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Travel Self-Containment in Master Planned Estates: Analysis of Recent Australian Trends

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ABSTRACT

Low density suburban development and excessive use of automobiles are associated with serious urban and environmental problems. Master planned development suggests itself as a possible palliative for these ills. This study examines the patterns and dynamics of movement in a selection of master planned estates in Australia with the aim of developing new approaches for assessing the containment of travel within planned development. A geographical information systems 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 findings of the pilot study demonstrate that proposed model is a useful starting point for a systematic and detailed analysis of self-containment in master planned estates.

Keywords

Travel self-containment, urban containment, urban form and travel behaviour, master planned estate, master planned community.

INTRODUCTION

The relationship between urban form and travel behaviour has been of substantial interest to urban researchers over the past four decades (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).

The key aim of this research is to investigate some of the complexities linking urban form, urban structure and travel behaviour by exploring and mapping travel self-containment in master planned estates (MPEs). The notion of 'travel self-containment' is used 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 needs without recourse to multiple external journeys involving dispersed destinations. Local travel reduces automobile use, adding to the environmental sustainability of a region.

This study is focused on Australian MPEs as to date there has been limited international consideration of travel containment in these developments. The only published international research on this topic was conducted by Ewing et al (2001). They examined 20 master-planned communities (MPCs) in South Florida and found the rates of self-containment ranged from 0-57 percent. In attempting to predict rates of self-containment they found two significant relationships – the size and scale of the MPE positively influenced self-containment rates while regional accessibility had a negative impact. Most of the other studies of travel and MPEs do not explicitly address the issue of self-containment (Gordon and Richardson 1989; Breheny 1992; Newman and Kenworthy 1992).

There are some differences between the mode and form of development that occurs under the rubric of 'master planning' in the US compared to Australia. In the US the term 'master planned' refers to the inclusion of a wider range and mix of land-uses than conventional housing estates. In Australia residential master planning on greenfield sites typically denotes the comprehensive prescription design and layout of the entire development which contrasts with traditional Australian residential designs that focused on subdivision of land with little attention to broader amenity. While contemporary Australian MPEs include some local provision for retail and commercial land-uses these are not generally present at a similar scale or comprehensiveness to that usually found in US master plans.

The question of whether Australian master planning produces positive transport behaviour remains critical to concerns about community cohesiveness and transport sustainability, given the contemporary prominence of this development mode. Information about self-containment rates at the suburb level in Australian cities is scant. There has been no research into the travel self-containment rates of MPCs in Australia.

This study investigates a set of locational, design and social variables, associated with self-containment and internal trip capture, in selected Australian MPEs. The objectives of the research are: to define local area travel containment; to examine the extent of travel self-containment in suburban localities with a geographical information system (GIS) based empirical analysis of suburban localities - using Australian Bureau of Statistics (ABS) Census journey-to-work (JTW) data for MPEs; and to identify the relationship between land-use characteristics (urban structure), household socio-economic profiles and travel preferences in MPEs.

The research reported here investigates three primary 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?

The methodology is threefold. First, the paper reviews existing literature on self-containment and reports on the major conclusions of this scholarship. The paper then analyses 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).

LITERATURE REVIEW

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, where the concept was first promoted by Ebenezer Howard via the Garden City Movement of the 1880s. It is usually understood as the number of people living and working in the same locally defined area or as Burby and Weiss (1976) state a local community with an even jobs-housing balance. A 'travel self-containment rate' is used to characterise, with a number, the fundamental pattern of travel of spatially-bound residents (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 needs. These conditions, in effect, reduce automobile use thus adding to regional environmental sustainability.

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 the '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).

Australian cities and towns designed to promote self-containment have rarely fulfilled their planner's ambitions. Newton et al. (1997) found that at the local government level travel self-containment rates of Australian capital cities are rather low (between 0.1 and 14.1%). In Canberra's new towns the employment self-containment rate is about 30 percent - half the original goal of the National Capital Development Commission (McNabb and MURT 2001).

Internationally travel self-containment rates were also as low as Australian figures. The new towns of Hong Kong and Seoul have, similarly (around 15%), been disappointing (Hui and Lam 2005). With its satellite towns Stockholm planned for a more modest target of 50 percent self-containment. Again only about half as many workers as anticipated were employed locally (Cervero 1998).

