unemployed Persons	0.671	0.004	0.328	-0.393

	Proportion of Purchasers	Proportion of Households who Rent from State Housing Authority	Proportion of Households who Rent from Other Sources	Proportion of Households who are Categorised as Having 'Other Tenure'
Proportion of Employed Persons who use a train	0.123	-0.157	0.228	-0.027
Persons per Household	-0.106	-0.073	0.231	-0.037
Proportion of couples without children	0.291	-0.329	0.264	-0.074
Proportion of one parent families	-0.051	0.488	-0.250	-0.097
Proportion of lone person households	-0.192	0.319	-0.234	0.180
Proportion of persons aged 0-14 years	0.094	0.061	0.085	-0.129
Proportion of persons aged 15-24 years	0.110	-0.220	0.249	-0.080
Proportion of persons aged 25-34 years	0.317	-0.475	0.519	-0.173
Proportion of persons aged 35-44 years	0.187	-0.295	0.353	-0.142
Proportion of persons aged 45-64 years	-0.284	0.398	-0.464	0.016
Proportion of persons aged 65 years or more	-0.346	0.425	-0.563	0.368
Proportion of households earning less than \$400 per week	-0.426	0.832	-0.561	0.076
Proportion of households earning more than \$2000 per week	0.143	-0.303	0.092	0.024
Proportion of Associate Professional workers	0.102	-0.272	0.089	0.054
Proportion of Tradespersons and Related Workers	0.210	0.057	0.055	-0.137
Proportion of Advanced Clerical and Service Workers	0.200	-0.159	-0.065	0.104
Proportion of Intermediate Clerical, Sales and Service workers	0.110	0.189	-0.105	-0.072
Proportion of Intermediate Production and Transport Workers	0.004	0.204	0.008	-0.132
Proportion of Elementary Clerical, Sales and Service workers	-0.152	0.390	-0.198	-0.121
Proportion of Labourers and Related Workers	-0.156	0.281	-0.021	-0.081
Proportion of Persons not in the Labour Force	-0.388	0.665	-0.518	0.178
Proportion of Households with Three or More Vehicles	0.183	-0.057	-0.079	0.111
Proportion of Indigenous Persons	-0.182	0.533	-0.384	-0.053
Proportion of Owner-occupiers	0.283	-0.472	-0.002	0.124
Proportion of Purchasers	1.000	-0.434	0.154	-0.113
Proportion of Households who Rent from State Housing Authority	-0.434	1.000	-0.727	-0.026
Proportion of Households who Rent from Other Sources	0.154	-0.727	1.000	-0.161
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.113	-0.026	-0.161	1.000
Proportion of Persons Separated or Divorced	-0.145	0.607	-0.459	0.007
Proportion of Persons Born Overseas	-0.097	0.027	0.237	-0.107
Proportion of Renters who pay less than \$200 per week	-0.166	0.488	-0.156	-0.090
Proportion of Renters who pay more than \$400 per week	-0.113	-0.183	-0.063	0.089
Proportion of Purchasers who pay less than \$400 per month	-0.189	0.241	-0.129	-0.051
Proportion of Purchasers who pay more than \$1600 per month	-0.010	-0.249	-0.023	0.076
Proportion of Persons with University Qualifications	0.082	-0.426	0.344	0.019
Proportion of persons at the same address five years earlier	-0.237	0.555	-0.486	0.093
Persons per Hectare	-0.096	0.076	-0.117	-0.043
Dwellings per Hectare	-0.118	0.127	-0.146	-0.033
Proportion of persons who travel to work by bus	-0.306	0.417	-0.340	0.018
Proportion of persons who travel to work by car	0.337	-0.014	0.007	-0.085
Proportion of Unemployed Persons	-0.360	0.603	-0.292	-0.067

	Proportion of Persons Separated or Divorced	Proportion of Persons Born Overseas	Proportion of Renters who pay less than \$200 per week	Proportion of Renters who pay more than \$400 per week
Proportion of Employed Persons who use a train	-0.170	0.370	0.058	-0.403
Persons per Household	0.047	-0.062	0.017	0.035
Proportion of couples without children	-0.201	-0.211	-0.473	0.217
Proportion of one parent families	0.353	0.360	0.569	-0.421
Proportion of lone person households	0.482	-0.441	0.134	-0.182
Proportion of persons aged 0-14 years	-0.016	0.580	0.529	-0.401
Proportion of persons aged 15-24 years	-0.415	0.158	-0.270	0.226
Proportion of persons aged 25-34 years	-0.356	-0.287	-0.472	0.150
Proportion of persons aged 35-44 years	-0.152	0.258	0.097	-0.169
Proportion of persons aged 45-64 years	0.402	-0.246	0.124	0.246
Proportion of persons aged 65 years or more	0.347	-0.222	0.088	-0.053
Proportion of households earning less than \$400 per week	0.561	0.297	0.683	-0.399
Proportion of households earning more than \$2000 per week	-0.276	-0.366	-0.692	0.666
Proportion of Associate Professional workers	-0.220	-0.465	-0.597	0.377
Proportion of Tradespersons and Related Workers	0.217	0.266	0.554	-0.520
Proportion of Advanced Clerical and Service Workers	-0.012	-0.332	-0.318	0.140
Proportion of Intermediate Clerical, Sales and Service workers	0.137	-0.004	0.162	-0.361
Proportion of Intermediate Production and Transport Workers	0.201	0.532	0.715	-0.472
Proportion of Elementary Clerical, Sales and Service workers	0.167	0.345	0.450	-0.315
Proportion of Labourers and Related Workers	0.184	0.549	0.698	-0.461
Proportion of Persons not in the Labour Force	0.347	0.407	0.524	-0.287
Proportion of Households with Three or More Vehicles	0.054	0.021	0.058	-0.080
Proportion of Indigenous Persons	0.342	-0.111	0.299	-0.140
Proportion of Owner-occupiers	-0.176	-0.127	-0.345	0.110
Proportion of Purchasers	-0.145	-0.097	-0.166	-0.113
Proportion of Households who Rent from State Housing Authority	0.607	0.027	0.488	-0.183
Proportion of Households who Rent from Other Sources	-0.459	0.237	-0.156	-0.063
Proportion of Households who are Categorised as Having 'Other Tenure'	0.007	-0.107	-0.090	0.089
Proportion of Persons Separated or Divorced	1.000	-0.240	0.420	-0.229
Proportion of Persons Born Overseas	-0.240	1.000	0.402	-0.239
Proportion of Renters who pay less than \$200 per week	0.420	0.402	1.000	-0.533
Proportion of Renters who pay more than \$400 per week	-0.229	-0.239	-0.533	1.000
Proportion of Purchasers who pay less than \$400 per month	0.145	0.091	0.230	-0.095
Proportion of Purchasers who pay more than \$1600 per month	-0.231	-0.407	-0.653	0.679
Proportion of Persons with University Qualifications	-0.405	-0.154	-0.641	0.420
Proportion of persons at the same address five years earlier	0.545	0.080	0.528	-0.456
Persons per Hectare	-0.059	0.021	-0.045	0.180
Dwellings per Hectare	0.003	-0.034	-0.026	0.122
Proportion of persons who travel to work by bus	0.139	-0.066	0.035	0.157
Proportion of persons who travel to work by car	0.164	0.136	0.341	-0.417
Proportion of Unemployed Persons	0.338	0.518	0.717	-0.297

