

# **Sustainable Australia: Containing Travel in Master Planned Estates**

**Tan Yigitcanlar, Jago Dodson, Brendan Gleeson and  
Neil Sipe**



**Urban Research Program**

**Research Monograph 9  
September 2005**

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ISBN 1 920952 46 2

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Brisbane, QLD 4111  
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Dr Stephen Horton provided editorial assistance with this Research Monograph.

**The Urban Research Program acknowledges the generous support provided by the *Brisbane City Council* for production of the Program's Issues and Research Papers and Research Monographs.**

## Executive summary

Low density suburban development and excessive use of automobiles are associated with serious urban and environmental problems. These problems include traffic congestion, longer commuting times, high automobile dependency, air and water pollution, and increased depletion of natural resources. Master planned development suggests itself as a possible palliative for the ills of low density and high travel. The following study examines the patterns and dynamics of movement in a selection of master planned estates in Australia.

The study develops new approaches for assessing the containment of travel within planned development. Its key aim is to clarify and map the relationships between trip generation and urban form and structure.

The initial conceptual framework of the report is developed in a review of literature related to urban form and travel behaviour. These concepts are tested empirically in a pilot study of suburban travel activity in master planned estates. A geographical information systems (GIS) methodology is used to determine regional journey-to-work patterns and travel containment rates. Factors that influence self-containment patterns are estimated with a regression model.

The key research findings of the pilot study are:

- There is a strong relation between urban structural form and patterns of trip generation;
- The travel self-containment of Australian master planned estates is lower than the scholarly literature implies would occur if appropriate planning principles to achieve sustainable urban travel were followed;
- Proximity to the central business district, income level and education status are positively correlated with travel containment;
- Master planned estates depend more on local and regional centres for employment than on the central business district;
- The service sector is the major employer in and around master planned estates. It tends to provide part-time and casual employment rather than full-time employment;
- Travel self-containment is negative correlated with car dependency. Master planned estates with less car dependent residents, and with good access to public transport, appear to be more self-contained and, consequently, more sustainable than the norm.

This research is a useful preliminary examination of travel self-containment in Australian master planned estates. It by no means exhausts the subject. In future research we hope to further assess sustainable travel patterns with more detailed spatial analysis.

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## List of abbreviations

CBD	Central Business District
CD	Census Collection District
DLL	Delfin Lend Lease
DV	Dependent Variable
DZN	Destination Zone
GIS	Geographical Information System
IV	Independent Variable
JTW	Journey to Work
LUPTAI	Land Use and Transport Accessibility Index
MPC	Master Planned Community
MPE	Master Planned Estate
NTD	Neo Traditional Design
OLS	Ordinary Least Squares
SEQ	South East Queensland
SLA	Statistical Local Area
TOD	Transit Oriented Development
TRS	Traditional Regulatory Subdivision
VHT	Vehicle Hours Travelled
VKT	Vehicle Kilometres Travelled

## Introduction

The relationship between urban form and travel behaviour has been of substantial interest to urban researchers (see Handy 1995; Ewing et al. 1996; Miller and Ibrahim 1998; Crane 2000; Cervero 2001). The link between land use patterns and travel demand is, however, complicated by the varying socio-economic and travel preference factors associated with different land uses (Stead et al. 2000). According to Stead (2001: 499) “the variation in socio-economic characteristics increases the difficulty in establishing the precise relationship between land use characteristics and travel patterns, and adds complexity to the comparison of travel patterns in different areas.”

The key aim of this research is to investigate the dynamics of travel self-containment by exploring and mapping the relationships between urban form, urban structure and trip generation. The notion of ‘travel self-containment’ is used by urban scholars to describe the spatial travel patterns of residents within a given locality. Empirically, it is the proportion of trips that are internal to the locality, relative to all trips made by residents (Cervero 1995; Healy and O’Connor 2001). A high rate of travel self-containment indicates a set of land use and transport conditions able to satisfy much of local resident need(s) without recourse to multiple external journeys involving dispersed destinations. Local travel reduces automobile use, adding to the environmental sustainability of a region.

Our study is focused on Australian master planned estates (MPEs). To date there has been limited international consideration of travel in MPEs. The research that does exist does not explicitly address the issue of self-containment. In Australia there has been no empirical research into any aspect of travel in MPEs.

The ambition of master planning, as its name suggests, is considerable. Its conceptual vision extends to all aspects of development (Gwyther 2005). Its spatial ambit is the entire project site. The idea of master planning dates back to Ebenezer Howard’s Garden City concept of the 1880s (Gwyther 2003). A developing practice in North America since the 1960s, master planning has, in the last 15 years, made its mark in Australia. MPEs or master planned communities (MPCs) are large-scale developments whose essential features are a definable boundary; a consistent, but not necessarily uniform, character; and overall control during the phasing and build-out process by a single development entity (Schmitz and Bookout 1998; Minnery and Bajracharya 1999). Such planned communities generally contain a wide range of residential and non-residential land uses, open space, and public services and facilities. MPEs tend to be low density and suburban in character. Of late, however, there has been a slight shift towards mixed densities, with some estates including areas of medium and high density development.

MPEs are becoming the dominant form of urban expansion in Australia, replacing traditional regulatory subdivisions (Blair et al. 2003). Historically, many MPEs offered limited residential products. The newer estates, however, are offering more varied options developed with better design principles that

allow open space preservation, integration of land uses to reduce auto trips, walkable pedestrian networks, and architectural details that foster social interaction (Schmitz and Bookout 1998; Cowley and Spillette 2000).

MPEs have attracted the attention of international scholars interested in the links between urban form and generated travel behaviour (e.g., Gordon and Richardson 1989; Breheny 1992; Newman and Kenworthy 1992; Cervero 1995). Few empirical studies, however, have been completed into MPEs' travel behaviour patterns (e.g., Ewing et al. 1993; Cervero 1995). In Australia, while a number of scholars have investigated MPEs, they have largely concentrated on the physical, environmental and social issues of such developments, rather than travel patterns (see Forsyth 1997; Minnerly and Bajracharya 1999; Gwyther 2002; Wood 2002; Blair et al. 2003; Bosman 2003; Dodson and Berry 2003; Gwyther 2005).

MPEs often claim to provide a strong sense of community identity, traffic and property safety, and to promote self-containment of travel within their region. They purport to conserve non-renewable energy sources and to reduce high levels of vehicular movement (Commonwealth of Australia 1995). It is also their aim to use available infrastructure and land more efficiently and, with higher density development, to increase resource and transport efficiencies (Blair et al. 2003).

Information about local self-containment rates for Australian suburbs is scant. To date there has been no research into the travel self-containment rates of master planned residential communities in Australia.

This study investigates a set of locational, design and social variables, associated with self-containment and internal trip capture, in selected Australian MPCs. The objectives of the research are:

- (1) to define local area travel containment;
- (2) to test the definition with a geographical information system (GIS) empirical analysis of suburban localities - using Australian Bureau of Statistics (ABS) Census journey to work (JTW) data for MPEs;
- (3) to identify the relationship between land use characteristics, household socio-economic profiles and travel preferences in MPEs.

The research investigates three primary questions:

- What is the relationship between land use form, household profiles and trip generation patterns?
- What are the local area travel self-containment values of MPEs?
- What factors influence travel self-containment in MPEs?

The methodology is threefold. First, the paper reviews existing literature on suburban travel patterns and self-containment and reports on the major conclusions of this scholarship. The paper then analyses journey to work (JTW) travel patterns as revealed by ABS Census data and measures local

travel containment rates. Finally, a statistical regression analysis is used to estimate factors affecting local trip generation patterns (i.e., self-containment).

The rest of this paper is structured as follows. In response to the first primary question Section Two provides a concise overview of the literature on urban form and travel behaviour. Issues of self-containment, automobile dependency, accessibility, urban design, integration of land use and transportation planning, and research methods for studying urban form and travel are discussed. Section Three introduces the empirical model used in the pilot study to address the second and third research questions. A regression model estimates the factors affecting self-containment patterns in Australian MPEs. Section 4 concludes with the research's overall findings and identifies opportunities for future research into MPEs in Australia and internationally.

## **Influence of urban form and structure on trip generation patterns**

Since the 1960s, the relationship between urban form and travel behaviour has been and continues to be of great interest to urban researchers. A large body of work assesses patterns of travel behaviour in urban forms, and the related issues of (a) travel self-containment, (b) automobile dependency, (c) accessibility, (d) density, (e) urban design, (f) the integration of land use and transport planning, as well as (g) research methods used in studies of urban form and travel (Banister and Lichtfield 1995; Jenks et al. 1996; Newman and Kenworthy 1999; Cervero 2001; Alexander and Tomalty 2002). We report this literature by focusing on the above mentioned seven factors.

### **Self-containment**

One of the major interests in scholarship relating to urban form and travel behaviour is the idea and practice of "self-containment" (Cervero 1995; Ewing et al. 1996; Healy and O'Connor 2001). The self-containment of a community has been a long established ambition in urban planning. The concept was first promoted by Ebenezer Howard via the Garden City Movement of the 1880s. It was notably incorporated in the Greater London Plan of 1945 (Hall et al. 1973; Hall 1988). Self-containment is usually understood as the numerical balance between the number of jobs and the number of dwellings in a geographically defined community. A community with an even jobs-housing balance is generally considered to be self-contained and self-reliant. The social vision of self-containment is of a people who, mostly, live, work, shop, and recreate in a defined area (Burby and Weiss 1976). Self-containment is not a description of a specific land use pattern but a concept of the overall activities and flow of people.

In the measurement of self-containment the 'energy flow', reflective of a base environmental concern, is the fundamental category. Practical imperatives have privileged the work commute as the preferred object of study (Cervero 1989; Debenham et al. 2003; Jarvis 2003). There are many indices of self-

containment based on the spatial pattern of the work commute. Thomas' (1969) 'Independence Index' was the first measure of self-containment in English new towns. The index measures the number of internal work commutes as a proportion of total work commutes.

Many planners argue in favour of locating housing areas and workplaces in the same area to reduce the demand for travel (Naess et al. 1995). Urban theory seems to support the view that comparatively self-contained, medium-size communities generate the least travel demand (Owens 1986; Rickaby et al. 1992). Healy and O'Connor (2001) consider whether this 'new urbanism' is, in effect, an attempt to encourage suburban self-containment over central city focused commuting. They suggest "smart urbanisation could really mean self-contained suburb development, and a smart policy could be one that enhanced suburban self-containment". (2001: 15)

Cities and towns designed to promote self-containment have rarely fulfilled their planner's ambitions. In Canberra's new towns the self-containment rate is about 30 per cent - half the original goal of the National Capital Development Commission (McNabb and Melbourne University Research Team 2001). The new towns of Hong Kong and Seoul have, similarly, been disappointing (Hui and Lam 2005). With its satellite towns Stockholm planned for a more modest target of 50 per cent self-containment. Again only about half as many workers as anticipated were employed locally (Cervero 1998). Stockholm's mode share for work trips, however, is highly favourable. While self-containment in satellite communities is low, a high proportion of trips are undertaken by rail. The result, arguably, is the world's best example of the coordinated planning of rail transit and urban development. Carefully planned co-development of new towns and rail transit has put the Stockholm region on a sustainable development trajectory, despite the failure to achieve positive self-containment objectives (Cervero 1995).

A 'travel self-containment rate' is used to characterise, with a number, the fundamental pattern of travel of spatially-bound residents (e.g., Cervero 1995; Healy and O'Connor 2001). As a number, it is the proportion of all trips captured by local activities. For urban policy, a high rate of travel self-containment indicates a set of land use and transport conditions sufficient to satisfy much of local resident need(s). These conditions, in effect, reduce automobile use thus adding to regional environmental sustainability.