In recent years Australia's urban policy makers are revisiting the notion of local area self-containment and, more modestly, high travel self-containment as a key residential policy concern (Curtis 2005). 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 South East Queensland (SEQ) Regional Plan (SEQRP) 2026 has identified improvements to local self-containment, particularly at the urban fringe, as an important dimension of regional sustainability. SEQRP 2026 hopes to achieve these higher levels of self-containment with greater integration of employment, services and population distribution (SEQROC 2005). The SEQRP 2026 (SEQROC

2005: 107) declares “[t]he Regional Plan places a strong emphasis on improving the public transport system… Policy directions include more compact forms of urban development and self-containment of travel”.

Travel Containment of MPEs

A developing practice in North America since the 1960s, master planned development has, in the last 15 years, made its mark in Australia. MPEs 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).

MPEs are often claimed to provide a strong sense of community identity, traffic and property safety, and to promote self-containment of travel within their region (Heim 2001; Blair et al. 2003). They are purported to conserve non-renewable energy sources and to reduce high levels of vehicular movement (Commonwealth of Australia 1995). Further, the aim of MPEs is to use available infrastructure and land more efficiently and, with higher density development, to increase resource and transport efficiencies (Blair et al. 2003).

Although MPEs have attracted the attention of international scholars interested in the links between urban form and generated travel behaviour

(Gordon and Richardson 1989; Breheny 1992; Newman and Kenworthy 1992), only few empirical studies, however, have been completed into travel behaviour in MPEs (Ewing et al. 1993; Cervero 1995). In Australia, while a number scholars have investigated MPEs, they have largely concentrated on the physical, environmental and social issues of such developments, rather than travel patterns (Forsyth 1997; Minnery and Bajracharya 1999; Wood 2002; Blair et al. 2003; Bosman 2003; Gwyther 2005).

In recent years MPEs have become the dominant form of urban expansion in Australia, and are replacing traditional regulatory subdivisions (Blair et al. 2003). Developers are also starting to recognise the importance of self-containment for new MPEs. 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 (Campbelltown and Liverpool city councils 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 Yarrabilba MPE development anticipates a mix of local activities sufficient to generate higher self-containment than that of conventional outer urban developments. Yarrabilba, proposed to start in 2007, will eventually house 52,000 people. Delfin commitment to self-containment is part of the company's broader goal of creating 'balanced communities' via a local mix of housing and employment (Delfin Lend Lease 2005).

Although there is interest from Australian developers and policy makers in the concept of travel containment, the 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.

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 six parts. First, we discuss research design. We then introduce the case study MPEs and discuss sources of empirical data and their limitations. Third, 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 and identifying data and methodological limitations.

Research Design

GIS-based analysis is increasingly used in land-use and transportation research (Crane and Crepeau 1998; Yigitcanlar et al. 2006). 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 JTW data from the 2001 ABS Census (Figure 1).

[FIGURE 1 IS ABOUT HERE]

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 (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.

Crane (2000) categorises methods of analysis of urban form and travel under three headings: Simulations, descriptive studies, and multivariate analysis. 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). This method is commonly used in research into the link between urban form and travel patterns (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 (Yigitcanlar and Duvarci 2006). 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; and
- 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 urban structure, travel and household characteristics as independent variables to represent it (Table 1). 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 (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.

[TABLE 1 IS ABOUT HERE]

Case Studies

Data and data gathering constraints restricted our case study to the following six MPEs, which are all located in metropolitan regions (Figure 2):

[FIGURE 2 IS ABOUT HERE]

The study MPEs were selected among the MPEs that: (i) their development commenced before 2000; and (ii) had at least 50 percent occupation rate by the 2001 Census. Some of the salient characteristics of these MPEs are: low to medium-low densities; medium to medium-high resident income levels; high level car ownership and dependency; distant from CBD; and a low travel self-containment rate (Table 2) [(i)].

[TABLE2 IS ABOUT HERE]

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 Census collection district (CCD) – variable areas with boundaries determined such that each CCD contains approximately 200 households. Workplace destination is specified at the level of the destination zones (DZN) [(ii)].