	Proportion of Purchasers who pay less than \$400 per month	Proportion of Purchasers who pay more than \$1600 per month	Proportion of Persons with University Qualifications	Proportion of persons at the same address five years earlier
Proportion of Employed Persons who use a train	-0.008	-0.254	0.082	0.129
Persons per Household	-0.038	-0.085	-0.053	-0.070
Proportion of couples without children	-0.192	0.314	0.373	-0.255
Proportion of one parent families	0.045	-0.453	-0.573	0.445
Proportion of lone person households	0.176	-0.021	0.095	0.373
Proportion of persons aged 0-14 years	0.030	-0.511	-0.507	0.192
Proportion of persons aged 15-24 years	-0.085	0.123	0.041	-0.552
Proportion of persons aged 25-34 years	-0.172	0.359	0.550	-0.592
Proportion of persons aged 35-44 years	-0.101	-0.158	0.107	-0.053
Proportion of persons aged 45-64 years	0.075	0.112	-0.040	0.380
Proportion of persons aged 65 years or more	0.228	-0.011	-0.207	0.521
Proportion of households earning less than \$400 per week	0.306	-0.493	-0.613	0.646
Proportion of households earning more than \$2000 per week	-0.158	0.734	0.700	-0.378
Proportion of Associate Professional workers	-0.103	0.498	0.451	-0.411
Proportion of Tradespersons and Related Workers	-0.020	-0.543	-0.647	0.268
Proportion of Advanced Clerical and Service Workers	-0.070	0.273	0.237	-0.026
Proportion of Intermediate Clerical, Sales and Service workers	-0.031	-0.227	-0.247	0.147
Proportion of Intermediate Production and Transport Workers	0.051	-0.588	-0.643	0.374
Proportion of Elementary Clerical, Sales and Service workers	0.176	-0.418	-0.482	0.253
Proportion of Labourers and Related Workers	0.072	-0.603	-0.634	0.376
Proportion of Persons not in the Labour Force	0.245	-0.371	-0.527	0.659
Proportion of Households with Three or More Vehicles	-0.015	-0.002	-0.067	0.248
Proportion of Indigenous Persons	0.010	-0.153	-0.304	0.271
Proportion of Owner-occupiers	-0.150	0.238	0.197	0.173
Proportion of Purchasers	-0.189	-0.010	0.082	-0.237
Proportion of Households who Rent from State Housing Authority	0.241	-0.249	-0.426	0.555
Proportion of Households who Rent from Other Sources	-0.129	-0.023	0.344	-0.486
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.051	0.076	0.019	0.093
Proportion of Persons Separated or Divorced	0.145	-0.231	-0.405	0.545
Proportion of Persons Born Overseas	0.091	-0.407	-0.154	0.080
Proportion of Renters who pay less than \$200 per week	0.230	-0.653	-0.641	0.528
Proportion of Renters who pay more than \$400 per week	-0.095	0.679	0.420	-0.456
Proportion of Purchasers who pay less than \$400 per month	1.000	-0.140	-0.111	0.156
Proportion of Purchasers who pay more than \$1600 per month	-0.140	1.000	0.548	-0.386
Proportion of Persons with University Qualifications	-0.111	0.548	1.000	-0.402
Proportion of persons at the same address five years earlier	0.156	-0.386	-0.402	1.000
Persons per Hectare	-0.055	0.065	0.004	-0.117
Dwellings per Hectare	-0.033	0.057	0.055	-0.051
Proportion of persons who travel to work by bus	0.146	0.098	0.022	0.061
Proportion of persons who travel to work by car	-0.029	-0.349	-0.427	0.260
Proportion of Unemployed Persons	0.261	-0.511	-0.593	0.365

	Persons per Hectare	Dwellings per Hectare	Proportion of persons who travel to work by bus	Proportion of persons who travel to work by car	Proportion of Unemployed Persons
Proportion of Employed Persons who use a train	-0.158	-0.148	-0.475	0.102	-0.022
Persons per Household	-0.028	-0.106	-0.084	-0.007	-0.034
Proportion of couples without children	-0.131	-0.126	-0.256	0.177	-0.446
Proportion of one parent families	-0.125	-0.162	-0.116	0.522	0.540
Proportion of lone person households	0.024	0.164	0.245	-0.232	-0.036
Proportion of persons aged 0-14 years	-0.133	-0.225	-0.304	0.548	0.476
Proportion of persons aged 15-24 years	0.144	0.022	0.087	-0.186	-0.072
Proportion of persons aged 25-34 years	0.012	0.052	-0.064	-0.204	-0.526
Proportion of persons aged 35-44 years	-0.093	-0.093	-0.224	0.031	-0.108
Proportion of persons aged 45-64 years	-0.002	0.054	0.204	-0.153	0.080
Proportion of persons aged 65 years or more	0.038	0.109	0.220	-0.063	0.168
Proportion of households earning less than \$400 per week	0.042	0.067	0.281	0.131	0.768
Proportion of households earning more than \$2000 per week	-0.024	0.002	-0.015	-0.249	-0.557
Proportion of Associate Professional workers	0.072	0.080	0.047	-0.320	-0.558
Proportion of Tradespersons and Related Workers	-0.106	-0.118	-0.329	0.648	0.371
Proportion of Advanced Clerical and Service Workers	-0.084	-0.046	-0.035	0.004	-0.387
Proportion of Intermediate Clerical, Sales and Service workers	0.046	0.022	0.066	0.049	0.037
Proportion of Intermediate Production and Transport Workers	-0.066	-0.102	-0.178	0.525	0.604
Proportion of Elementary Clerical, Sales and Service workers	0.148	0.122	0.284	0.013	0.530
Proportion of Labourers and Related Workers	0.004	-0.042	-0.065	0.388	0.675
Proportion of Persons not in the Labour Force	0.021	0.026	0.216	0.173	0.671
Proportion of Households with Three or More Vehicles	-0.202	-0.212	-0.282	0.420	0.004
Proportion of Indigenous Persons	-0.021	0.000	0.348	-0.036	0.328
Proportion of Owner-occupiers	-0.151	-0.167	-0.373	0.293	-0.393
Proportion of Purchasers	-0.096	-0.118	-0.306	0.337	-0.360
Proportion of Households who Rent from State Housing Authority	0.076	0.127	0.417	-0.014	0.603
Proportion of Households who Rent from Other Sources	-0.117	-0.146	-0.340	0.007	-0.292
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.043	-0.033	0.018	-0.085	-0.067
Proportion of Persons Separated or Divorced	-0.059	0.003	0.139	0.164	0.338
Proportion of Persons Born Overseas	0.021	-0.034	-0.066	0.136	0.518
Proportion of Renters who pay less than \$200 per week	-0.045	-0.026	0.035	0.341	0.717
Proportion of Renters who pay more than \$400 per week	0.180	0.122	0.157	-0.417	-0.297
Proportion of Purchasers who pay less than \$400 per month	-0.055	-0.033	0.146	-0.029	0.261
Proportion of Purchasers who pay more than \$1600 per month	0.065	0.057	0.098	-0.349	-0.511
Proportion of Persons with University Qualifications	0.004	0.055	0.022	-0.427	-0.593
Proportion of persons at the same address five years earlier	-0.117	-0.051	0.061	0.260	0.365
Persons per Hectare	1.000	0.933	0.211	-0.237	0.120
Dwellings per Hectare	0.933	1.000	0.225	-0.265	0.104
Proportion of persons who travel to work by bus	0.211	0.225	1.000	-0.487	0.236
Proportion of persons who travel to work by car	-0.237	-0.265	-0.487	1.000	0.176
Proportion of Unemployed Persons	0.120	0.104	0.236	0.176	1.000