Australia's urban policy makers are beginning to recognise local area self-containment and, more modestly, high travel self-containment as a key residential policy concern. This is reflected in recent metropolitan strategies. The Melbourne 2030 Metropolitan Strategy seeks to improve travel self-containment by concentrating new development around mixed-use multi-modal activity centres (DOI 2002). This strategy draws on the earlier Urban Villages report (DOI 1996) promoting new urbanist principles for the redevelopment of suburban centres. In Queensland the SEQ 2026 Regional Plan has identified improvements to local self-containment, particularly at the urban fringe, as an important dimension of regional sustainability. SEQ 2026 hopes to achieve these higher levels of self-containment with greater

integration of employment, services and population distribution (SEQROC 2005). The SEQ 2026 Regional Plan (SEQROC 2005: 107) declares:

The Regional Plan places a strong emphasis on improving the public transport system in SEQ. Policy directions include more compact forms of urban development and self-containment of travel.

Residential developers are also starting to recognise the importance of self-containment for new suburban estates. In New South Wales the public land developer, Landcom, is currently involved in a new MPE development at Edmondson Park in Sydney's outer south west. This development is focussed on encouraging self-containment and reducing reliance on automobile travel. The Edmondson Park background report (2004: 76) claims: "[a] cycle and pedestrian network linking residential areas, villages and the town centre provides the opportunity to discourage the uses of private vehicles and promotes exercise and enjoyment of the environment."

In SEQ, the Delfin Lend Lease (DLL) Yarrabilba MPE development anticipates a mix of local activities sufficient to generate higher self-containment than that of conventional outer urban developments. Yarrabilba, slated to start in 2007, will eventually house 52,000 people. Key in DLL's planning of the estate is the environment, transport, employment opportunities, education and the delivery of community facilities. DLL commitment to self-containment is part of the company's broader goal of creating 'balanced communities' via a local mix of housing, employment and other services within its master plans (Delfin Lend Lease 2005). As with the all other MPEs, however, there has so far been little evidence that desired self-containment outcomes are being achieved.

In the Australian context, self-containment objectives are often weakly expressed, either in conceptual or practical terms. This makes assessing the achievement of self-containment objectives difficult as it is often uncertain as to the aspirations against which outcomes are to be measured. However it is feasible to assess the self-containment of recent Australian MPEs relative to the objectives and outcomes posited by the scientific planning literature. Hence it is this concern which drives the present study.

### **Automobile dependency**

The expectation that automobiles will be the dominant mode of travel is one of the most important factors in shaping contemporary urban form and travel. Newman and Kenworthy (1996) and Newton et al. (1997) provide an historical overview of 'the land use and transport connection'. They propose an evolutionary city climbing the historical steps of: (a) the walking city; (b) the transit city; (c) the automobile city; and (d) the virtual city with global transport and communication networks. The evolution of the transit into the automobile city marks the dependence of the majority of urban residents on automobile travel.

Newman (1991) argues that, on a world-wide scale, cities now assume the dominance of the automobile in their planning and layout, and provide

predominantly for it in their decision priorities. A host of physical characteristics typify the condition of automobile dependence as described by Newman (1991). These include low density housing, dispersed employment, highly zoned and thus spatially differentiated land uses, poor public transport and high road and parking provision.

Historically Australian cities were, in the round, surrounded by relatively low-density suburbs, consequent on extensive rail and tram services that enabled continued urban expansion. Being transit oriented, this urban development was by contemporary standards relatively sustainable. However, auto-dominated planning has exacerbated, rather than ameliorated, many of the disadvantages of this form of urbanisation. For example, the spatial disadvantages of the transit city that have been particularly compounded by the re-orientation of non-residential activities, such as employment and services, around automobiles. Since the 1950s urban planners have, with transport and land use plans, promoted automobile travel over all other modes of movement. Comprehensive freeway networks have rolled out across many Australian cities. Practical urban mobility is overwhelmingly conceived of by urban planners as equating to automobile mobility. The result, perhaps unsurprisingly, is high levels of car-dependence in Australian cities.

### **Accessibility**

A wide range of well-documented problems result from urban automobile dependence (see Newman 1996). It is argued a re-conception of urban travel in terms of accessibility rather than mobility is a necessary first step in addressing these problems (Cervero 1989; Levinson and Kumar 1994; Levinson 1998; Scott 1998). Hansen (1959) defines accessibility as the potential for interaction. The discussion on mobility and accessibility is often associated with the dichotomy of urban and suburban travel. Diffuse suburbs with limited accessibility tend toward the limit level of automobile dependency (Salomon and Mokhtarian 1998).

A large number of studies (e.g., Vickerman 1974; Dalvi and Martin 1976; Handy 1993; Kockelman 1997; Lee and Goulias 1997) have used the concept of accessibility to investigate the effects of land use patterns on various aspects of travel behaviour. The conventional wisdom that residents surrounded with greater numbers of jobsites and activities (i.e., having better spatial access) travel less is not uncontested (see Ewing et al. 1996). The consensus, however, is that planning for accessibility rather than mobility can expand choice and reduce the need to drive (Salomon and Mokhtarian 1998; Handy 2002). For Bertolini et al. (2005) the fundamental goal behind shifting from mobility to accessibility is sustainability. They suggest:

[a] shift of focus in urban transport planning from catering for mobility to catering for accessibility may help see how more sustainable travel options (e.g. walking, cycling, public transport, shorter car trips) can, under certain land use conditions (e.g. higher densities, more finely-tuned functional mix), provide a degree of accessibility that matches less sustainable options. (Bertolini et al. 2005: 207).

Common strategies to increase access to needed and desired activities include: bringing activities closer to home, providing alternatives to automobile travel to activities, and expanding choice among activities (Handy 2002). Cervero (1997) sees the paradigm shift from 'automobility planning' to 'accessibility planning' as the appropriate means of increasing accessibility and decreasing the negative environmental impacts of transportation.

In recent years, Australian State governments and their transportation agencies have shown more interest in accessibility as a sustainability indicator. The National Centre for Social Applications of GIS has developed a 'metropolitan accessibility index' (GISCA 2005). Queensland Transport has recently made use of a 'land use and transport accessibility index' (LUPTAI). This index was developed by the authors of the present study for analysis of Gold Coast City. LUPTAI measures and quantifies the accessibility of a given location within an urban area using a series of destination-based accessibility indexes (Sipe et al. 2005).

## **Density**

Urban density – the number of people or dwellings per unit of land area – is highly correlated with automobile ownership and use, and associated parameters of sustainability. Declining urban density is viewed by many scholars and policy makers as effectively privileging private motorised transportation over public transit and thus preventing the realisation of a more balanced modal split. Low density developments often rely heavily on automobiles, and can lack recreational and civic open spaces (Newman and Kenworthy 1989). Low density development is widespread and its effects are considered by many to be, perhaps, undermining the quality of life in every major Australian city.

In Europe, planners and politicians have proposed, and implemented, measures to limit low density expansion and to develop compact urban forms as a means of reducing energy consumption/transport (Gale and Hart 1992; Williams et al. 2000). In the 1980s and 1990s many countries in Europe (e.g., The Netherlands, UK, Germany, Sweden, Paris region) and Asia (Hong Kong, Singapore) implemented compact urban growth policies (Cervero 1996; Schwanen et al. 2004). Similar 'compact city' policies have been proposed in the US, although those adopted have been notably less restrictive than the European standard.

Urban compactness is distinguished from conventional low-density suburbia by functional context as well as density of form. It tends to high(er) density residential development situated within suburban concentrations of a mix of compatible land uses including commercial and retail employment and services.

Attempts, such as compact city policies, to regulate transport choice through spatial manipulation are broadly based on the premise that urban compactness induces a higher proportion of public transport, cycling and walking trips (Schwanen et al. 2004). Compact urban structures are viewed by

many as generating travel patterns that are environmentally and economically efficient in the sense that the distances travelled are shorter than the norm in lower-density, more dispersed urban areas (Camagni et al. 2002). Shorter trips lower energy consumption. Shorter travel distances also improve the potential for healthy walking and cycling.

## **Urban design**

Changing travel behaviour by the manipulation of urban form with land use regulation is a long-term strategy. Urban design concepts developed in North America such as neo-traditional design (NTD) and transit oriented development (TOD) have gained popularity as means of addressing a number of urban problems, including traffic congestion, affordable housing shortages, air pollution, and ongoing suburban sprawl (Cervero et al. 2002). TOD is defined as relatively high-density, mixed-use, pedestrian-oriented development around public transport nodes. TOD planning is dependent on the capacity of the core public transit system to deliver large, and increasing, volumes of urban travellers to nodal points (Handy 2002). Some Australian cities have included TOD principles in their metropolitan plans. Melbourne 2030 Metropolitan strategy develops a 'Transit Cities' policy. In general, however, TODs as envisaged by contemporary planners remain as yet unrealised in Australia.

TODs have the potential to deliver substantial social, environmental and economic benefits. Focused growth around transit stations capitalises on expensive public investments to deliver local and regional benefits, such as reduced automobile dependence, improved public transport efficiency and greater local amenity. TOD proponents claim it to be an effective tool in curbing low density development, reducing traffic congestion, and expanding housing choices (Cervero et al. 2004). Arrington and Parker (2001) suggest TOD allows for greater mobility mode choice, increased public safety, increased transit ridership, reduced rates of VKT, and increased households' disposable income (via travel cost savings). Further possible benefits of TODs include reduced air pollution and energy consumption, conservation of resource lands and open space, economic development, affordable housing and decreased local infrastructure costs (Cervero et al. 2002)

South East Queensland Regional Organisation of Councils identifies TODs as a powerful potential component of renewed attempts to stabilise if not reverse the pattern of dispersed urbanisation prevalent in the region. The SEQ 2026 Regional Plan commits to:

Transit oriented development and regional activity centres [as] essential components of urban structure and form. Transport investment by the Queensland Government, particularly in public transport, will support transit oriented development and regional activity centres. (SEQROC 2005: 107)

TODs are viewed by the SEQ Regional Plan as a framework that:

accommodate[s] higher density residential development and land uses that support high levels of employment and trip generating activities. (SEQROC 2005: 107)

The role for TODs in the SEQ Regional Plan and, in particular, the extent to which this mode of planning is presumed to generate positive self-containment benefits highlights the growing importance for policy makers of the integration of land use and transport planning. The potential TOD sites identified by the SEQ Regional Plan are, however, largely located within central areas of the region's major cities. Accordingly, the majority already possess superior transit connections relative to other, less central, urban localities. This begs the question of the role of TODs on the urban fringe, particularly in relation to greenfield sites – such as MPEs – and the importance of planning for sustainable transport and urban development within fringe areas. In this context it is important to examine how land use(s) and transport systems are presently planned and the extent to which they integrate sustainable travel patterns, including self-containment.

### **Land use and transport planning integration**

Policy makers usually see land use management to achieve desired metropolitan planning outcomes as a long-term strategy, since the rate of change achieved through land use shift, subject as it is to the inertia of land markets and development cycles, is typically slow for most forms of urban development. Land use strategies are, nevertheless, used in travel demand management. As noted above, land use characteristics and patterns influence the aggregate level of demand and can influence travel mode choices, thus potentially influencing the level of vehicle hours travelled (VHT) and vehicle kilometres travelled (VKT) (see Miller and Ibrahim 1998; Ewing and Cervero 2001; McCormack et al. 2001). Transportation planning and the location of transportation investments can influence the location of development and hence can, potentially, impact on the levels and types of travel demand (Polzin 2004). The integration of land use activities and transport systems to achieve sustainable travel outcomes has been identified as a planning opportunity of considerable potential by many commentators (Cervero, 1998).

The Western Australian Government has recently developed an institutional model for the integration of land use planning and transport planning within the Perth metropolitan area (see Curtis and James 2004). The model draws together principles of transport planning, land use planning, public policy and organisational behaviour. Its conceptual focus is accessibility. The mechanism of implementation is a place-based planning development process that consolidates land use planning, transportation planning and urban design regulation in a specially created institutional vehicle. Similar successful integrated approaches have also been used in European and North American planning (Geerlings and Stead 2003).

### **Research methods**

The above discussion has focussed on the principles of urban development thought to promote greater sustainability through reductions in the demand for

urban travel in private motor vehicles. In this context the specification of the dynamics of urban land use and travel, a methodological question, becomes urgent. A number of disciplinary perspectives across social and political science, engineering and mathematics have been used to define these relationships. Useful summaries and reviews of the relevant literature include Cervero and Gorham (1995), Handy (1996), Crane (2000) and Polzin (2004).