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 CCD 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 networks to yield a travel route distance. Each CCD-DZN route distance was then multiplied by the number of recorded trips, to calculate a residence-to-work vehicle kilometres travelled (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 IS ABOUT HERE]

[FIGURE 4 IS ABOUT HERE]

The next task of the study was to measure the travel self-containment values for MPEs. Work trips from each CCD to each DZN were calculated. The ratio of work trips from a given CCD to the DZN, which includes the home CCD, as a percentage of total work trips from that CCD provides the self-containment ratio for that CCD (Figure 5 and 6).

[FIGURE 5 IS ABOUT HERE]

[FIGURE 6 IS ABOUT HERE]

The model also included several proximity analyses that measured distances from the MPE CCD centroids to such land-use and transport features as the metropolitan central business district (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 IS ABOUT HERE]

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 distances from each MPE CCD to the nearest public transit nodes. 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 2). In Figure 8 the Forest Lake example typifies the 'shortest path' analysis used to gauge public transport access.

[FIGURE 8 IS ABOUT HERE]

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 CCD. There were, in total, 82 Census CCDs 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 (Cervero and Gorham 1995; Handy 1996; Crane 2000; Polzin 2004), 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 3.

[TABLE3 IS ABOUT HERE]

The regression equation consists of three types of independent variables. They are: (a) urban structure; (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 4. 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 4 show socio-economic variables to be the least effective – because of the low coefficients – of the three variable sets in explaining or having major influence on self-containment levels. Travel behaviour, specified in JTW and proximity measurements, had the greatest explanatory power, exceeding that of urban structure 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.

[TABLE4 IS ABOUT HERE]

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 or interdependent relations between variables. 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 (Table 5). Of these dimensions travel method and employment level were negatively associated with self-containment, meaning that MPEs with more car-based JTW trips and more full-time employment (as well as other factors) would likely to have a lower self-containment levels. 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 percent possibility the result is not due to random chance. Using a five percent ($p<.05$) 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 percent;
- for each dollar increase in mean weekly household income, self-containment rate goes up by 0.004 percent;
- for each percentage increase in full-time employment, the self-containment declines by 0.245 percent; and
- for each percentage increase in motor vehicle use for the JTW, self-containment rate decreases by 0.196 percent. (see Table 5, Coefficient B).

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

- for each percentage increase in bachelor and post-grad degrees, self-containment rate goes up by 0.059 percent (Table 5, Coefficient B).

In summary, when distance to CBD, income and higher education levels, part-time and casual employment, and non car-based JTW trips increases, travel self-containment rates of MPEs would likely to increase accordingly.

[TABLE 5 IS ABOUT HERE]

CONCLUSIONS AND FURTHER RESERACH

The first conclusion to be drawn from our study is that in terms of JTW 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 three percent in Caroline Springs. Overall, the travel self-containment findings in our research are as low as 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 and less dependent on the metropolitan CBD. 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 (Table 2).

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 with the lowest self-containment rate and income levels. 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, which employs 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 owner residents appear to represent a proportionally higher rate of self-containment and more sustainability. Caroline Springs and Golden Grove again demonstrate this (negative) relation. Caroline Springs has the lowest self-containment rate and the highest car ownership rate (for work trips), whereas Golden Grove has the second highest self-containment rate and the second lowest rate of car ownership in our study.

Education appears to be a significant factor in the self-containment of the MPE work commute. It is hypothesised that 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 other words, estates poorly connected to regional employment concentrations via the public transport system generate higher levels of external and automobile travel.

Although the results are preliminary, and as we discuss below, limited by methodological expedience, the study has exposed important relationships in contemporary urbanism, the understanding of which would greatly benefit from further research.

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 the 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.

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 (Getis 1995; Anselin 2002; Mitchell and Bill 2005). Our future research will include spatial statistical techniques able to account for spatial dependence and weightings.

The self-containment ratios for MPEs are determined by the availability (also capacity, accessibility and quality) of land-use destinations (i.e. employment, shopping, recreational, education, health) within their DZNs.