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-Order	Partial	Part	Tolerance	VIF
(Constant)	18.537	3.657		5.069	.000	11.347	25.727					
Bus users (%)	-1.027	.070	-.606	-14.684	.000	-1.164	-.889	-.475	-.599	-.449	.550	1.818
Overseas born (%)	.139	.027	.209	5.132	.000	.085	.192	.370	.253	.157	.564	1.774
Weekly rent over \$400 (%)	-.225	.025	-.434	-8.959	.000	-.274	-.176	-.403	-.415	-.274	.398	2.511
Car users (%)	-.307	.036	-.390	-8.591	.000	-.378	-.237	.102	-.401	-.263	.453	2.207
Owner occupiers (%)	.136	.042	.124	3.216	.001	.053	.219	.211	.162	.098	.632	1.582
Household income over \$2000 per week (%)	.194	.094	.126	2.070	.039	.010	.379	-.132	.105	.063	.254	3.930
Not in the labour force (%)	.244	.043	.258	5.645	.000	.159	.329	.136	.276	.173	.448	2.231
Intermediate clerical workers (%)	.281	.076	.126	3.688	.000	.131	.430	.153	.185	.113	.796	1.257
Person with university qualifications (%)	.245	.058	.240	4.212	.000	.131	.359	.082	.210	.129	.288	3.475
Person per household	-.563	.180	-.101	-3.129	.002	-.917	-.209	-.144	-.157	-.096	.902	1.109
Aged 45 to 64 years (%)	-.170	.069	-.087	-2.474	.014	-.306	-.035	-.292	-.125	-.076	.751	1.331
Elementary clerical workers (%)	.206	.088	.097	2.348	.019	.034	.378	.050	.119	.072	.547	1.830
Dwelling density (ha)	-.006	.003	-.075	-2.308	.022	-.011	-.001	-.148	-.117	-.071	.882	1.134

Dependent Variable: train users (%)

Higher Density CDs more than 800m from a rail station

Variable	R Square	Significant F Change
Travel to Work by Bus	.222	.000
Lack Fluency in English	.147	.000
Three or more Motor Vehicles	.034	.000
Same Address at Previous Census	.020	.000
Weekly Rent is under \$200 per week	.028	.000
Travel to Work by Car	.016	.001
Household Income less than \$400 per week	.016	.001
Elementary Clerical, Sales and Service Workers	.009	.011
Other Tenure	.007	.023
Purchaser	.008	.021
Total R Square	0.508	
Adjusted R Square	0.494	

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Regression	6573.215	10	657.321	36.201	.000
Residual	6373.361	351	18.158		
Total	12946.576	361			

Correlation matrix (cells coloured gray are not significant at p=0.05)

	Proportion of Employed Persons who use a train	Proportion of persons who travel to work by bus	Proportion of persons who travel to work by car	Dwellings per Hectare	Proportion of Flats
Proportion of Employed Persons who use a train	1.000	-0.471	0.057	0.002	0.026
Proportion of persons who travel to work by bus	-0.471	1.000	-0.370	0.212	0.058
Proportion of persons who travel to work by car	0.057	-0.370	1.000	-0.256	0.037
Dwellings per Hectare	0.002	0.212	-0.256	1.000	0.414
Proportion of Flats	0.026	0.058	0.037	0.414	1.000
Proportion of persons at the same address five years earlier	-0.119	0.048	-0.087	0.078	-0.074
Proportion of Purchasers	0.079	-0.082	0.426	-0.077	-0.009
Proportion of Households who Rent from State Housing Authority	-0.011	0.234	-0.251	0.235	0.098
Proportion of Households who Rent from Other Sources	0.104	-0.040	0.032	-0.075	0.048
Proportion of Households who are Categorised as Having 'Other Tenure'	0.037	0.030	0.017	-0.099	-0.033
Proportion of Persons Separated or Divorced	0.066	-0.114	0.089	0.088	0.163
Proportion of Persons Born Overseas	0.255	0.108	-0.061	0.164	0.195
Proportion of Persons Lacking Fluency in English	0.379	0.008	0.074	0.137	0.217
Proportion of Renters who pay less than \$200 per week	0.399	-0.083	-0.015	0.102	0.130
Proportion of Renters who pay more than \$400 per week	-0.122	-0.168	-0.075	-0.107	-0.157
Proportion of Purchasers who pay less than \$400 per month	-0.017	0.039	-0.018	-0.049	0.067
Proportion of Purchasers who pay more than \$1600 per month	-0.237	-0.011	-0.020	-0.089	-0.197
Proportion of Persons with University Qualifications	-0.167	0.060	-0.237	0.052	-0.141
Proportion of couples without children	-0.169	-0.136	0.194	-0.161	-0.113
Proportion of one parent families	0.201	0.035	0.236	-0.015	0.122
Proportion of lone person households	-0.087	0.088	-0.212	0.239	0.083
Proportion of persons aged 0-14 years	0.306	-0.141	0.378	-0.156	0.034
Proportion of persons aged 15-24 years	0.028	0.216	-0.054	0.007	-0.010
Proportion of persons aged 25-34 years	-0.077	0.048	-0.052	0.056	0.013
Proportion of persons aged 35-44 years	0.120	-0.125	0.141	0.045	0.170
Proportion of persons aged 45-64 years	-0.119	-0.099	-0.001	0.075	-0.051
Proportion of persons aged 65 years or more	-0.095	0.033	-0.172	-0.004	-0.057
Proportion of households earning less than \$400 per week	0.080	0.158	-0.188	0.164	0.112
Proportion of households earning more than \$2000 per week	-0.221	-0.057	-0.061	-0.136	-0.233
Proportion of Associate Professional workers	-0.183	-0.024	0.103	-0.094	-0.106
Proportion of Tradespersons and Related Workers	0.153	-0.105	0.311	0.110	0.126
Proportion of Advanced Clerical and Service Workers	-0.148	0.033	0.018	-0.011	-0.098
Proportion of Intermediate Clerical, Sales and Service workers	-0.011	0.334	-0.100	0.057	0.122
Proportion of Intermediate Production and Transport Workers	0.313	-0.099	0.229	0.032	0.207
Proportion of Elementary Clerical, Sales and Service workers	0.052	0.395	-0.151	0.131	0.117
Proportion of Persons not in the Labour Force	0.025	0.338	-0.636	0.342	0.110
Proportion of Households with No Motor Vehicle	-0.099	-0.229	0.334	-0.238	-0.240
Proportion of Households with Three or More Vehicles	0.044	0.098	-0.209	0.110	0.054
Proportion of Indigenous Persons	-0.170	-0.201	0.229	-0.210	-0.213
Proportion of Owner-occupiers	0.154	-0.032	0.144	-0.313	-0.143
Persons per Household	0.002	0.273	0.003	0.000	0.003