Cervero and Gorham (1995) categorise urban transport and land use research into two basic camps: (a) simulation studies; and (b) comparative empirical studies. Handy (1996) suggests distinguishing five groups, namely: (a) simulation studies; (b) aggregate analysis; (c) disaggregate analysis; (d) choice models; and (e) activity-based analyses. Crane (2000) groups methods as: (a) hypothetical studies; (b) descriptive studies; and (c) multivariate statistical studies. For Polzin (2004) analysis on urban form and travel occurs at three different spatial scales: (a) site level; (b) neighbourhood level; and (c) urban area level.

Table 1, below, summarises into four categories the questions, methods and outcomes of the study of urban form and travel. The first column, travel behaviour measures, includes trip generation rates, car ownership, modal choice, and the length of JTW. The second column lists the urban form and land use measures associated with travel behaviour. It includes measures of population density and form, employment location, land use mix, street and sidewalk circulation patterns, and the balance of jobs and housing. The third column records possible methods of analysis. It lists include simulations, descriptions, and multivariate statistical analysis. The fourth column shows other distinctions and issues such as land use and urban design, composition of trip chains and tours, and use of aggregate versus individual level traveller data (Crane 2000). The table allows a first, quick comparison of alternative research methodologies. It has been used in the design of our own study on travel self-containment in Australian MPEs.

<b>Travel Outcome Measures</b>	<b>Urban Form and Land Use Measures</b>	<b>Methods of Analysis</b>	<b>Other Distinctions and Issues</b>
1. Total miles traveled; e.g., VMT	1. Density, e.g., (a) simple residential/ employment, or (b) more complex “accessibility”, “subcenter” or “polycentrism” measures	1. Simulation; i.e., (a) simple hypothetical impacts based on assumed behavior, or (b) more complex integrated land use/traffic impact models based on forecasts of observed behavior, economic trends & demographics	1. Land Use and urban design at the trip origin versus the trip destination versus the entire trip route
2. Number of trips	2. Extent of land use mixing	2. Description of observed travel behavior in different settings; e.g., commute length in big cities as compared with small cities	2. Composition of trip chains and tours; e.g., use of commute home to buy groceries and pick up laundry
3. Car ownership	3. Traffic calming	3. Multivariate statistical analysis of observed behavior; i.e., (a) ad hoc correlation analysis of travel outcomes and variables thought to be associated with travel, or (b) model specified and estimated according to behavioral theory	3. Use of aggregate versus individual level traveler data, and aggregate versus site-specific land use & design data
4. Mode; e.g., Car, Rail Transit, Bus, Walk, & Bike,	4. Street and circulation pattern		
5. Congestion	5. Jobs/housing and/or land use balance		
6. Commute length; i.e., the journey-to-work	6. Pedestrian features; e.g., sidewalks, perceived safety, visual amenities, etc.		
7. Other Commute measures; e.g., speed, time			
8. Differences by purpose; e.g., for work versus nonwork travel, regional versus local travel			

**Table 1: Methods in studies of urban form and travel (Crane 2000: 37)**

The vast literature on transportation and automobile dependence shows 'urban form and travel behaviour' – in other words 'land use and travel demand' – to be strongly associated (see Ewing et al. 1996; Handy 1996; Crane 2000; Cervero 2001). The literature review reveals a substantial body of thinking that suggests accessibility planning, linking land use and transportation planning, and the effective use of urban design tools have considerable potential to positively affect travel behaviour including self-containment rates.

Most of the literature and research has been undertaken in North America, Europe and (to a lesser degree) South East Asia. Literature that considers the urban form and travel behaviour relationship in an Australian context is very limited. Most of this work is comprised of recommendations to Australian Governments from North American scholars (e.g., Cervero 2001), or Australian research that does not directly explore the form-travel link (e.g., Newton et al. 1997; Healy and O'Connor 2001). This limited literature and research base does not adequately clarify the general Australian relationship between urban form and travel behaviour, let alone Australian MPE patterns. Burke's (2005) study of Australian gated communities is perhaps the closest approximation to the present investigation. Gated communities, however, can only be reasonably understood as corollaries and not equivalents of MPEs. Burke (2005) found those gated estates with significant internal community activities and services, such as recreational and retail services, certainly retain a number of trips internally to these locations. There was no evidence, however, of a noticeably reduction in the relative proportions of external trips.

There are a number of reasons why urban scholars should dedicate greater attention to the relationships between urban form, urban location and travel behaviour in MPEs. There is the simple prominence of MPEs. In terms of total annual dwelling units created it is the prevalent form of contemporary urban development in Australia. This dominance suggests an urgent need to understand MPEs travel dynamics, and to investigate means of increasing self-containment. Many MPEs seek to incorporate a mix of land use activities presumed to result in greater self-containment. Two South East Queensland examples illustrate the trend. The Springfield Lakes estate in South East Queensland anticipates eventual population of 80,000 residents. It plans for multiple major land uses include a major retail complex and combined tertiary and secondary educational facilities served by a rail link. A similar project proposed for Yarrabilba is anticipated to house an eventual population of approximately 50,000 and to include a mix of commercial and retail activities. In South West Sydney the proposed Edmondson Park MPE anticipates high residential densities around a commercial and retail centre joined to a rail node. The Aurora estate in Melbourne north will attempt a comparable combination of residential and other land use activities served by a rail. There is an urgent policy (and scholarly) imperative to understand the opportunities to integrate land use and travel behaviour in these new major urban developments.

The new Australian MPEs are being developed in a policy environment which is increasingly attentive to sustainability concerns, particularly in relation to

transport. The Springfield Lakes, Yarrabilba, Edmondson Park and Aurora developments all include substantial elements which their proponents claim will encourage patterns of sustainable travel. Springfield Lakes has even established a local bus service, in the absence of early government provision, while it waits for an anticipated rail line. Claims regarding beneficial travel impacts need to be closely evaluated to ensure anticipated outcomes are realised. The fundamental question is whether, and if so how, MPEs generate travel patterns that are substantially different from those of conventional dispersed suburban forms. The extent of self-containment is identified by the literature as one of the key indicators of sustainable travel behaviour. This study begins to answer questions about self-containment in Australian MPEs.

It is essential to rigorously analyse MPEs in terms of demographic, design, location and socio-economic characteristics to determine which factors contribute to sustainable travel. Consequently, the method of analysis must be capable of distinguishing between different development elements and other variables to identify those which are most positively associated with better transport outcomes. The development of such a method is a key objective of this paper.

We hope to report our research on the impact of MPEs on the Australian urban context to an international audience. Australian cities reflect both European and North American urban patterns. Comprehending how new patterns of urban development generated by MPEs might transform Australia's urban environments and hence alter the historical trajectory of transport and land use arrangements is of more than local interest.

Given the research imperatives associated with the ongoing development of scholarly understanding of urban land use and transport relationships, and in particular the lack of substantial Australian or international knowledge of the characteristics of MPEs, there is a clear need for some basic empirical analysis to illuminate these relationships. The remainder of this paper sets out an empirical investigation of travel in a selected set of Australian MPEs with a focus on self-containment patterns.

## **Empirical study**

The empirical goal of the pilot study is to map and explore the relationships between urban form, urban structure and trip generation patterns to better understand the sustainable options of urban development. The empirical section of our investigation is presented in eight parts. First, we introduce our research questions. Second, we discuss research design. We then introduce the case study MPEs. Next, we discuss sources of empirical data and their limitations. Fifth, we analyse regional JTW data using a GIS-based methodology and present the preliminary travel patterns. The heart of the empirical study is an 'ordinary least squares' (OLS) statistical regression model of factors presumed to influence travel self-containment. Factors found to be inadequate are discarded and a final model is estimated. We conclude

by discussing the research findings, including data and methodological limitations, and identifying opportunities for future research.

### **Research questions**

The preceding discussion on self-containment in outer-suburban MPEs raises the following basic questions:

- How can urban scholars measure self-containment?
- What are the local area (travel) self-containment characteristics of Australian MPEs?
- What factors influence the travel self-containment in Australian MPEs?

This pilot study is necessarily robust in both ambition and data use. It is, nevertheless, a useful first insight into the travel behaviour of master planned estates.

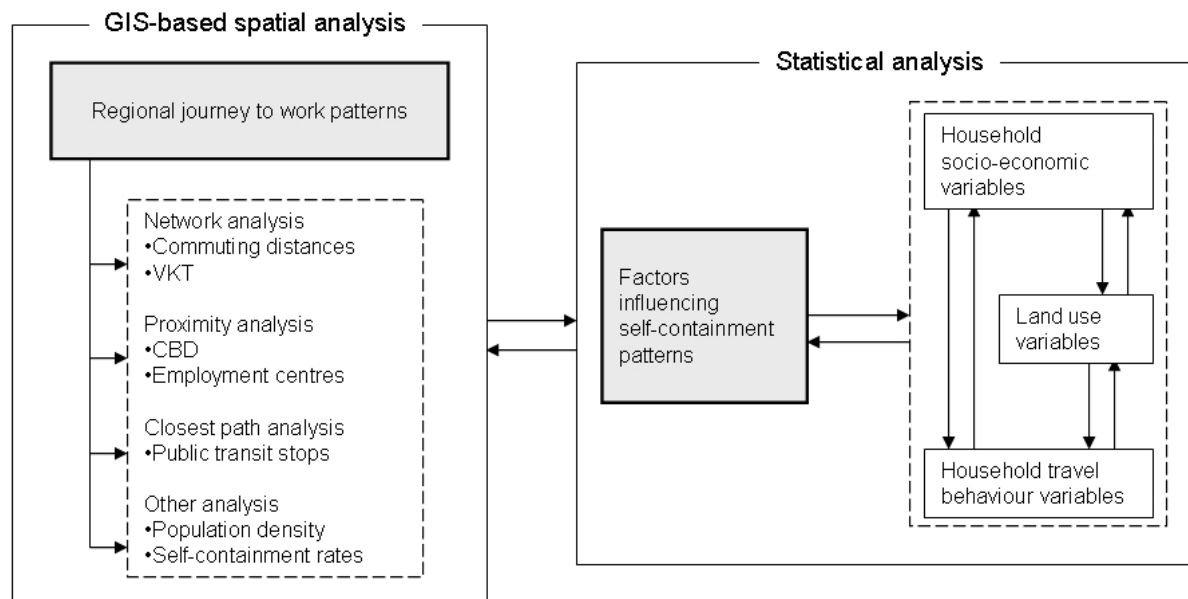
### **Research design**

Earlier sections of this paper reviewed previous research on the relation between urban form, urban structure and trip generation patterns, urban design philosophies, and travel self-containment. In this section we discuss methods to analyse JTW travel patterns, measuring (travel) self-containment, and means of determining the influence of various urban variables on internal trip-capture rates.

GIS-based analysis is increasingly used in land use and transportation research (Crane and Crepeau 1998). Its biggest advantage is it allows spatial and non-spatial attributes of the urban built environment, including their populations, to be relatively easily defined, quantified and manipulated (Cervero and Duncan 2003). This study employs a GIS-based spatial analysis to define local area travel containment values and measure internal trip capture rates for MPEs. The basic input into the analysis is journey to work (JTW) data from the ABS Census (Figure 1).

JTW patterns have been the focus of much research on the relationship between urban form and travel behaviour. Many scholars have used JTW data to investigate the links between job access, work place location, and commuting trips (see Giuliano and Small 1993; Cervero and Gorham 1995; Forrest 1996; Naess and Sandberg 1996; Levinson 1998; Ong and Blumenberg 1998; Healy and O'Connor 2001). In this research JTW data is used to measure commuting distances and travel self-containment rates for a selection of Australian MPEs. The restriction of the analysis solely to home-to-work trips is driven by pragmatic considerations of data availability and relative ease of manipulation. While it is desirable for research into self-containment to investigate trip-capture rates for non-work trips, such as shopping and recreation journeys, such data is difficult to obtain to a statistically valid sample size. The lack of prior travel containment research in Australia means there is little, if any, existing data to draw upon. For a pilot

study such as this, the JTW Census is an available and easily accessible, albeit limited, data source.