For example, if a MPE has 1,000 employed workers, located in a DZN with only 500 jobs, then even all of these local jobs were taken by the workers of this MPE, self-containment could still never be more than 50 percent.

Non-work trip generation, to supplement work travel patterns, is a key additional dimension to be included in further 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 destinations travel. Richardson and Gordon (1989) found non-working trips account for approximately three-quarters of all trips in large American metropolitan areas, which is supported by the European research of Salomon et al. (1993). 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).

Along with self-containment another possible way to reflect environmental impact of travel is simply averaging VKT per head of population, measured across all trips, and to explore how land-use, socio-economic and travel variables impact on VKT. This could be undertaken by comparing ‘master planned’ and ‘traditional regulatory subdivision’ developments in similar locations with similar socio-economic characteristics, to see if master planning was having any impact on overall travel behaviour, over and above the impact of other variables.

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.

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NOTES

[i] Total daily journey-to-work vehicle kilometres of the employed residents is referred as "vehicle kilometres travelled" in Table 2. When we divide this value by the number of employed residents and then divide it by 2, we are

left with one way vehicle kilometres travelled per employed capita which is referred as “average commuting distance”.

(ii) The 2001 Census of Population and Housing, as well as 2001 Census boundaries and 2001 Census ‘Detailed Study Area’ JTW data, were obtained from the ABS. Detailed Study Areas have been created by State transport agencies and comprise DZNs that aggregate to statistical local areas. The core data was JTW detail collected at the level of the CCD. 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.