	Proportion of persons at the same address five years earlier	Proportion of Purchasers	Proportion of Households who Rent from State Housing Authority	Proportion of Households who Rent from Other Sources	Proportion of Households who are Categorised as Having 'Other Tenure'
Proportion of Employed Persons who use a train	-0.119	0.079	-0.011	0.104	0.037
Proportion of persons who travel to work by bus	0.048	-0.082	0.234	-0.040	0.030
Proportion of persons who travel to work by car	-0.087	0.426	-0.251	0.032	0.017
Dwellings per Hectare	0.078	-0.077	0.235	-0.075	-0.099
Proportion of Flats	-0.074	-0.009	0.098	0.048	-0.033
Proportion of persons at the same address five years earlier	1.000	-0.364	0.484	-0.599	0.138
Proportion of Purchasers	-0.364	1.000	-0.374	0.188	-0.114
Proportion of Households who Rent from State Housing Authority	0.484	-0.374	1.000	-0.692	0.005
Proportion of Households who Rent from Other Sources	-0.599	0.188	-0.692	1.000	-0.079
Proportion of Households who are Categorised as Having 'Other Tenure'	0.138	-0.114	0.005	-0.079	1.000
Proportion of Persons Separated or Divorced	0.275	-0.156	0.479	-0.275	-0.029
Proportion of Persons Born Overseas	-0.010	0.018	0.011	0.222	-0.010
Proportion of Persons Lacking Fluency in English	0.189	-0.022	0.322	-0.080	0.033
Proportion of Renters who pay less than \$200 per week	0.284	-0.216	0.593	-0.253	0.106
Proportion of Renters who pay more than \$400 per week	-0.098	-0.063	-0.202	-0.167	-0.020
Proportion of Purchasers who pay less than \$400 per month	0.177	-0.112	0.122	-0.088	0.200
Proportion of Purchasers who pay more than \$1600 per month	-0.173	0.060	-0.246	-0.052	-0.037
Proportion of Persons with University Qualifications	-0.318	0.132	-0.413	0.291	-0.109
Proportion of couples without children	-0.222	0.299	-0.383	0.101	-0.166
Proportion of one parent families	0.271	0.042	0.473	-0.237	-0.059
Proportion of lone person households	0.331	-0.305	0.352	-0.215	0.259
Proportion of persons aged 0-14 years	0.063	0.186	0.048	0.015	-0.069
Proportion of persons aged 15-24 years	-0.406	0.146	-0.163	0.364	-0.121
Proportion of persons aged 25-34 years	-0.615	0.328	-0.464	0.595	-0.204
Proportion of persons aged 35-44 years	-0.286	0.258	-0.179	0.313	-0.239
Proportion of persons aged 45-64 years	0.444	-0.238	0.335	-0.490	-0.104
Proportion of persons aged 65 years or more	0.592	-0.431	0.331	-0.570	0.436
Proportion of households earning less than \$400 per week	0.526	-0.393	0.785	-0.513	0.249
Proportion of households earning more than \$2000 per week	-0.261	0.203	-0.332	0.046	-0.075
Proportion of Associate Professional workers	-0.272	0.215	-0.368	0.216	-0.058
Proportion of Tradespersons and Related Workers	0.170	0.051	0.147	-0.005	-0.094
Proportion of Advanced Clerical and Service Workers	-0.078	0.088	-0.176	0.006	-0.101
Proportion of Intermediate Clerical, Sales and Service workers	0.059	-0.095	0.408	-0.185	0.021
Proportion of Intermediate Production and Transport Workers	0.199	-0.021	0.219	-0.013	-0.047
Proportion of Elementary Clerical, Sales and Service workers	0.216	-0.172	0.408	-0.206	0.143
Proportion of Persons not in the Labour Force	0.331	-0.539	0.616	-0.216	0.179
Proportion of Households with No Motor Vehicle	0.143	0.110	-0.092	-0.141	0.090
Proportion of Households with Three or More Vehicles	0.283	-0.260	0.658	-0.413	0.037
Proportion of Indigenous Persons	0.259	0.024	-0.451	-0.196	-0.035
Proportion of Owner-occupiers	-0.132	0.081	0.007	0.020	0.154
Persons per Household	0.006	0.062	0.45	0.352	0.002

	Proportion of Persons Separated or Divorced	Proportion of Persons Born Overseas	Proportion of Persons Lacking Fluency in English	Proportion of Renters who pay less than \$200 per week	Proportion of Renters who pay more than \$400 per week
Proportion of Employed Persons who use a train	0.066	0.255	0.379	0.399	-0.122
Proportion of persons who travel to work by bus	-0.114	0.108	0.008	-0.083	-0.168
Proportion of persons who travel to work by car	0.089	-0.061	0.074	-0.015	-0.075
Dwellings per Hectare	0.088	0.164	0.137	0.102	-0.107
Proportion of Flats	0.163	0.195	0.217	0.130	-0.157
Proportion of persons at the same address five years earlier	0.275	-0.010	0.189	0.284	-0.098
Proportion of Purchasers	-0.156	0.018	-0.022	-0.216	-0.063
Proportion of Households who Rent from State Housing Authority	0.479	0.011	0.322	0.593	-0.202
Proportion of Households who Rent from Other Sources	-0.275	0.222	-0.080	-0.253	-0.167
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.029	-0.010	0.033	0.106	-0.020
Proportion of Persons Separated or Divorced	1.000	-0.210	0.106	0.417	-0.274
Proportion of Persons Born Overseas	-0.210	1.000	0.711	0.221	-0.233
Proportion of Persons Lacking Fluency in English	0.106	0.711	1.000	0.617	-0.411
Proportion of Renters who pay less than \$200 per week	0.417	0.221	0.617	1.000	-0.455
Proportion of Renters who pay more than \$400 per week	-0.274	-0.233	-0.411	-0.455	1.000
Proportion of Purchasers who pay less than \$400 per month	0.077	-0.076	0.030	0.197	-0.143
Proportion of Purchasers who pay more than \$1600 per month	-0.242	-0.333	-0.519	-0.578	0.621
Proportion of Persons with University Qualifications	-0.421	-0.096	-0.477	-0.633	0.552
Proportion of couples without children	-0.197	-0.313	-0.427	-0.589	0.526
Proportion of one parent families	0.358	0.316	0.520	0.530	-0.432
Proportion of lone person households	0.429	-0.353	-0.148	0.335	-0.171
Proportion of persons aged 0-14 years	0.037	0.487	0.601	0.360	-0.324
Proportion of persons aged 15-24 years	-0.335	0.387	0.094	-0.104	-0.223
Proportion of persons aged 25-34 years	-0.260	-0.179	-0.411	-0.489	0.115
Proportion of persons aged 35-44 years	0.031	0.103	0.105	0.011	-0.056
Proportion of persons aged 45-64 years	0.336	-0.193	-0.030	0.066	0.243
Proportion of persons aged 65 years or more	0.161	-0.249	-0.037	0.229	0.107
Proportion of households earning less than \$400 per week	0.424	0.178	0.493	0.738	-0.433
Proportion of households earning more than \$2000 per week	-0.326	-0.341	-0.566	-0.661	0.770
Proportion of Associate Professional workers	-0.100	-0.287	-0.466	-0.467	0.316
Proportion of Tradespersons and Related Workers	0.247	0.196	0.443	0.353	-0.445
Proportion of Advanced Clerical and Service Workers	-0.080	-0.308	-0.350	-0.271	0.141
Proportion of Intermediate Clerical, Sales and Service workers	0.236	-0.032	0.122	0.331	-0.373
Proportion of Intermediate Production and Transport Workers	0.230	0.445	0.652	0.549	-0.489
Proportion of Elementary Clerical, Sales and Service workers	0.129	0.247	0.416	0.389	-0.341
Proportion of Persons not in the Labour Force	0.197	0.243	0.322	0.508	-0.354
Proportion of Households with No Motor Vehicle	-0.073	-0.129	-0.074	-0.172	0.269
Proportion of Households with Three or More Vehicles	0.380	-0.112	0.127	0.452	-0.193
Proportion of Indigenous Persons	-0.277	-0.181	-0.304	-0.476	0.460
Proportion of Owner-occupiers	-0.239	0.267	0.276	0.134	-0.103
Persons per Household	0.000	0.000	0.000	0.005	0.025