**Figure 1: Model for analysing JTW and self-containment patterns**

Crane (2000) categorises methods of analysis of urban form and travel under three headings (see Table 1). Simulations are based on either: (i) entirely hypothetical situations, and thus succeed or fail depending on the validity of their assumptions, or (ii) on more complex combinations of assumed and manifest behaviours. Descriptive studies restrict themselves wholly to observable data. Multivariate analysis— usually some form of linear regression – is a framework able to span a large number of variables, expressed in numbers, representing a complex net of relationships (Crane 2000). It is common to much research into the link between urban form and travel patterns (e.g., Cervero and Gorham 1995; Cervero 1996; Kitamura et al. 1997; Boarnet and Sarmiento 1998; Stead 2001; Dieleman et al. 2002; Krizek 2003; Schwanen et al. 2004).

When the relevant data is available, multivariate regression analysis permits the identification of key socioeconomic and land use characteristics associated with travel behaviour. We believe multivariate statistical analysis to be the most suitable technique for our study because it:

- processes observed as well as hypothetical behaviour;
- assigns weights (i.e. rude quality) to causal relations until now only described;
- has the capacity for multi-linear complexity.

Ewing et al. (1994), Cervero and Kockelman (1997) and Stead et al. (2000) all produce evidence to suggest household demographic and socio-economic attributes, as well as the characteristics of residential environments, have a strong effect on travel patterns. Dodson (2003) finds the age of residential areas likely to impact on access to employment.

To measure ‘travel self-containment level’ (dependent variable) we selected a set of empirical land use, travel and household characteristics as independent variables to represent it (Table 2, below). In defining the set we included variables considered to affect the pattern of travel and variables demonstrated by the literature to possess trip generation effect (See Southworth and Owens 1993; Cervero and Gorham 1995; Cervero and Kockelman 1997; Hess et al. 1999; Krizek 2003). The Census data narrowly confined the definitional possibilities of variables. In the absence of superior data, however, this constraint is unavoidable.

Land Use Variables	Household Socio-economic Variables	Household Travel Behaviour Variables
Population density	Income level	Travel method
Age of estate	Employment level	Proximity to employment centres
Proximity to CBD	Education level	Commuting distance
Proximity to public transport	Car ownership	Vehicle Kilometres Travelled

*Note: Dependent Variable is 'travel self containment level'*

**Table 2: Regression analysis variables used in this study**

### Case Studies and datasets

Data and data gathering constraints restricted our case study to the following six MPEs (Figure 2):

- Forest Lake (Queensland),
- Golden Grove (South Australia),
- Caroline Springs (Victoria)
- Roxburgh Park (Victoria)
- Harrington Park (New South Wales)
- Garden Gates (New South Wales).

The study MPEs were selected such that each had: (i) been established before 2000; and (ii) had achieved a take-up ratio of at least 50 per cent by the March 2001 Census. Some of the salient characteristics of these MPEs are identified in Table 3, below.



**Figure 2: Location of the case studies**

The 2001 Census of Population and Housing, as well as 2001 Census boundaries and 2001 Census 'Detailed Study Area' Journey-To-Work data, were obtained from the ABS. Detailed Study Areas have been created by State transport agencies and comprise destination zones (DZNs) that aggregate to statistical local areas (SLAs). The core data was JTW detail collected at the level of the Census collection district (CD). DZN boundaries were provided by NSW Department of Transport – Transport Data Centre, VIC roads – Road System Management, QLD Department of Transport – Strategy and Planning Services, and Transport SA. Road and rail networks were derived from MapInfo Street Pro road network database for Australia.

	Harrington Park, NSW	Garden Gates, NSW	Caroline Springs, VIC	Roxburgh Park, VIC	Forest Lake, QLD	Golden Grove, SA
Developer	Hassell	Landcom	Delfin Lend Lease	VicUrban	Delfin Lend Lease	Delfin Lend Lease
Population	3027	3829	5356	9487	15062	26029
Population density (person/hectare)	8.9	6.5	7.9	18.1	11.8	18.2
Year of completion	1994	1991	1999	1992	1991	1986
Full-time employment level (%)	36.9	35.9	39.6	30.4	33.0	32.9
Higher education level (%)	8.6	4.4	8.5	6.4	6.5	6.8
Household weekly income level (\$)	1,500-1,999	1,500-1,999	800-999	800-999	1,000-1,199	1,000-1,199
Car ownership per dwelling	1.9	1.9	1.9	1.7	1.6	1.8
Motor vehicle use in JTVV (%)	88.2	86.4	90.0	89.8	46.5	46.5
Proximity to CBD (km)	57	56	25	26	21	22
Proximity to public transit - train station (km)	9	5	6	5	7	8
Proximity to employment centers (km)	45	44	33	26	24	12
Average commuting distance (km)	23	22	16	13	12	13
Daily journey to work VKT (km)	21510	24926	9428	7732	82838	8390
Travel self containment rate (%)	13.8	8.9	3.0	4.4	11.1	11.8

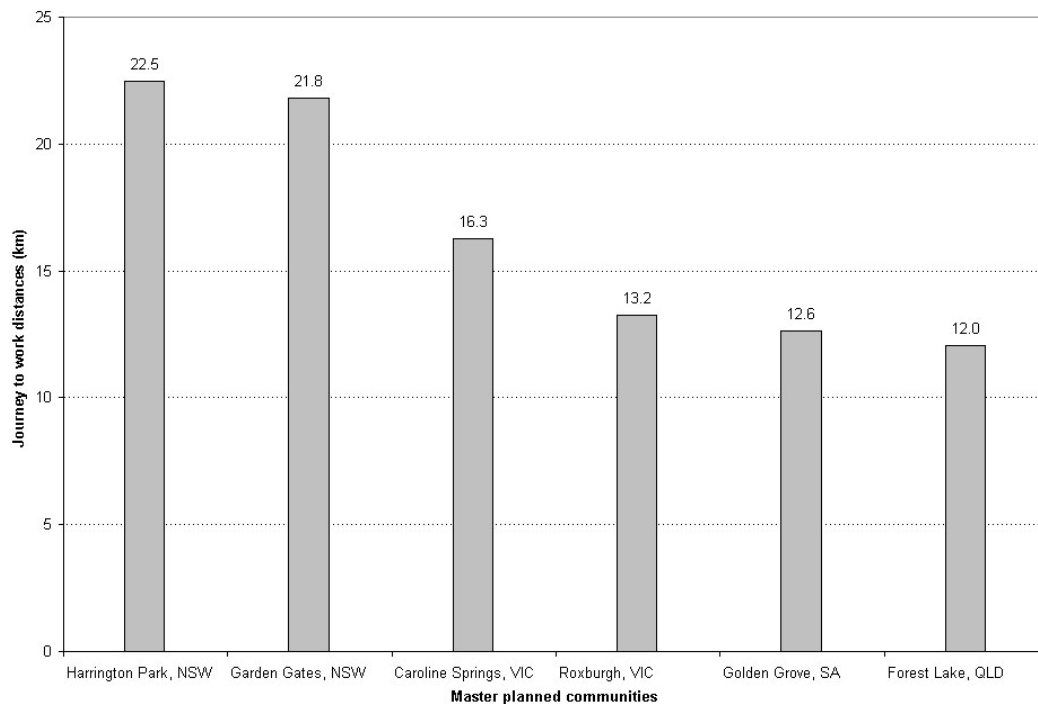
*Note: Figures presented in this table are based on year 2001*

**Table 3: The salient characteristics of the MPEs**

## Regional journey to work patterns

This study estimates travel self-containment values with a GIS-based model used in conjunction with spatial statistical techniques. Detailed JTW data is the primary input of the model. The dataset records each employed person's usual residence (origin) and workplace (destination). Residential location is identified at the level of the CD – variable areas with boundaries determined such that each CD contains approximately 200 households. Workplace destination is specified at the level of the DZN.

GIS software was used to link JTW data with DZN boundaries and determine the number of work trips undertaken between each MPE census district and each JTW destination zone. The calculation required CD and DZN 'centroids' be imputed as the origin and destination, respectively, of a representative journey. This journey was notionally traced on the road and public transport network(s) to yield a travel route distance. Each CD-DZN route distance was then multiplied by the number of recorded trips, to calculate a residence-to-work VKT. Total VKT was calculated by doubling the number of trips, to account for return journeys from work. The results of this analysis are provided in Figures 3 and 4.