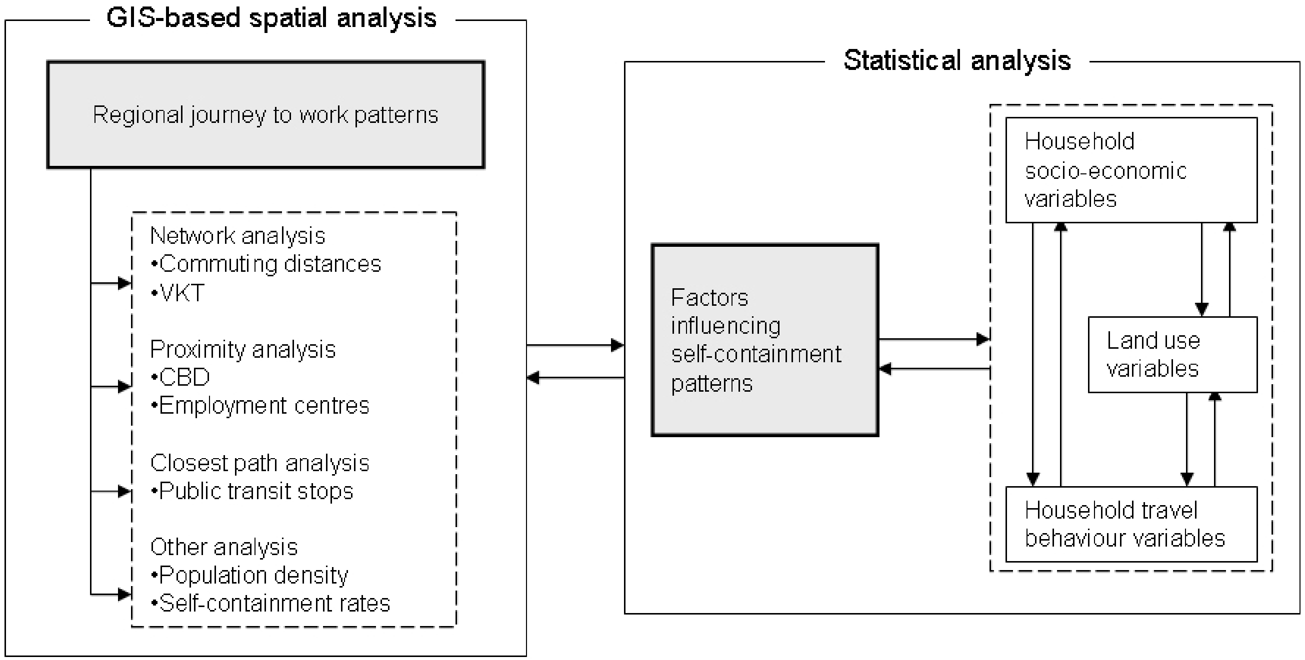

Figure 1: Model for analysing JTW and self-containment patterns

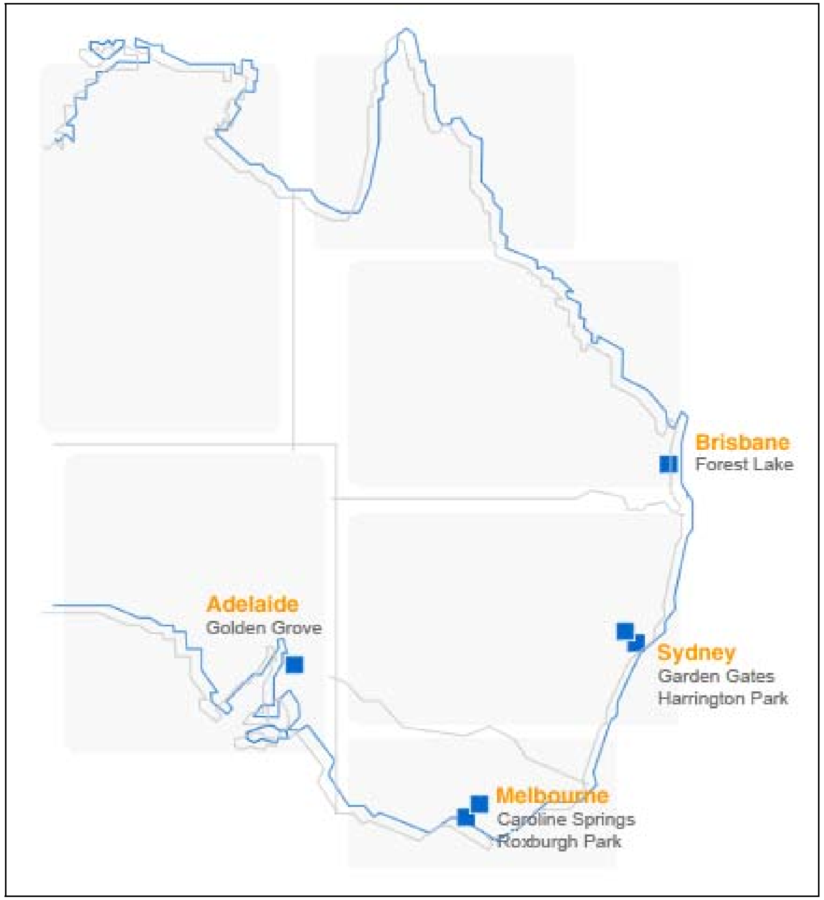