	Proportion of Persons Separated or Divorced	Proportion of Persons Born Overseas	Proportion of Persons Lacking Fluency in English	Proportion of Renters who pay less than \$200 per week	Proportion of Renters who pay more than \$400 per week
Proportion of Employed Persons who use a train	0.066	0.255	0.379	0.399	-0.122
Proportion of persons who travel to work by bus	-0.114	0.108	0.008	-0.083	-0.168
Proportion of persons who travel to work by car	0.089	-0.061	0.074	-0.015	-0.075
Dwellings per Hectare	0.088	0.164	0.137	0.102	-0.107
Proportion of Flats	0.163	0.195	0.217	0.130	-0.157
Proportion of persons at the same address five years earlier	0.275	-0.010	0.189	0.284	-0.098
Proportion of Purchasers	-0.156	0.018	-0.022	-0.216	-0.063
Proportion of Households who Rent from State Housing Authority	0.479	0.011	0.322	0.593	-0.202
Proportion of Households who Rent from Other Sources	-0.275	0.222	-0.080	-0.253	-0.167
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.029	-0.010	0.033	0.106	-0.020
Proportion of Persons Separated or Divorced	1.000	-0.210	0.106	0.417	-0.274
Proportion of Persons Born Overseas	-0.210	1.000	0.711	0.221	-0.233
Proportion of Persons Lacking Fluency in English	0.106	0.711	1.000	0.617	-0.411
Proportion of Renters who pay less than \$200 per week	0.417	0.221	0.617	1.000	-0.455
Proportion of Renters who pay more than \$400 per week	-0.274	-0.233	-0.411	-0.455	1.000
Proportion of Purchasers who pay less than \$400 per month	0.077	-0.076	0.030	0.197	-0.143
Proportion of Purchasers who pay more than \$1600 per month	-0.242	-0.333	-0.519	-0.578	0.621
Proportion of Persons with University Qualifications	-0.421	-0.096	-0.477	-0.633	0.552
Proportion of couples without children	-0.197	-0.313	-0.427	-0.589	0.526
Proportion of one parent families	0.358	0.316	0.520	0.530	-0.432
Proportion of lone person households	0.429	-0.353	-0.148	0.335	-0.171
Proportion of persons aged 0-14 years	0.037	0.487	0.601	0.360	-0.324
Proportion of persons aged 15-24 years	-0.335	0.387	0.094	-0.104	-0.223
Proportion of persons aged 25-34 years	-0.260	-0.179	-0.411	-0.489	0.115
Proportion of persons aged 35-44 years	0.031	0.103	0.105	0.011	-0.056
Proportion of persons aged 45-64 years	0.336	-0.193	-0.030	0.066	0.243
Proportion of persons aged 65 years or more	0.161	-0.249	-0.037	0.229	0.107
Proportion of households earning less than \$400 per week	0.424	0.178	0.493	0.738	-0.433
Proportion of households earning more than \$2000 per week	-0.326	-0.341	-0.566	-0.661	0.770
Proportion of Associate Professional workers	-0.100	-0.287	-0.466	-0.467	0.316
Proportion of Tradespersons and Related Workers	0.247	0.196	0.443	0.353	-0.445
Proportion of Advanced Clerical and Service Workers	-0.080	-0.308	-0.350	-0.271	0.141
Proportion of Intermediate Clerical, Sales and Service workers	0.236	-0.032	0.122	0.331	-0.373
Proportion of Intermediate Production and Transport Workers	0.230	0.445	0.652	0.549	-0.489
Proportion of Elementary Clerical, Sales and Service workers	0.129	0.247	0.416	0.389	-0.341
Proportion of Persons not in the Labour Force	0.197	0.243	0.322	0.508	-0.354
Proportion of Households with No Motor Vehicle	-0.073	-0.129	-0.074	-0.172	0.269
Proportion of Households with Three or More Vehicles	0.380	-0.112	0.127	0.452	-0.193
Proportion of Indigenous Persons	-0.277	-0.181	-0.304	-0.476	0.460
Proportion of Owner-occupiers	-0.239	0.267	0.276	0.134	-0.103
Persons per Household	0.000	0.000	0.000	0.005	0.025