**Figure 3: Average commuting distances**

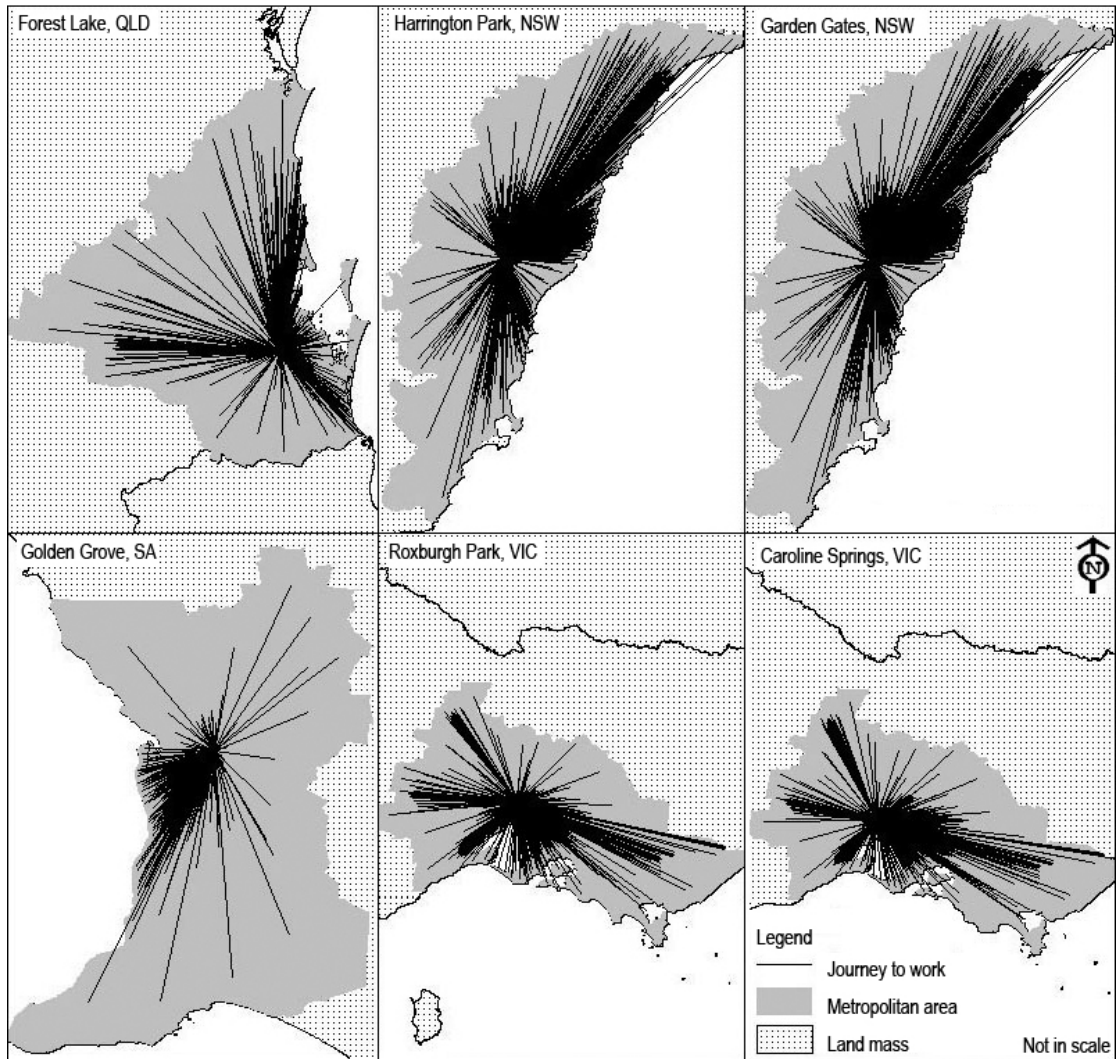


Figure 4: Distribution of work trips

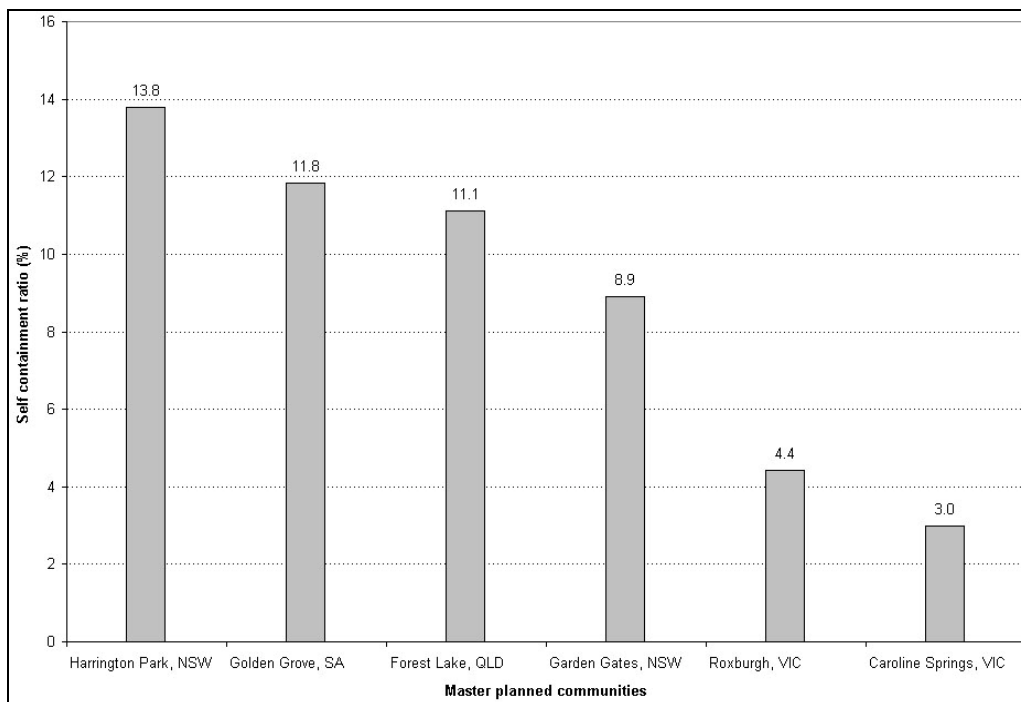


Figure 5: Travel self-containment rates

The next task of the study was to measure the travel self-containment values for MPEs. Work trips from each CD to each DZN were calculated. The ratio of work trips to DZNs within each CD relative to work trips to DZNs external to each CD provides the self-containment ratio for each CD (Figure 5 and 6).

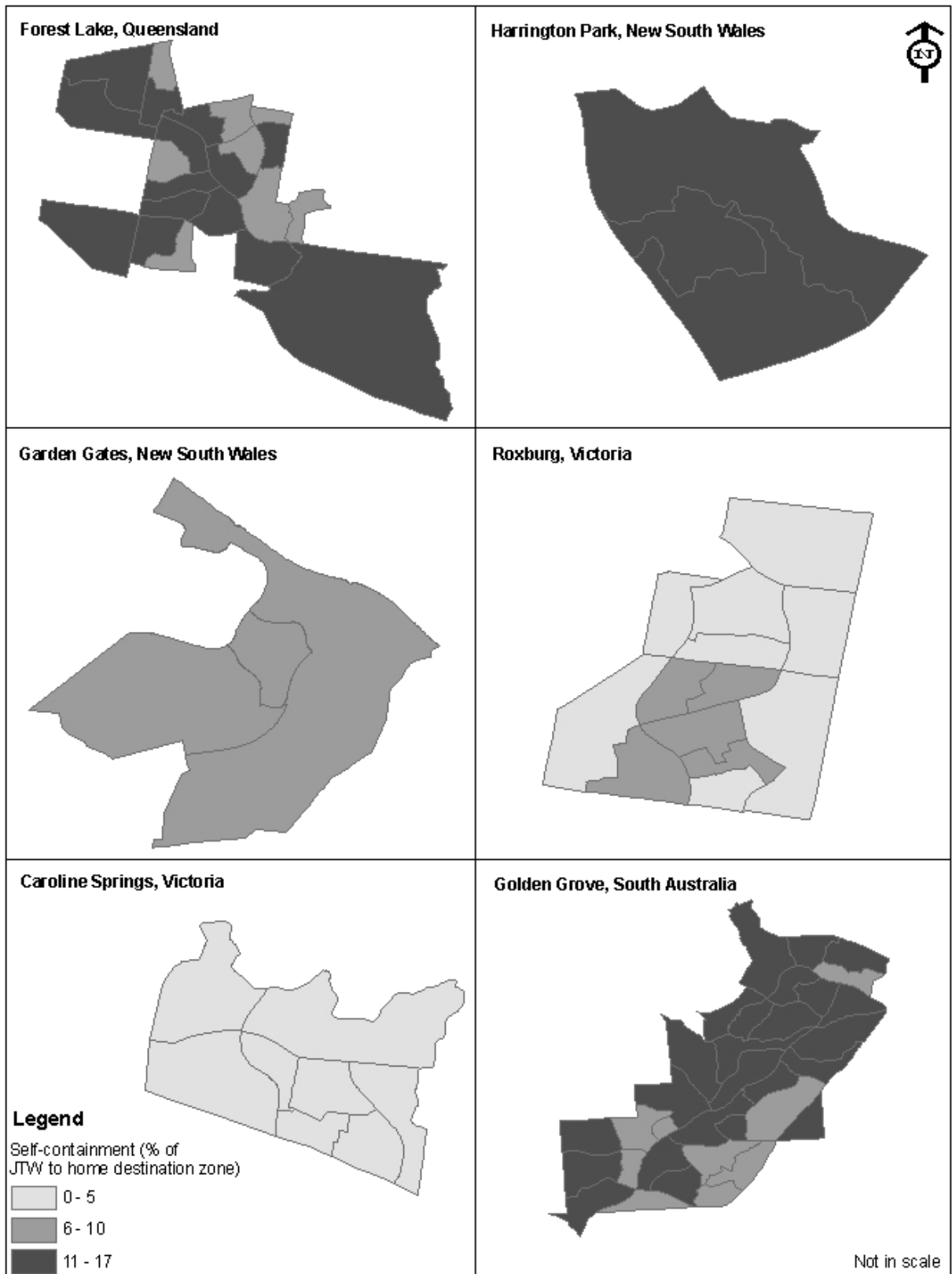
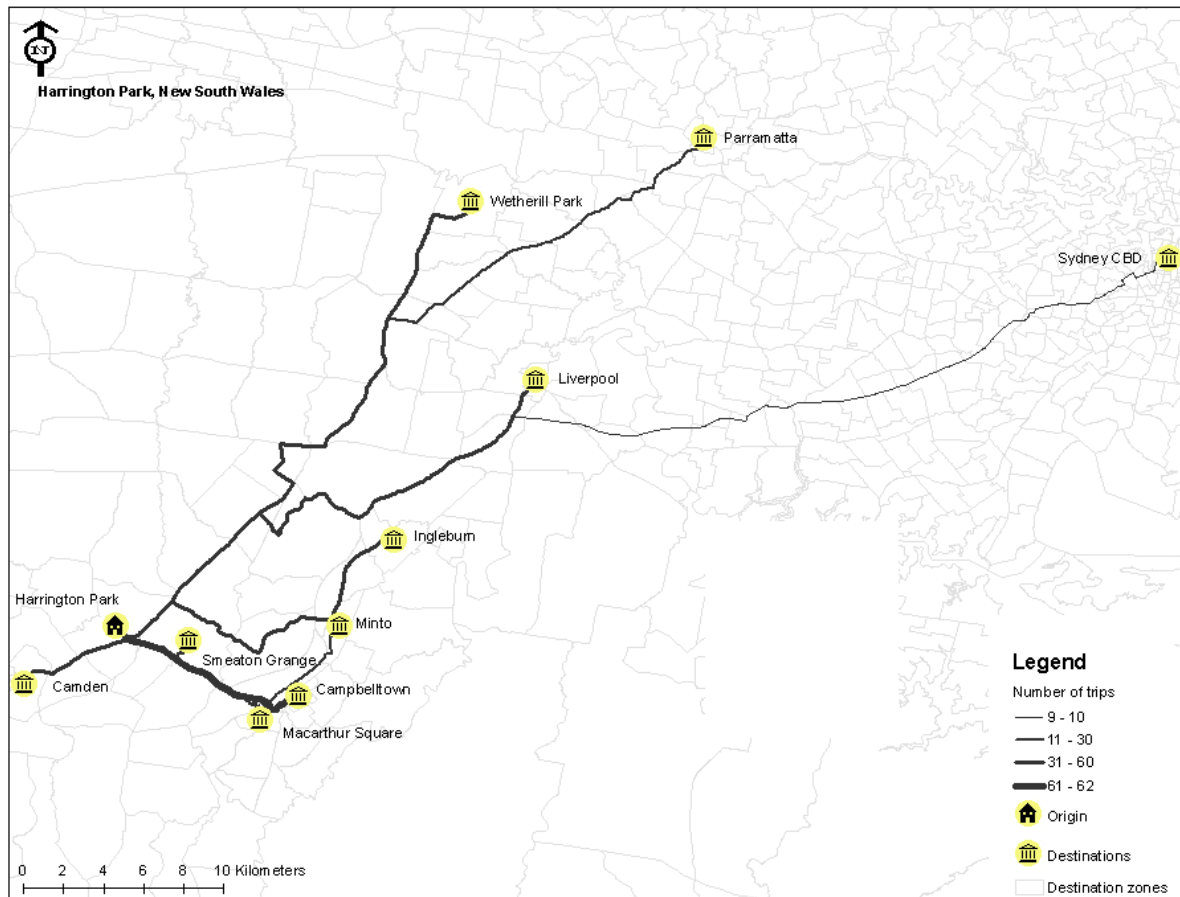


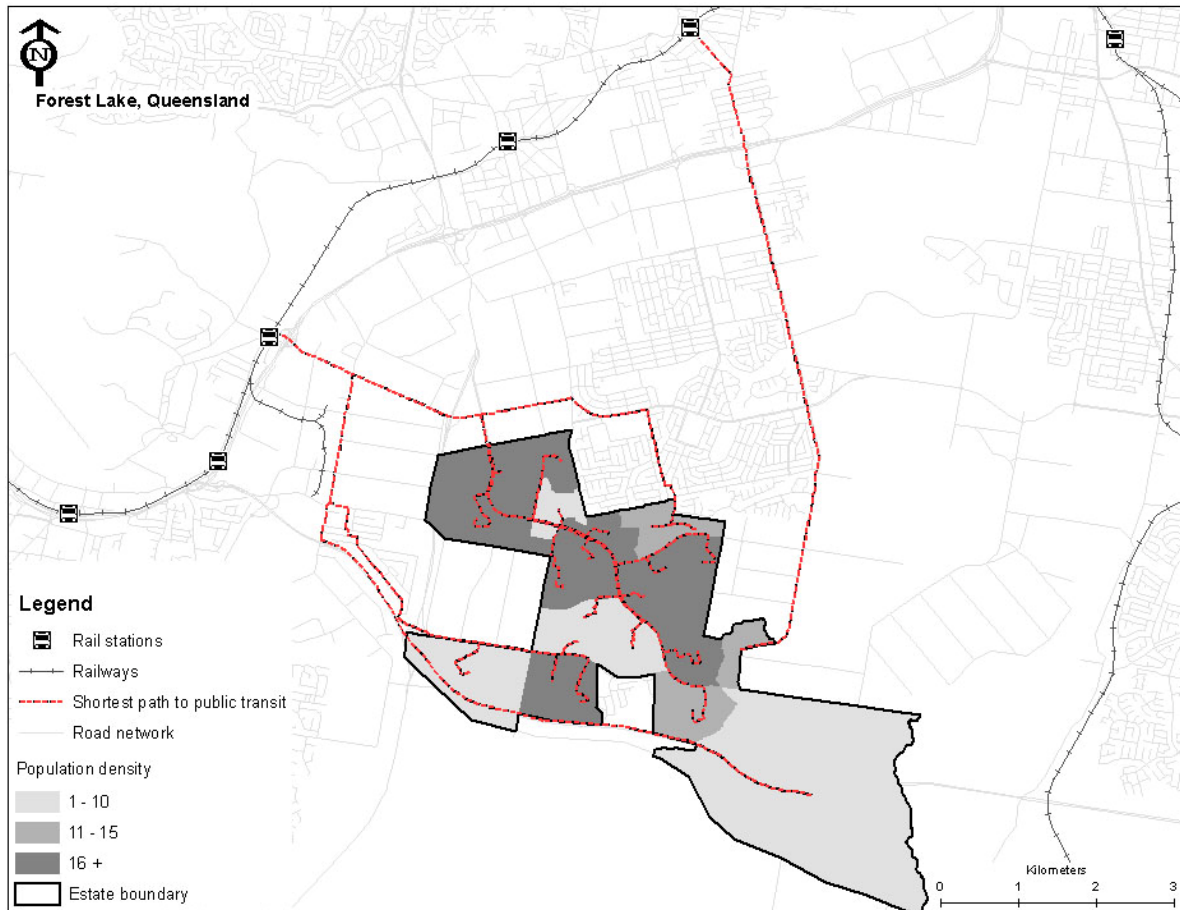
Figure 6: Census CD level travel self-containment rates

The model also included several proximity analyses that measured distances from the MPE CD centroids to such land use and transport features as the metropolitan CBD, regional employment centres and rail stations. The model, using road and/or rail networks, calculated actual rather than Euclidean distances. Figure 7 shows, as an example, the results from Sydney's Harrington Park MPE . It visually defines the proximity of the MPE to the Sydney CBD and regional employment centres. The regional employment centres were, in all cases, selected as the destinations of elevated numbers of MPE work trips.