Figure 2: Location of the case studies

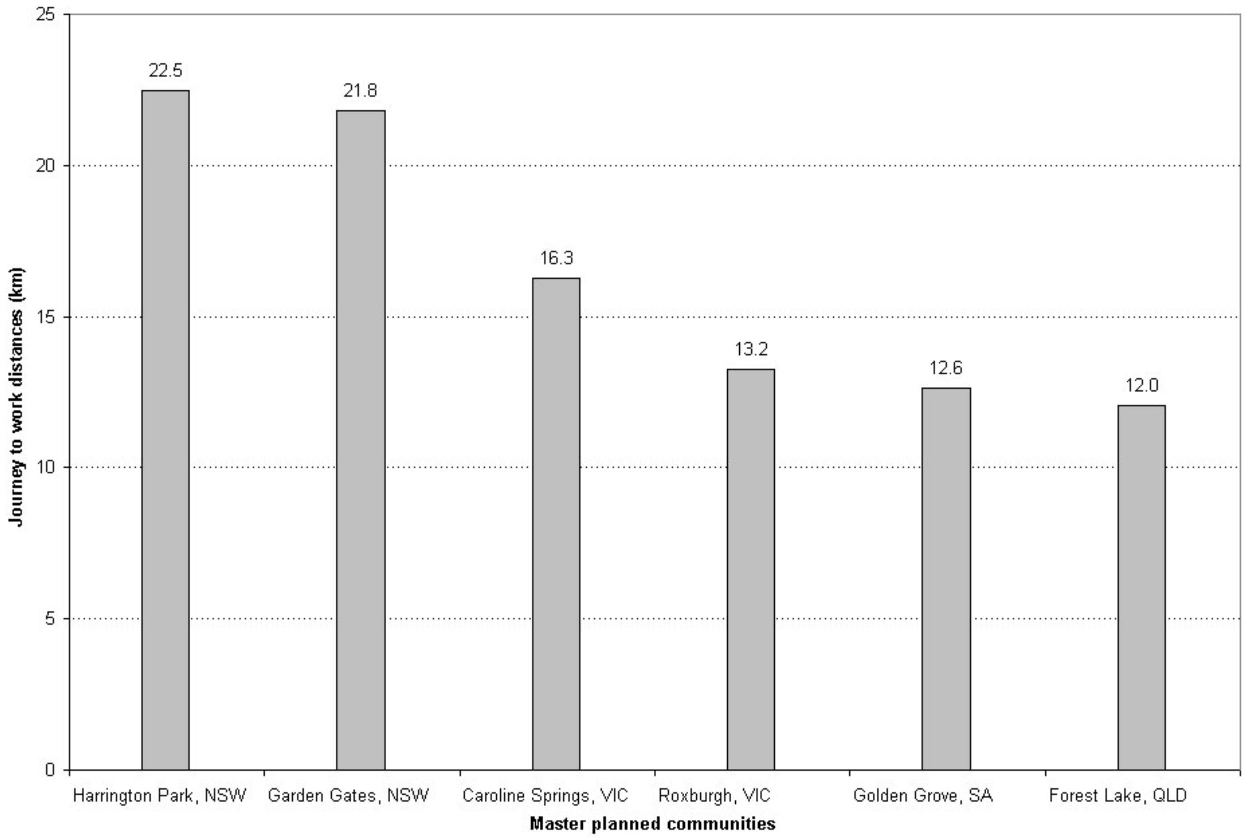

Figure 3: Average commuting distances