	Proportion of Purchasers who pay less than \$400 per month	Proportion of Purchasers who pay more than \$1600 per month	Proportion of Persons with University Qualifications	Proportion of couples without children	Proportion of one parent families
Proportion of Employed Persons who use a train	-0.017	-0.237	-0.167	-0.169	0.201
Proportion of persons who travel to work by bus	0.039	-0.011	0.060	-0.136	0.035
Proportion of persons who travel to work by car	-0.018	-0.020	-0.237	0.194	0.236
Dwellings per Hectare	-0.049	-0.089	0.052	-0.161	-0.015
Proportion of Flats	0.067	-0.197	-0.141	-0.113	0.122
Proportion of persons at the same address five years earlier	0.177	-0.173	-0.318	-0.222	0.271
Proportion of Purchasers	-0.112	0.060	0.132	0.299	0.042
Proportion of Households who Rent from State Housing Authority	0.122	-0.246	-0.413	-0.383	0.473
Proportion of Households who Rent from Other Sources	-0.088	-0.052	0.291	0.101	-0.237
Proportion of Households who are Categorised as Having 'Other Tenure'	0.200	-0.037	-0.109	-0.166	-0.059
Proportion of Persons Separated or Divorced	0.077	-0.242	-0.421	-0.197	0.358
Proportion of Persons Born Overseas	-0.076	-0.333	-0.096	-0.313	0.316
Proportion of Persons Lacking Fluency in English	0.030	-0.519	-0.477	-0.427	0.520
Proportion of Renters who pay less than \$200 per week	0.197	-0.578	-0.633	-0.589	0.530
Proportion of Renters who pay more than \$400 per week	-0.143	0.621	0.552	0.526	-0.432
Proportion of Purchasers who pay less than \$400 per month	1.000	-0.118	-0.200	-0.175	0.091
Proportion of Purchasers who pay more than \$1600 per month	-0.118	1.000	0.511	0.498	-0.399
Proportion of Persons with University Qualifications	-0.200	0.511	1.000	0.523	-0.596
Proportion of couples without children	-0.175	0.498	0.523	1.000	-0.380
Proportion of one parent families	0.091	-0.399	-0.596	-0.380	1.000
Proportion of lone person households	0.226	-0.116	-0.130	-0.235	-0.136
Proportion of persons aged 0-14 years	-0.035	-0.353	-0.427	-0.348	0.605
Proportion of persons aged 15-24 years	-0.064	-0.107	0.015	-0.164	0.049
Proportion of persons aged 25-34 years	-0.193	0.254	0.564	0.407	-0.390
Proportion of persons aged 35-44 years	-0.172	-0.085	0.117	-0.011	0.074
Proportion of persons aged 45-64 years	0.035	0.151	-0.120	0.049	0.091
Proportion of persons aged 65 years or more	0.241	-0.008	-0.270	-0.110	-0.096
Proportion of households earning less than \$400 per week	0.260	-0.463	-0.622	-0.565	0.465
Proportion of households earning more than \$2000 per week	-0.166	0.675	0.756	0.700	-0.505
Proportion of Associate Professional workers	-0.063	0.383	0.408	0.368	-0.363
Proportion of Tradespersons and Related Workers	-0.014	-0.404	-0.523	-0.209	0.353
Proportion of Advanced Clerical and Service Workers	-0.039	0.252	0.188	0.261	-0.209
Proportion of Intermediate Clerical, Sales and Service workers	0.066	-0.360	-0.410	-0.311	0.325
Proportion of Intermediate Production and Transport Workers	0.017	-0.540	-0.637	-0.444	0.566
Proportion of Elementary Clerical, Sales and Service workers	0.030	-0.368	-0.400	-0.373	0.362
Proportion of Persons not in the Labour Force	0.172	-0.354	-0.299	-0.588	0.185
Proportion of Households with No Motor Vehicle	-0.072	0.205	0.033	0.248	-0.001
Proportion of Households with Three or More Vehicles	0.162	-0.253	-0.360	-0.314	0.297
Proportion of Indigenous Persons	-0.070	0.339	0.241	0.447	-0.303
Proportion of Owner-occupiers	-0.031	-0.198	-0.259	-0.146	0.285
Persons per Household	0.278	0.000	0.000	0.003	0.000

	Proportion of lone person households	Proportion of persons aged 0-14 years	Proportion of persons aged 15-24 years	Proportion of persons aged 25-34 years	Proportion of persons aged 35-44 years
Proportion of Employed Persons who use a train	-0.087	0.306	0.028	-0.077	0.120
Proportion of persons who travel to work by bus	0.088	-0.141	0.216	0.048	-0.125
Proportion of persons who travel to work by car	-0.212	0.378	-0.054	-0.052	0.141
Dwellings per Hectare	0.239	-0.156	0.007	0.056	0.045
Proportion of Flats	0.083	0.034	-0.010	0.013	0.170
Proportion of persons at the same address five years earlier	0.331	0.063	-0.406	-0.615	-0.286
Proportion of Purchasers	-0.305	0.186	0.146	0.328	0.258
Proportion of Households who Rent from State Housing Authority	0.352	0.048	-0.163	-0.464	-0.179
Proportion of Households who Rent from Other Sources	-0.215	0.015	0.364	0.595	0.313
Proportion of Households who are Categorised as Having 'Other Tenure'	0.259	-0.069	-0.121	-0.204	-0.239
Proportion of Persons Separated or Divorced	0.429	0.037	-0.335	-0.260	0.031
Proportion of Persons Born Overseas	-0.353	0.487	0.387	-0.179	0.103
Proportion of Persons Lacking Fluency in English	-0.148	0.601	0.094	-0.411	0.105
Proportion of Renters who pay less than \$200 per week	0.335	0.360	-0.104	-0.489	0.011
Proportion of Renters who pay more than \$400 per week	-0.171	-0.324	-0.223	0.115	-0.056
Proportion of Purchasers who pay less than \$400 per month	0.226	-0.035	-0.064	-0.193	-0.172
Proportion of Purchasers who pay more than \$1600 per month	-0.116	-0.353	-0.107	0.254	-0.085
Proportion of Persons with University Qualifications	-0.130	-0.427	0.015	0.564	0.117
Proportion of couples without children	-0.235	-0.348	-0.164	0.407	-0.011
Proportion of one parent families	-0.136	0.605	0.049	-0.390	0.074
Proportion of lone person households	1.000	-0.460	-0.359	-0.173	-0.181
Proportion of persons aged 0-14 years	-0.460	1.000	0.073	-0.312	0.267
Proportion of persons aged 15-24 years	-0.359	0.073	1.000	0.113	-0.084
Proportion of persons aged 25-34 years	-0.173	-0.312	0.113	1.000	0.246
Proportion of persons aged 35-44 years	-0.181	0.267	-0.084	0.246	1.000
Proportion of persons aged 45-64 years	0.234	-0.124	-0.401	-0.414	-0.073
Proportion of persons aged 65 years or more	0.548	-0.281	-0.451	-0.593	-0.544
Proportion of households earning less than \$400 per week	0.473	0.121	-0.078	-0.649	-0.291
Proportion of households earning more than \$2000 per week	-0.225	-0.412	-0.184	0.480	0.000
Proportion of Associate Professional workers	-0.023	-0.283	-0.036	0.377	0.052
Proportion of Tradespersons and Related Workers	-0.055	0.322	0.047	-0.157	-0.006
Proportion of Advanced Clerical and Service Workers	0.044	-0.183	-0.061	0.170	-0.025
Proportion of Intermediate Clerical, Sales and Service workers	0.151	0.067	0.127	-0.183	-0.035
Proportion of Intermediate Production and Transport Workers	-0.098	0.581	0.081	-0.380	0.076
Proportion of Elementary Clerical, Sales and Service workers	0.048	0.203	0.102	-0.369	-0.119
Proportion of Persons not in the Labour Force	0.444	-0.104	0.099	-0.321	-0.225
Proportion of Households with No Motor Vehicle	-0.184	0.076	-0.088	-0.127	-0.070
Proportion of Households with Three or More Vehicles	0.279	-0.020	-0.074	-0.292	-0.129
Proportion of Indigenous Persons	-0.108	-0.133	-0.231	-0.153	-0.192
Proportion of Owner-occupiers	-0.382	0.335	0.190	-0.148	0.086
Persons per Household	0.000	0.000	0.000	0.002	0.051