**Figure 7: Proximity to CBD and regional employment centres**

Accessibility and the quality and frequency of public transit services are major factors in commuter modal choice (Litman 2001, 2003). To measure public transport access we determined network distance(s) from each MPE CD to the nearest public transit node(s). Unfortunately we could only measure for rail transport. Difficulty in obtaining up-to-date bus, tram and ferry routes, including stop locations and service timetables, precluded accessibility measurement for other public transport modes. Over the case study set distance to nearest rail station varies between five and nine kilometres (Table 3). In Figure 8 the Forest Lake example typifies the 'shortest path' analysis used to gauge public transport access.



**Figure 8: Proximity to public transport**

### **Factors influencing self-containment patterns**

The final stage of the project sought to identify the major demographic, land use and socio-economic factors that affect travel self-containment in MPEs. The tool of analysis was multivariate linear regression. With self-containment defined as the dependent variable it was regressed against 12 independent variables in an OLS analysis using SPSS software. The basic spatial unit of the model was the CD. There were, in total, 82 Census CDs from six different MPEs. Having 82 statistical observations enabled us to use up to eight concurrent independent variables in a single regression analysis. The selection of these variables was based on both the literature review, which identified likely factors contributing to self-containment variance, as well as pragmatic imperatives associated with data availability. The selected variables included attributes of land use, household demography, socio-economic profile and travel behaviour. The dependent variable (self-containment) and the independent variables, their formal definitions as well as their mean and standard deviations derived from 82 observations, are listed in Table 4, below.

Variables	Definition	Mean	Standard Deviation	Observations
Self-containment ( <i>DV</i> )	Percentage of work trips occurring into home destination zone(s)	9.56	4.57	82
Population Density ( <i>IV</i> )	Number of people per hectare	18.11	13.32	82
Age of Estate ( <i>IV</i> )	Years since first residents moved into the MPC	14.96	4.01	82
Proximity to CBD ( <i>IV</i> )	Kilometre distance to central business district	24.30	8.98	82
Proximity to public transport ( <i>IV</i> )	Kilometre distance to nearest rail station	6.83	1.55	82
Income level ( <i>IV</i> )	Mean weekly household income in dollars	1079	211	82
Employment level ( <i>IV</i> )	Percentage of full-time employed people	34.03	4.04	82
Education level ( <i>IV</i> )	Percentage of people with bachelor or post-graduate degree	9.13	8.55	82
Car ownership ( <i>IV</i> )	Average car ownership per dwelling	1.72	0.15	82
Travel method ( <i>IV</i> )	Percentage of motor vehicle use in work trips	60.56	20.20	82
Proximity to employment centres ( <i>IV</i> )	Average kilometre distance to five most travelled employment centres from each CD	8.17	5.13	82
Commuting distance ( <i>IV</i> )	Average kilometre distance of commuting	11.81	4.403	82
Vehicle Kilometres Travelled ( <i>IV</i> )	Vehicle kilometres travelled to and from work	8428	5364	82

*DV: Dependent variable*

*IV: Independent variable*

**Table 4: Definitions, means and standard deviations of variables**

Independent Variables	Column A: Land Use Variables only		Column B: Socio-economic Variables only		Column C: Travel Behaviour Variables only		Column D: All Variables	
	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance
Population Density	0.004	0.889	–	–	–	–	0.012	0.541
Age of estate	<b>0.603</b>	<b>0.000</b>	–	–	–	–	0.151	0.325
Proximity to CBD	0.063	0.175	–	–	–	–	<b>0.384</b>	<b>0.000</b>
Proximity to public transport	<b>0.794</b>	<b>0.008</b>	–	–	–	–	0.084	0.685
Income level	–	–	<b>0.008</b>	<b>0.032</b>	–	–	-0.004	0.107
Employment level	–	–	<b>-0.493</b>	<b>0.001</b>	–	–	-0.140	0.101
Education level	–	–	<b>0.130</b>	<b>0.022</b>	–	–	0.016	0.629
Car ownership	–	–	-5.379	0.226	–	–	<b>11.830</b>	<b>0.000</b>
Travel method	–	–	–	–	<b>-0.170</b>	<b>0.000</b>	<b>-0.200</b>	<b>0.000</b>
Proximity to employment centres	–	–	–	–	<b>-0.212</b>	<b>0.002</b>	0.026	0.734
Commuting distance	–	–	–	–	0.012	0.945	-0.219	0.190
Vehicle Kilometres Travelled	–	–	–	–	0.000	0.096	0.000	0.158
Constant	-6.503	0.007	25.875	0.000	19.839	0.000	1.232	0.830
Number of observations		82		82		82		82
R-squared		0.450		0.147		0.597		0.805
F statistics		17.566		4.484		30.952		28.802
Probability		0.000		0.003		0.000		0.000

Note: Coefficients that are significant at the 5 per cent level are shown in bold.

**Table 5: Results of Regression Analysis of MPE Travel Characteristics**

The regression equation consists of three types of independent variables. They are: (a) land use; (b) household socio-economic; and (c) travel behaviour. The variable sets were entered in the regression both separately and together and their variance in relation to the dependent variable calculated. The adjusted R squared ( $R^2$ ) values are recorded in Table 5. The  $R^2$  value reflects the proportion of the variance in travel self-containment accounted for by the regression model. The higher the  $R^2$  value the better the “explanation” of the pattern of the dependent variable by the multi-linear pattern of the independent variables. Results in Table 5 show socio-economic variables to be the least effective of the three variable sets in explaining self containment. Travel behaviour, specified in JTW and proximity measurements, had the greatest explanatory power, exceeding that of land use variables. When all variable sets were included in the model the explanatory effect was maximised. The suggestion is self-containment is best explained as a function of a combination of the variable categories.

When all the independent variables were included in the regression analysis, the adjusted  $R^2$  value was 0.805. Within this 80 percent account of the variation of the dependent variable, the regression identified five sets of highly correlated variable pairs. These pairs were:

- proximity to CBD and commuting distance;
- income level and car ownership;
- travel method and age of estate;
- VKT and proximity to CBD; and
- commuting distance and VKT.

A very close match between two variables suggests one variable is a substitute (or repeat) of the other. After careful inspection of the correlated pairs, and testing of the model to balance the minimisation of the number of independent variables (i.e., simplicity of explanation) with the maximization of  $R^2$  (breadth of explanation) only proximity to CBD, income level and travel method were retained from the above list. These three were included with population density, proximity to public transport, level of employment, level of education and proximity to employment centres to give an eight dimensional model (see Table 6, below). Of these dimensions travel method and employment level were negatively associated with self-containment. The rest contributed positively to local travel containment. The  $R^2$  value for our final model was 0.735.

In sum our regression model explains almost three-quarter of the total variance in self-containment. Collinearity checks were performed to find out whether, within the final dimension set, some of the independent variables were totally predicted by other independent variables. Some correlation was apparent but the problem was not substantive. Similarly, the standard errors were low enough relative to the coefficients to suggest the variables were, at the level of statistical significance, singularly as well as jointly independent. In short, none of the independent variables can be construed as a linear combination of the others.

In statistical analysis the level of significance measures the likelihood that the result would occur as a result of random chance. A significance level of <0.05 indicates there is a ninety-five per cent possibility the result is not due to random chance. Using a five per cent ( $p < .05$ ) significance level for the model, it was found:

- for each kilometre increase in the distance from the MPE to the CBD, the self-containment rate increased by 0.186 per cent;
- for each dollar increase in mean weekly household income, self-containment rate goes up by 0.004 per cent;
- for each percentage increase in full-time employment, the self-containment declines by 0.245 per cent; and
- for each percentage increase in motor vehicle use for the JTW, self-containment rate goes down by 0.196 per cent. (see Table 6, below, Coefficient B).

At the ten per cent ( $p < .10$ ) level of significance:

- for each percentage increase in bachelor and post-grad degrees, self-containment rate goes up by 0.059 per cent (Table 6, Coefficient B).

Independent Variables	Coefficient - B	Significance
Population Density	0.001	0.960
Proximity to CBD	<b>0.186</b>	<b>0.000</b>
Proximity to public transport	0.108	0.625
Income level	<b>0.004</b>	<b>0.019</b>
Employment level	<b>-0.245</b>	<b>0.006</b>
Education level	<i>0.059</i>	<i>0.090</i>
Travel method	<b>-0.196</b>	<b>0.000</b>
Proximity to employment centres	-0.077	0.242
Constant	20.043	0.000
Number of observations	82	
R-squared	0.735	
F statistics	29.138	
Probability	0.000	

*Note:* Coefficients that are significant at the 5 per cent level are shown in bold & at the 10 per cent level are shown in italic.

**Table 6: OLS Regression model for travel self-containment**

### Research findings and future directions

The first conclusion to be drawn from our study is that in terms of journey-to-work patterns MPEs are not as self-contained as many commentators claim. Harrington Park has the highest JTW self-containment rate of our sample with only 13.8 percent capture. The retention rate declines to a very low 3 percent

in Caroline Springs. Overall, the travel containment findings in our research are markedly lower than those of Newton et al (1997).

As MPEs locate on metropolitan fringes, and at greater distance from the CBD, they become more dependent for employment on local and regional activity centres. CBD dependency declines. This positive correlation between self-containment and distance from CBD is apparent from the results presented above. Harrington Park is the clearest example. Located most distant from its CBD it has the highest self-containment rate of all the case studies. At the other end of the scale Forest Lake, most closely situated relative to its metropolitan CBD, has the third lowest self-containment rate (see Table 3).

Travel self-containment values appear to increase in conjunction with the affluence of MPE households. Harrington Park has both the highest income level and the highest self-containment rate. Caroline Springs is its mirror reverse. It combines the lowest self-containment rate with the lowest income level. These findings unambiguously illustrate a positive statistical correlation. Garden Gates confirms the relationship. It is home to a relatively high level income population and manifests an elevated JTW retention pattern.

MPEs with a relatively greater number of retirees and part-time workers generate less external work trips compared to settlements with high full-time employment participation rates. It can be reasonably suggested that residents in full-time employment are likely to travel further to access full-time work opportunities thus depressing the locality's self-containment rate. Moreover, MPEs do not, typically, contain manufacturing industries. Rather, the service sector is the usual major proximate employer. This sector requires disproportionately high levels of part-time and casual workers. Caroline Springs and Golden Grove illustrate the negative correlation between full-time employment and self-containment. Caroline Springs has the lowest self-containment rate and the highest full-time employment ratio among all MPEs. Golden Grove has the second highest self-containment and the second lowest full-time employment ratio.