	Proportion of persons aged 45-64 years	Proportion of persons aged 65 years or more	Proportion of households earning less than \$400 per week	Proportion of households earning more than \$2000 per week	Proportion of Associate Professional workers
Proportion of Employed Persons who use a train	-0.119	-0.095	0.080	-0.221	-0.183
Proportion of persons who travel to work by bus	-0.099	0.033	0.158	-0.057	-0.024
Proportion of persons who travel to work by car	-0.001	-0.172	-0.188	-0.061	0.103
Dwellings per Hectare	0.075	-0.004	0.164	-0.136	-0.094
Proportion of Flats	-0.051	-0.057	0.112	-0.233	-0.106
Proportion of persons at the same address five years earlier	0.444	0.592	0.526	-0.261	-0.272
Proportion of Purchasers	-0.238	-0.431	-0.393	0.203	0.215
Proportion of Households who Rent from State Housing Authority	0.335	0.331	0.785	-0.332	-0.368
Proportion of Households who Rent from Other Sources	-0.490	-0.570	-0.513	0.046	0.216
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.104	0.436	0.249	-0.075	-0.058
Proportion of Persons Separated or Divorced	0.336	0.161	0.424	-0.326	-0.100
Proportion of Persons Born Overseas	-0.193	-0.249	0.178	-0.341	-0.287
Proportion of Persons Lacking Fluency in English	-0.030	-0.037	0.493	-0.566	-0.466
Proportion of Renters who pay less than \$200 per week	0.066	0.229	0.738	-0.661	-0.467
Proportion of Renters who pay more than \$400 per week	0.243	0.107	-0.433	0.770	0.316
Proportion of Purchasers who pay less than \$400 per month	0.035	0.241	0.260	-0.166	-0.063
Proportion of Purchasers who pay more than \$1600 per month	0.151	-0.008	-0.463	0.675	0.383
Proportion of Persons with University Qualifications	-0.120	-0.270	-0.622	0.756	0.408
Proportion of couples without children	0.049	-0.110	-0.565	0.700	0.368
Proportion of one parent families	0.091	-0.096	0.465	-0.505	-0.363
Proportion of lone person households	0.234	0.548	0.473	-0.225	-0.023
Proportion of persons aged 0-14 years	-0.124	-0.281	0.121	-0.412	-0.283
Proportion of persons aged 15-24 years	-0.401	-0.451	-0.078	-0.184	-0.036
Proportion of persons aged 25-34 years	-0.414	-0.593	-0.649	0.480	0.377
Proportion of persons aged 35-44 years	-0.073	-0.544	-0.291	0.000	0.052
Proportion of persons aged 45-64 years	1.000	0.276	0.170	0.061	-0.059
Proportion of persons aged 65 years or more	0.276	1.000	0.515	-0.116	-0.160
Proportion of households earning less than \$400 per week	0.170	0.515	1.000	-0.621	-0.497
Proportion of households earning more than \$2000 per week	0.061	-0.116	-0.621	1.000	0.451
Proportion of Associate Professional workers	-0.059	-0.160	-0.497	0.451	1.000
Proportion of Tradespersons and Related Workers	-0.115	-0.038	0.273	-0.466	-0.220
Proportion of Advanced Clerical and Service Workers	-0.016	0.012	-0.236	0.239	0.208
Proportion of Intermediate Clerical, Sales and Service workers	-0.031	0.083	0.385	-0.403	-0.292
Proportion of Intermediate Production and Transport Workers	-0.023	-0.050	0.425	-0.644	-0.444
Proportion of Elementary Clerical, Sales and Service workers	-0.042	0.226	0.461	-0.423	-0.341
Proportion of Persons not in the Labour Force	0.026	0.321	0.724	-0.492	-0.413
Proportion of Households with No Motor Vehicle	0.220	0.033	-0.112	0.262	0.028
Proportion of Households with Three or More Vehicles	0.229	0.199	0.542	-0.283	-0.251
Proportion of Indigenous Persons	0.233	0.297	-0.349	0.374	0.186
Proportion of Owner-occupiers	-0.111	-0.125	0.071	-0.161	-0.216
Persons per Household	0.017	0.008	0.09	0.001	0.000

	Proportion of Tradespersons and Related Workers	Proportion of Advanced Clerical and Service Workers	Proportion of Intermediate Clerical, Sales and Service workers	Proportion of Intermediate Production and Transport Workers	Proportion of Elementary Clerical, Sales and Service workers
Proportion of Employed Persons who use a train	0.153	-0.148	-0.011	0.313	0.052
Proportion of persons who travel to work by bus	-0.105	0.033	0.334	-0.099	0.395
Proportion of persons who travel to work by car	0.311	0.018	-0.100	0.229	-0.151
Dwellings per Hectare	0.110	-0.011	0.057	0.032	0.131
Proportion of Flats	0.126	-0.098	0.122	0.207	0.117
Proportion of persons at the same address five years earlier	0.170	-0.078	0.059	0.199	0.216
Proportion of Purchasers	0.051	0.088	-0.095	-0.021	-0.172
Proportion of Households who Rent from State Housing Authority	0.147	-0.176	0.408	0.219	0.408
Proportion of Households who Rent from Other Sources	-0.005	0.006	-0.185	-0.013	-0.206
Proportion of Households who are Categorised as Having 'Other Tenure'	-0.094	-0.101	0.021	-0.047	0.143
Proportion of Persons Separated or Divorced	0.247	-0.080	0.236	0.230	0.129
Proportion of Persons Born Overseas	0.196	-0.308	-0.032	0.445	0.247
Proportion of Persons Lacking Fluency in English	0.443	-0.350	0.122	0.652	0.416
Proportion of Renters who pay less than \$200 per week	0.353	-0.271	0.331	0.549	0.389
Proportion of Renters who pay more than \$400 per week	-0.445	0.141	-0.373	-0.489	-0.341
Proportion of Purchasers who pay less than \$400 per month	-0.014	-0.039	0.066	0.017	0.030
Proportion of Purchasers who pay more than \$1600 per month	-0.404	0.252	-0.360	-0.540	-0.368
Proportion of Persons with University Qualifications	-0.523	0.188	-0.410	-0.637	-0.400
Proportion of couples without children	-0.209	0.261	-0.311	-0.444	-0.373
Proportion of one parent families	0.353	-0.209	0.325	0.566	0.362
Proportion of lone person households	-0.055	0.044	0.151	-0.098	0.048
Proportion of persons aged 0-14 years	0.322	-0.183	0.067	0.581	0.203
Proportion of persons aged 15-24 years	0.047	-0.061	0.127	0.081	0.102
Proportion of persons aged 25-34 years	-0.157	0.170	-0.183	-0.380	-0.369
Proportion of persons aged 35-44 years	-0.006	-0.025	-0.035	0.076	-0.119
Proportion of persons aged 45-64 years	-0.115	-0.016	-0.031	-0.023	-0.042
Proportion of persons aged 65 years or more	-0.038	0.012	0.083	-0.050	0.226
Proportion of households earning less than \$400 per week	0.273	-0.236	0.385	0.425	0.461
Proportion of households earning more than \$2000 per week	-0.466	0.239	-0.403	-0.644	-0.423
Proportion of Associate Professional workers	-0.220	0.208	-0.292	-0.444	-0.341
Proportion of Tradespersons and Related Workers	1.000	-0.159	0.062	0.406	0.284
Proportion of Advanced Clerical and Service Workers	-0.159	1.000	-0.125	-0.311	-0.259
Proportion of Intermediate Clerical, Sales and Service workers	0.062	-0.125	1.000	0.153	0.595
Proportion of Intermediate Production and Transport Workers	0.406	-0.311	0.153	1.000	0.239
Proportion of Elementary Clerical, Sales and Service workers	0.284	-0.259	0.595	0.239	1.000
Proportion of Persons not in the Labour Force	0.128	-0.208	0.304	0.199	0.408
Proportion of Households with No Motor Vehicle	-0.015	0.010	-0.132	-0.042	-0.099
Proportion of Households with Three or More Vehicles	0.071	-0.180	0.402	0.208	0.283
Proportion of Indigenous Persons	-0.149	0.268	-0.330	-0.211	-0.279
Proportion of Owner-occupiers	0.070	-0.204	0.162	0.248	0.209
Persons per Household	0.093	0.000	0.001	0.000	0.000