MPEs with fewer car dependent residents appear to be proportional more self-contained and more sustainable. Caroline Springs and Golden Grove again demonstrate this (negative) relation. Caroline Springs has the lowest self-containment rate and the highest car dependency rate (for work trips), whereas Golden Grove has the second highest self-containment rate and the second lowest rate of car dependency in our study.

Education appears to be a significant factor in the self-containment of the MPE work commute. It is hypothesised as education levels increase white-collar jobs proximate to the estates are readily taken up such residents. In short white-collar workers seem to have more choice in their job market. What is certain is the greater the education status in an MPE the shorter the commute times and distances. Our results show Roxburgh Park to have the second lowest higher degree ratio and the second lowest travel self-

containment rate, while Harrington Park has both the highest education level and self-containment rate.

Finally, our study shows self-containment decreases as the proportion of car-dependent work journeys increases. In sum estates poorly connected to regional employment concentrations via the public transport system generate higher levels of external and automobile travel.

The findings presented above are, as far as we are aware, the only analysis and assessment of MPE travel relationships in Australia. They should be of considerable interest to scholars, policy makers and planners. The results are preliminary, and as we discuss below, limited by methodological expedience. Nonetheless, the study has exposed important relationships in contemporary urbanism, the understanding of which would greatly benefit from further research.

### **Limitations of the study**

It is important to acknowledge the major conceptual and methodological limitations of the study. The lack of accurate, comprehensive data is the most serious constraint. This lack restricted of analysis to a comparatively small number of factors (12). The consequent model of travel self-containment is coarse. In future studies, we hope to include a larger number of variables by obtaining comprehensive travel data via direct surveys of MPE residents. Such data will permit not only more wide-ranging analysis but analysis at different geographical scales - such as the neighbourhood, the sub-region and the region.

Our pilot study, limited in case studies and observations, allows for only a preliminary explanation of self-containment patterns. More methodologically sophisticated research should enable the complexity of urban land use, demographic profile and travel behaviour to be drawn out in greater detail.

It is also important to note our OLS regression does not take spatial dependency and weight into account. Spatial weighting according to Stetzer (1982:571) represents “a priori knowledge of the strength of the relationships between all pairs of places in the spatial system.” Sophisticated spatial statistical analysis requires the specification of spatial weight matrices to capture the pattern of dependence across observed space (see Getis and Ord 1992; Anselin and Bera 1995; Getis 1995; Anselin 2002; Mitchell and Bill 2004; Mitchell and Bill 2005). Future research should include spatial statistical techniques able to account for spatial dependence and weightings.

Non-work trip generation, to supplement work travel patterns, is a key additional dimension to be included in further MPE research. Giuliano (1991) and Giuliano and Small (1993) claim work-housing balance does not by itself effectively promote travel self-containment. They argue for an additional spatial balance between home and other destination(s) travel. Richardson and Gordon (1989) found non-working trips account for approximately three-quarters of all trips in large American metropolitan areas. The European

research of Salomon et al. (1993) supports this finding. The most important non-work travel flows are for shopping, recreation and education. The fact that, in face of its known inadequacy, job-housing balance remains the most common index of travel self-containment reflects the ongoing difficulties of collecting reliable non-work trip data (Cervero 1995).

Despite the above limitations we are keen to develop a GIS-based decision support tool for local government. Its prime use would be in development assessment. It would depend on substantial prior analysis at a scale many times greater than that presented in this study, yet it would need to be user-friendly. Its task would be to identify problems and highlight opportunities in the development of MPEs. Its challenge would be to improve the design of sustainable urban forms, and both the quality and the efficiency of Government assessment.

We note that the MPEs examined in this study were selected as examples of recent practice in the Australian development context. The planning processes by which these estates were developed and the elements they incorporate may be at substantial variance with the principles of comprehensive master planning identified in the literature on balanced and sustainable communities. Further research is therefore imperative to better comprehend the links between scholarly prescriptions for sustainable development practices and the actual outcomes achieved within Australian MPEs.

## **Conclusions**

This study arose from a concern about the sustainability of urban development. A comprehensive literature review found a substantial body of empirical research evidence linking land use and travel patterns. Most of the literature and research, however, draws from North America and Europe. As such most of it is perhaps tangential to the patterns of urbanisation found in Australia. In short a simple application of borrowed concepts, methods and findings to the Australian context is inappropriate. Our pilot study is a start in developing a specifically Australian understanding of land use, travel and urban sustainability. More research is clearly needed.

The literature review suggests urban design philosophies that emphasise local-scale integration of residential and other compatible land uses are important in the development of less automobile reliant suburban communities. More specifically this requires the integration of land use and transportation planning, and a conceptual shift from the goal of mobility to the goal accessibility. Increasing the densities and compactness of cities would support the provision of public transit and non-motorised forms of transportation. There remains, however, considerable debate over the worth of such policy in Australia (Troy 1996; Newman and Kenworthy 1999; Mees 2000).

The first part of our empirical study, focused on sub-regional JTW patterns, required we develop and apply a GIS methodology to measure local area

travel self-containment values. GIS, state-of-the-art technology, is extremely productive and able to generate quick and accurate results. However, as always, the accuracy of output(s) is dependent on the quality of input data. The imperfections of our data render our conclusions tentative. Nevertheless, we have been able to broadly map a research way forward. A clearer understanding of suburban travel behaviour and the impact of MPEs is in sight.

The second part of the empirical study examined the factors that influence self-containment patterns in MPEs. Analysis finds travel preference and behaviour to account for the greatest proportion of the variance in self-containment. The most important single factors influencing travel patterns in MPEs, identified by our analysis, are:

- Distance to CBD,
- Work travel mode,
- Employment level,
- Income level,
- Education level.

These findings are preliminary and should be verified by further research.

Despite the many limitations of the study its model of urban form and travel behaviour is a useful starting point for a systematic and detailed analysis of self-containment in Australian MPEs. We anticipate continuing our work in this area. We believe it can benefit both scholarly and policy understandings of contemporary urban forms. The most important criteria, however, is it plays its part in the construction of a sustainable Australia.

## **Acknowledgements**

The authors wish to thank Griffith University Industry Collaborative Scheme and Delfin Lend Lease for funding support for this pilot study. We also would like to thank NSW Department of Transport – Transport Data Centre, VIC roads – Road System Management, QLD Department of Transport – Strategy and Planning Services, and Transport SA for providing us with JTW destination zone boundaries.

## References

- Alexander, D. and R. Tomalty (2002). "Smart growth and sustainable development: challenges, solutions, and policy directions." *Local Environment* 7: 397-409.
- Anselin, L. (2002). "Under the Hood. Issues in the Specification and Interpretation of Spatial Regression Models." *Agricultural Economics* 27: 247-267.
- Anselin, L. and A. Bera (1995). *Spatial Dependence in Linear Regression Models with an Introduction to Spatial Econometrics*. Handbook of Applied Economic Statistics. Ullah and Giles. Berlin, Springer.
- Arrington, G. and T. Parker (2001). *Factors for Success in California's Transit-Oriented Development*. State-wide Transit-Oriented Development Study. California Department of Transportation. Sacramento.
- Banister, D. and N. Lichtfield (1995). *The key issues in transport and urban development*. Transport and urban development. Banister. London, E and FN Spon: 1-16.
- Bertolini, L., F. I. Clercq and L. Kapoen (2005). "Sustainable accessibility: a conceptual framework to integrate transport and land use plan-making. Two test-applications in the Netherlands and a reflection on the way forward." *Transport Policy* 12: 207-220.
- Blair, J., M. Fisher, D. Prasad, B. Judd, V. Soebarto, R. Hyde and R. Zehner (2003). *Affordability and Sustainability Outcomes of 'Greenfield' Suburban Development and Master Planned Communities - a case study approach using triple bottom line assessment*, Australian Housing and Urban Research Institute, UNSW-UWS Research Centre.
- Boarnet, M. and S. Sarmiento (1998). "Can Land use Policy Really Affect Travel Behaviour? A Study of the Link Between Non-work Travel and Land use Characteristics." *Urban Studies* 35(7): 1155-1169.
- Bosman, C. (2003). "A District Package: Constituting - Community Golden Grove 1984-2002." *Journal of Australian Studies* 76: 17-26.
- Breheny, M. (1992). "The Compact City: An Introduction." *Built Environment* 18(4): 241-246.
- Burby, R. and S. Weiss (1976). *New Communities USA*. Lexington, MA: Lexington Books.
- Burke, M. (2005). *Gated Communities and Residential Travel Behaviour*. School of Geography, Planning and Architecture. PhD dissertation, University of Queensland, Brisbane.
- Camagni, R., M. Gibelli and P. Rigamonti (2002). "Urban mobility and urban form: the social and environmental costs of different patterns of urban expansion." *Ecological Economics* 40: 199-216.
- Campbelltown and Liverpool City Councils (2004). *Edmondson Park background report*. Sydney, Campbelltown City Council and Liverpool City Council.
- Cervero, R. (1989). "Jobs-housing balance and regional mobility." *Journal of the American Planning Association* 55(Z): 136-150.
- Cervero, R. (1995). "Planned communities, self-containment and commuting: a cross-national perspective." *Urban Studies* 32(7): 1135-1161.
- Cervero, R. (1996). "Mixed Land uses and Commuting: Evidence from the American Housing Survey." *Transpn Res.-A* 30(5): 361-377.

- Cervero, R. (1997). "Paradigm Shift: From Automobility to Accessibility Planning." *Urban Futures Journal* 22(9-20).
- Cervero, R. (1998). *The Transit Metropolis: A Global Inquiry*. Washington DC, Island Press.
- Cervero, R. (2001). "Transport and Land Use." *Australian Planner* 38(1): 29-37.
- Cervero, R. and M. Duncan (2003). "Walking, Bicycling, and Urban Landscapes: Evidence from the San Francisco Bay Area." *American Journal of Public Health* 93(9): 1478-1483.
- Cervero, R., C. Ferrell and S. Murphy (2002). *Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects*. Legal Research Digest 52, Transit Cooperative Research Program. Transportation Research Board of the National Academies: 1-144.
- Cervero, R. and R. Gorham (1995). "Commuting in transit versus automobile neighbourhoods." *Journal of the American Planning Association* 61: 210-225.
- Cervero, R. and K. Kockelman (1997). "Travel demand and the three Ds: density, diversity, and design." *Transpn Res.-D* 2(3): 199-219.
- Cervero, R., S. Murphy, C. Ferrell, N. Goguts and Y. Tsai (2004). *Transit-Oriented Development and Joint Development in the United States: A Literature Review*. Legal Research Digest 102, Transit Cooperative Research Program. Transportation Research Board of the National Academies: 1-534.
- Commonwealth of Australia (1995). *Australian Model Code on Residential Development A: National Resource Document for Residential Development*. Canberra, Commonwealth Department of Housing and Regulation Development.
- Cowley, J. and S. Spillette (2000). "Master Planned Communities Market Lifestyles." *Homebuying* 1426: 1-6.
- Crane, R. (2000). "The Influence of Urban Form on Travel: An Interpretive Review." *Journal of Planning Literature* 15(1): 3.
- Crane, R. and R. Crepeau (1998). "Does Neighbourhood Design Influence Travel? A Behavioural Analysis of Travel Diary and GIS Data." *Transpn Res.-D* 3(4): 225-238.
- Curtis, C. and B. James (2004). "An Institutional Model for Land Use and Transport Integration." *Urban Policy and Research* 22(3): 277-297.
- Dalvi, M. and K. Martin (1976). "The measurement of accessibility: some preliminary results." *Transportation* 5: 17-42.
- Debenham, J., J. Stillwell and G. Clarke (2003). "The estimation of self-containment and catchment size indicators for use in small area classification." *International Journal of Population Geography* 9(3): 253-271.
- Delfin Lend Lease (2005). *Yarrabilba Master Planned Community Project*. 2005.
- Dieleman, F., M. Dijst and G. Burghouwt (2002). "Urban Form and Travel Behaviour: Micro-level Household Attributes and Residential Context." *Urban Studies* 39(3): 507-527.
- Dodson, J. (2003). *Is there a spatial mismatch between housing affordability and employment opportunity in Melbourne? State of Australian Conference 2003, Parramatta*.

- Dodson, J. and M. Berry (2003). Community Regeneration in Melbourne's West? AHURI: RMIT-NATSEM Final Report.
- DOI (1996). Urban Villages Project: Encouraging Sustainable Urban Form. Melbourne, Victorian Department of Infrastructure.
- DOI (2002). Melbourne 2030: Planning for Sustainable Growth. Melbourne, Victorian Department of Infrastructure.
- Ewing, R. (1994). "Characteristics, causes, and Effects of Sprawl: A Literature Review." *Environmental and Urban Issues* 21(2): 1-15.
- Ewing, R. and R. Cervero (2001). "Travel and the Built Environment; A Synthesis, Transportation Research Record." *Journal of the Transportation Research Board*(Paper No. 01-3515): 87-114.
- Ewing, R., M. DeAnna and S. Li (1996). "Land Use Impacts on Trip Generation Rates." *Transportation Research Record* 1518: 1-6.
- Ewing, R., P. Haliyur and G. Page (1993). Getting around a Traditional City, a Suburban PUD and everything in between. *Alternative Transportation: Planning, Design, Issues, Solutions: Proceedings of the 14th International Pedestrian Conference*, Boulder.
- Forrest, J. (1996). "Place of Residence, Place of Work: The Spatial Clustering of the Journey to Work in Sydney." *Australian Planner* 33(3): 132-135.
- Forsyth, A. (1997). "Five Images of a Suburb: Perspectives on a New Urban Development." *Journal of the American Planning Association* 63(1): 45-60.
- Gale, D. and S. Hart (1992). "Public support for local comprehensive planning under state-wide growth management: Insights from Maine." *Journal of Planning Education and Research* 11(3): 192–205.
- Geerlings, H. and D. Stead (2003). "The integration of land use planning, transport and environment in European policy and research." *Transport Policy* 10: 187-196.
- Getis, A. (1995). *Spatial filtering in a regression framework: examples using data on urban crime, regional inequality, and government expenditures. New directions in spatial econometrics.* Anselin and Florax. Berlin, Springer.
- Getis, A. and J. Ord (1992). "The analysis of spatial association by use of distance statistics." *Geographical Analysis* 24(3): 189-206.
- GISCA (2005). *About ARIA+ (Accessibility/Remoteness Index of Australia).* Adelaide, University of Adelaide. 2005.
- Giuliano, G. (1991). "Is Jobs-Housing Balance a Transportation Issue?" *Transportation Research Record* 1305: 305-312.
- Giuliano, G. and K. Small (1993). "Is the journey to work explained by urban structure?" *Urban Studies* 30: 1485–1500.
- Gordon, P. and H. Richardson (1989). "Gasoline Consumption and Cities: A Reply." *Journal of the American Planning Association* 55(3): 342-345.
- Gwyther, G. (2002). *Socio-Spatial Differentiation and the Master Planned Community in a Global City.* Research Paper No.8, UWS. Program.
- Gwyther, G. (2003). *Paradise Planned: Socio-economic Differentiation and the Master Planned Community on Sydney's Urban Fringe.* State of Australian Cities National Conference, Parramatta.
- Gwyther, G. (2005). "Paradise Planned: Community Formation and the Master Planned Estate." *Urban Policy and Research* 23(1): 57-72.
- Hall, P. (1988). *Cities of Tomorrow.* Oxford, Blackwell.

- Hall, P., R. Thomas, H. Gracey and R. Drewett (1973). *The Containment of Urban England*. London, Allen and Unwin.
- Handy, S. (1993). "Regional versus local accessibility: implications for nonwork travel." *Transportation Research Record* 1400: 58-66.
- Handy, S. (1995). *Understanding the Link between Urban Form and Travel Behaviour*. Paper presented at the 74th Annual Meeting. Board. Washington D.C.
- Handy, S. (1996). "Methodologies for Exploring the Link between Urban Form and Travel Behaviour." *Transportation Research D: Transport and Environment* 1(2): 151-165.
- Handy, S. (2002). *Accessibility- vs. Mobility-Enhancing Strategies for Addressing Automobile Dependence in the U.S.* European Conference of Ministers of Transport.
- Hansen, W. (1959). "How Accessibility Shapes Land Use." *Journal of the American Planning Institute* 25(73-76).
- Healy, E. and K. O'Connor (2001). "Jobs and Housing Location in Melbourne, 1986-1996." *Australian Planner* 38(1): 9-15.
- Hess, P., A. Moudon, M. Snyder and K. Stanilov (1999). "Site Design and Pedestrian Travel." *Transportation Research record* 1674: 9-19.
- Hui, E. and M. Lam (2005). "A Study of Commuting Patterns of New town residents in Hong Kong." *Habitat International* 29(3): 421-437.
- Jarvis, H. (2003). "Dispelling the Myth that Preference makes Practice in Residential Location and Transport Behaviour." *Housing Studies* 18(4): 587-606.
- Jenks, M., E. Burton and K. Williams (1996). *The compact city: A sustainable form?* London, E & FN Spon.
- Kitamura, R., P. Mokhtarian and L. Laidet (1997). "A micro-analysis of land use and travel in five neighbourhoods in the San Francisco Bay Area." *Transportation* 24: 125-158.
- Kockelman, K. (1997). "Travel behaviour as function of accessibility, land use mixing, and land use balance: evidence from San Francisco Bay Area." *Transportation Research Record* 1607: 116-125.
- Krizek, K. (2003). "Residential Relocation and Changes in Urban Travel: Does Neighbourhood-scale Urban Form Matter?" *Journal of the American Planning Association* 69(3): 265-281.
- Lee, M. and K. Goulias (1997). *Accessibility Indicators for Transportation Planning Using GIS*.
- Levinson, D. (1998). "Accessibility and the Journey to work." *Journal of Transport Geography* 6(1): 11-21.
- Levinson, D. and A. Kumar (1994). "Operational evidence for changing travel patterns." *ITE Journal*: 30-40.
- Litman, T. (2001). "Evaluating Transportation Choice, Transportation Research Board." *Journal of the Transportation Research Record* 1756: 32-41.
- Litman, T. (2003). "Measuring Transportation: Traffic, Mobility and Accessibility." *The Institute of Transportation Engineers Journal* 73(10): 28-32.
- McCormack, E., S. Rutherford and M. Wilkinson (2001). "Travel Impacts of Mixed Land Use Neighbourhoods in Seattle, Washington,

- Transportation Research Record: Paper No. 01-2588." Journal of the Transportation Research Board: 24-32.
- McNabb, P. and Melbourne University Research Team (2001). Activity Centres Review - A Study of policy and centres of activity in metropolitan Melbourne and Geelong: Final Report.
- Mees, P. (2000). A Very Public Solution: Transport in the Dispersed City. Melbourne, Melbourne University Press.
- Miller, E. and A. Ibrahim (1998). "Urban Form and Vehicular Travel; Some Empirical Findings: Paper No. 98-1067." Journal of the Transportation Research Board(No. 1617): 18-27.
- Minnery, J. and B. Bajracharya (1999). "Visions, Planning Processes and Outcomes: Master Planned Communities in South East Queensland." Australian Planner 36(1): 33-41.
- Mitchell, W. and A. Bill (2004). Spatial dependence in regional unemployment in Australia. A Future that works: economics, employment and the environment.
- Mitchell, W. and A. Bill (2005). A spatial econometric analysis of the irreversibility of long term unemployment in Australia. Working Paper No. 05-05: Centre of Full Employment and Equity. The University of Newcastle.
- Naess, P., P. Rue and S. Larsen (1995). "Travelling Distances, modal Split and Transportation Energy in Thirty Residential areas in Oslo." Journal of Environmental Planning and Management 38(3): 349-370.
- Naess, P. and S. Sandberg (1996). "Workplace Location, Modal Split and Energy Use for Commuting Trips." Urban Studies 33(3): 557-580.
- Newman, P. (1991). Sustainable urban structures: Overcoming automobile dependence. Seminar on Sustainable Municipalities. retrieved from <http://www.istp.murdoch.edu.au/teaching/istpline/studygds/S455/Week%201.html> on 27 June 2005, Danish Building Research Institute.
- Newman, P. (1996). "Reducing Automobile Dependence." Environment and Urbanization 8(1): 67-92.
- Newman, P. and J. Kenworthy (1989). Cities and Automobile Dependence: An International Sourcebook. Brookfield, VT, Gower Publishing.
- Newman, P. and J. Kenworthy (1992). "Is There a Role for Physical Planners?" Journal of the American Planning Association 58(3): 24-37.
- Newman, P. and J. Kenworthy (1996). "The land use - transport connection: An overview." Land Use Policy 13(1): 1-22.
- Newman, P. and J. Kenworthy (1999). Sustainability and Cities: Overcoming Automobile Dependence. Washington D.C., Island Press.
- Newton, P., J. Britchie and P. Gipps (1997). Cities in Transition: Changing Economic and Technological Processes and Australia's Settlement System. Australia: State of the Environment, Technical Paper Series.
- Ong, P. and E. Blumenberg (1998). "Job Access, Commute and Travel Burden among Welfare Recipients." Urban Studies 35(1): 77-93.
- Owens, S. (1986). Energy, Planning and Urban Form. London, Pion.
- Polzin, S. (2004). The Relationship between Land Use, Urban Form and Vehicle Miles of Travel: The State of Knowledge and Implications for Transportation Planning. White Paper Prepared for the Florida Department of Transportation, University of South Florida.

- Rickaby, P., J. Steadman and M. Barret (1992). Patterns of land use in English towns: implications for energy use and carbon dioxide emissions. *Sustainable Development and Urban Form*. Breheny. London, Pion.
- Salomon, I., P. Bovy and J. Orfeuil (1993). A billion trips a day: Tradition and transition in European travel patterns. Dordrecht, Kluwer.
- Salomon, I. and P. Mokhtarian (1998). "What happens when mobility-inclined market segments face accessibility-enhanced policies?" *Transpn Res.-D* 3(3): 129-140.
- Schmitz, A. and L. Bookout (1998). Trends and Innovations in Master planned Communities, Urban Land Institute.
- Schwanen, T., M. Dijst and F. Dieleman (2004). "Policies for Urban Form and their Impact on Travel: The Netherlands Experience." *Urban Studies* 41(3): 579-603.
- Scott, A. (1998). *Metropolis*. Berkeley, University of California Press.
- SEQROC (2005). South East Queensland Regional Plan 2005-2006. South East Queensland Regional Organisation of Councils. Brisbane.
- Sipe, N., T. Yigitcanlar, M. Burke and R. Evans (2005). Land Use and Public Transportation Accessibility Index: LUPTAI Phase One Report. Brisbane, Urban Research Program, Griffith University.
- Southworth, M. and P. Owens (1993). "The Evolving Metropolis: Studies of Community, Neighbourhood, and Street Form at the Urban Edge." *Journal of the American Planning Institute* 59: 271-287.
- Stead, D. (2001). "Relationships between Land Use, Socioeconomic Factors, and Travel Patterns in Britain." *Environment and Planning B: Planning and Design* 28: 499-528.
- Stead, D., J. Williams and H. Titheridge (2000). Land use, transport and people: identifying the connections. *Achieving Sustainable Urban Form*. Williams, Burton and Jenks. London, E & FN Spon: 174-186.
- Stetzer, F. (1982). "Specifying Weights in Spatial Forecasting Models: The Results of Some Experiments." *Environment and Planning* 14: 571-584.
- Thomas, R. (1969). London's new towns: A study of self-contained and balanced communities. London, PEP.
- Troy, P. (1996). *The Perils of Urban Consolidation*, The Federation Press.
- Vickerman, R. (1974). "Accessibility, attraction, and potential: a review of some concepts and their use in determining mobility." *Environment and Planning A* 6: 675-691.
- Williams, K., E. Burton and M. Jenks (2000). *Achieving Sustainable Urban Form*. London, E& FN Spon.
- Wood, D. (2002). "Selling the Suburbs: Nature, Landscape, Adverts, Community." *Transformations*(5): 1-10.