	Proportion of Persons not in the Labour Force	Proportion of Households with No Motor Vehicle	Proportion of Households with Three or More Vehicles	Proportion of Indigenous Persons	Proportion of Owner- occupiers	Persons per Household
Proportion of Employed Persons who use a train	0.057	0.025	-0.099	0.044	-0.170	0.154
Proportion of persons who travel to work by bus	0.138	0.338	-0.229	0.098	-0.201	-0.032
Proportion of persons who travel to work by car	-0.184	-0.636	0.334	-0.209	0.229	0.144
Dwellings per Hectare	0.059	0.342	-0.238	0.110	-0.210	-0.313
Proportion of Flats	0.024	0.110	-0.240	0.054	-0.213	-0.143
Proportion of persons at the same address five years earlier	0.530	0.331	0.143	0.283	0.259	-0.132
Proportion of Purchasers	-0.453	-0.539	0.110	-0.260	0.024	0.081
Proportion of Households who Rent from State Housing Authority	0.653	0.616	-0.092	0.658	-0.451	0.007
Proportion of Households who Rent from Other Sources	-0.594	-0.216	-0.141	-0.413	-0.196	0.020
Proportion of Households who are Categorised as Having 'Other Tenure'	0.315	0.179	0.090	0.037	-0.035	0.154
Proportion of Persons Separated or Divorced	0.221	0.197	-0.073	0.380	-0.277	-0.239
Proportion of Persons Born Overseas	0.193	0.243	-0.129	-0.112	-0.181	0.267
Proportion of Persons Lacking Fluency in English	0.411	0.322	-0.074	0.127	-0.304	0.276
Proportion of Renters who pay less than \$200 per week	0.575	0.508	-0.172	0.452	-0.476	0.134
Proportion of Renters who pay more than \$400 per week	-0.165	-0.354	0.269	-0.193	0.460	-0.103
Proportion of Purchasers who pay less than \$400 per month	0.191	0.172	-0.072	0.162	-0.070	-0.031
Proportion of Purchasers who pay more than \$1600 per month	-0.320	-0.354	0.205	-0.253	0.339	-0.198
Proportion of Persons with University Qualifications	-0.506	-0.299	0.033	-0.360	0.241	-0.259
Proportion of couples without children	-0.408	-0.588	0.248	-0.314	0.447	-0.146
Proportion of one parent families	0.287	0.185	-0.001	0.297	-0.303	0.285
Proportion of lone person households	0.375	0.444	-0.184	0.279	-0.108	-0.382
Proportion of persons aged 0-14 years	0.012	-0.104	0.076	-0.020	-0.133	0.335
Proportion of persons aged 15-24 years	-0.079	0.099	-0.088	-0.074	-0.231	0.190
Proportion of persons aged 25-34 years	-0.734	-0.321	-0.127	-0.292	-0.153	-0.148
Proportion of persons aged 35-44 years	-0.445	-0.225	-0.070	-0.129	-0.192	0.086
Proportion of persons aged 45-64 years	0.206	0.026	0.220	0.229	0.233	-0.111
Proportion of persons aged 65 years or more	0.689	0.321	0.033	0.199	0.297	-0.125
Proportion of households earning less than \$400 per week	0.834	0.724	-0.112	0.542	-0.349	0.071
Proportion of households earning more than \$2000 per week	-0.457	-0.492	0.262	-0.283	0.374	-0.161
Proportion of Associate Professional workers	-0.435	-0.413	0.028	-0.251	0.186	-0.216
Proportion of Tradespersons and Related Workers	0.149	0.128	-0.015	0.071	-0.149	0.070
Proportion of Advanced Clerical and Service Workers	-0.213	-0.208	0.010	-0.180	0.268	-0.204
Proportion of Intermediate Clerical, Sales and Service workers	0.323	0.304	-0.132	0.402	-0.330	0.162
Proportion of Intermediate Production and Transport Workers	0.325	0.199	-0.042	0.208	-0.211	0.248
Proportion of Elementary Clerical, Sales and Service workers	0.450	0.408	-0.099	0.283	-0.279	0.209
Proportion of Persons not in the Labour Force	1.000	0.590	-0.023	0.463	-0.033	0.252
Proportion of Households with No Motor Vehicle	0.590	1.000	-0.332	0.454	-0.451	-0.034
Proportion of Households with Three or More Vehicles	-0.023	-0.332	1.000	-0.061	0.336	0.180
Proportion of Indigenous Persons	0.463	0.454	-0.061	1.000	-0.351	0.113
Proportion of Owner-occupiers	-0.033	-0.451	0.336	-0.351	1.000	-0.067
Persons per Household	0.252	-0.034	0.180	0.113	-0.067	1.000

Coefficients

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-Order	Partial	Part	Tolerance	VIF
(Constant)	12.656	1.435		8.819	.000	9.834	15.479					
Bus users (%)	-.287	.025	-.538	-11.398	.000	-.337	-.237	-.471	-.520	-.427	.630	1.588
Lacking fluency in English (%)	.283	.053	.269	5.349	.000	.179	.387	.379	.275	.200	.553	1.808
More than 3 motor vehicles (%)	-.275	.131	-.089	-2.090	.037	-.533	-.016	-.099	-.111	-.078	.777	1.287
Person at same address 5 years before (%)	-.064	.026	-.115	-2.452	.015	-.115	-.013	-.119	-.130	-.092	.633	1.580
Weekly rent under \$200 (%)	.084	.016	.362	5.366	.000	.053	.115	.399	.275	.201	.308	3.247
Car users (%)	-.114	.025	-.215	-4.594	.000	-.163	-.065	.057	-.238	-.172	.639	1.566
Household income less than \$400 per week (%)	-.131	.036	-.263	-3.650	.000	-.201	-.060	.080	-.191	-.137	.271	3.690
Elementary clerical workers (%)	.107	.042	.121	2.522	.012	.023	.190	.052	.133	.094	.606	1.649
Other tenure (%)	.226	.095	.094	2.375	.018	.039	.412	.037	.126	.089	.898	1.114
Purchasers (%)	.109	.047	.107	2.316	.021	.016	.202	.079	.123	.087	.655	1.528

Dependent Variable: train users (%)

APPENDIX 10: LIST OF CENSUS COLLECTOR DISTRICTS IN THE CASE STUDY AREAS

Cronulla

1312103	1312201
1312105	1312202
1312106	1312203
1312107	1312204
1312109	1312210
1312111	1312211

Edgecliff

1440307
1440308
1440410
1440503
1440504
1440507

Fairfield/Cabramatta

1320710
1320711
1320803
1320804
1321310

Liverpool

1290701
1290706
1290707
1290709
1290712
1290713
1290714

St Leonards/Wollstonecraft

1382808
1382813
1390305
1390308
1390313