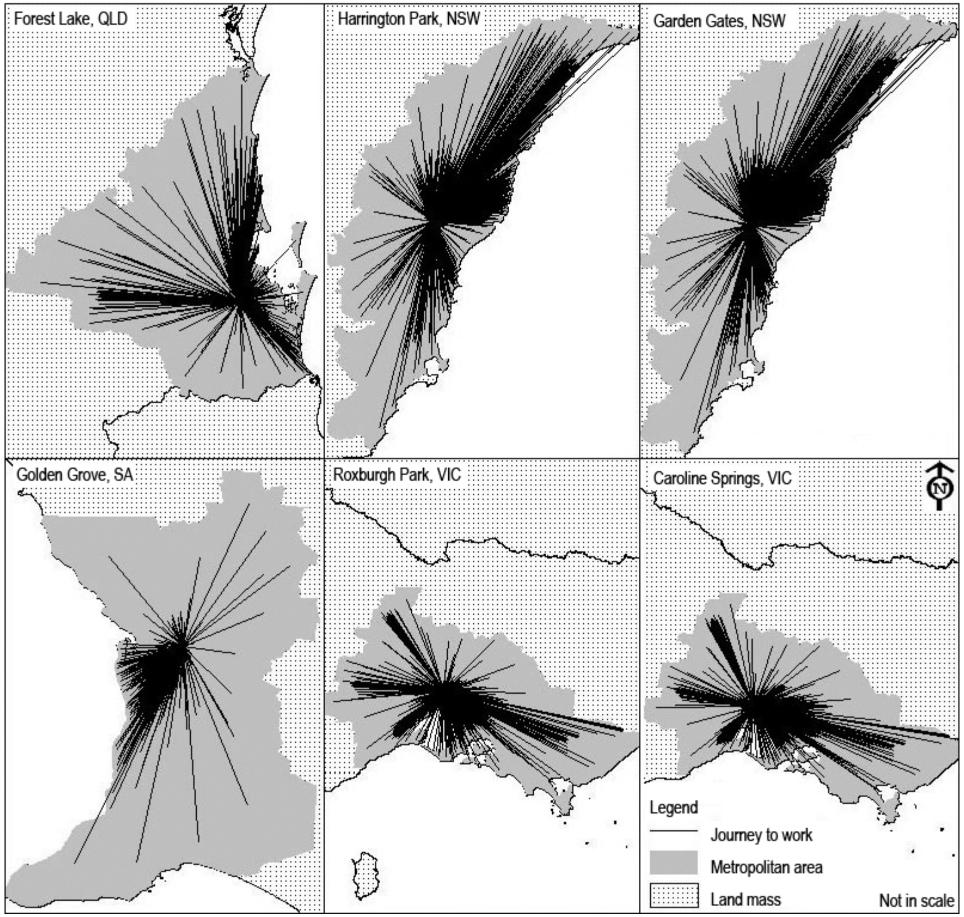

Figure 4: Distribution of work trips

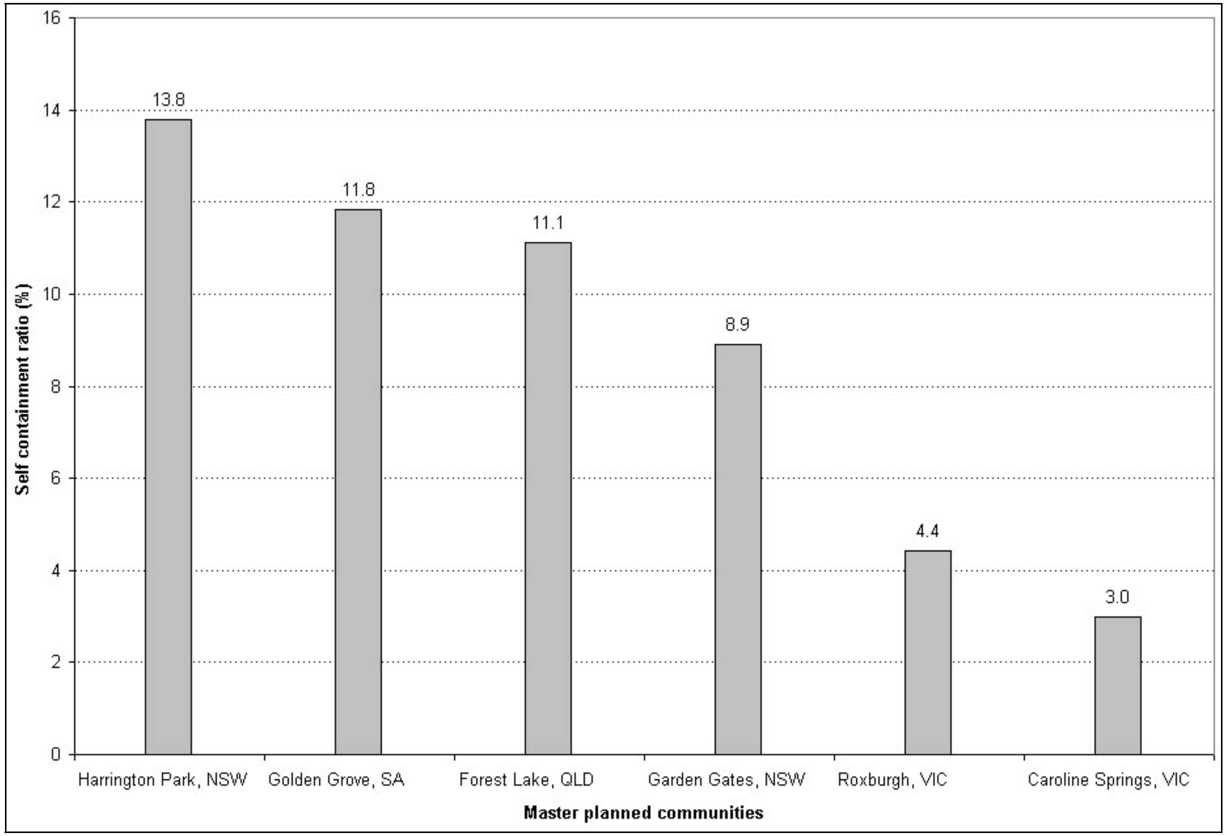

Figure 5: Travel self-containment rates

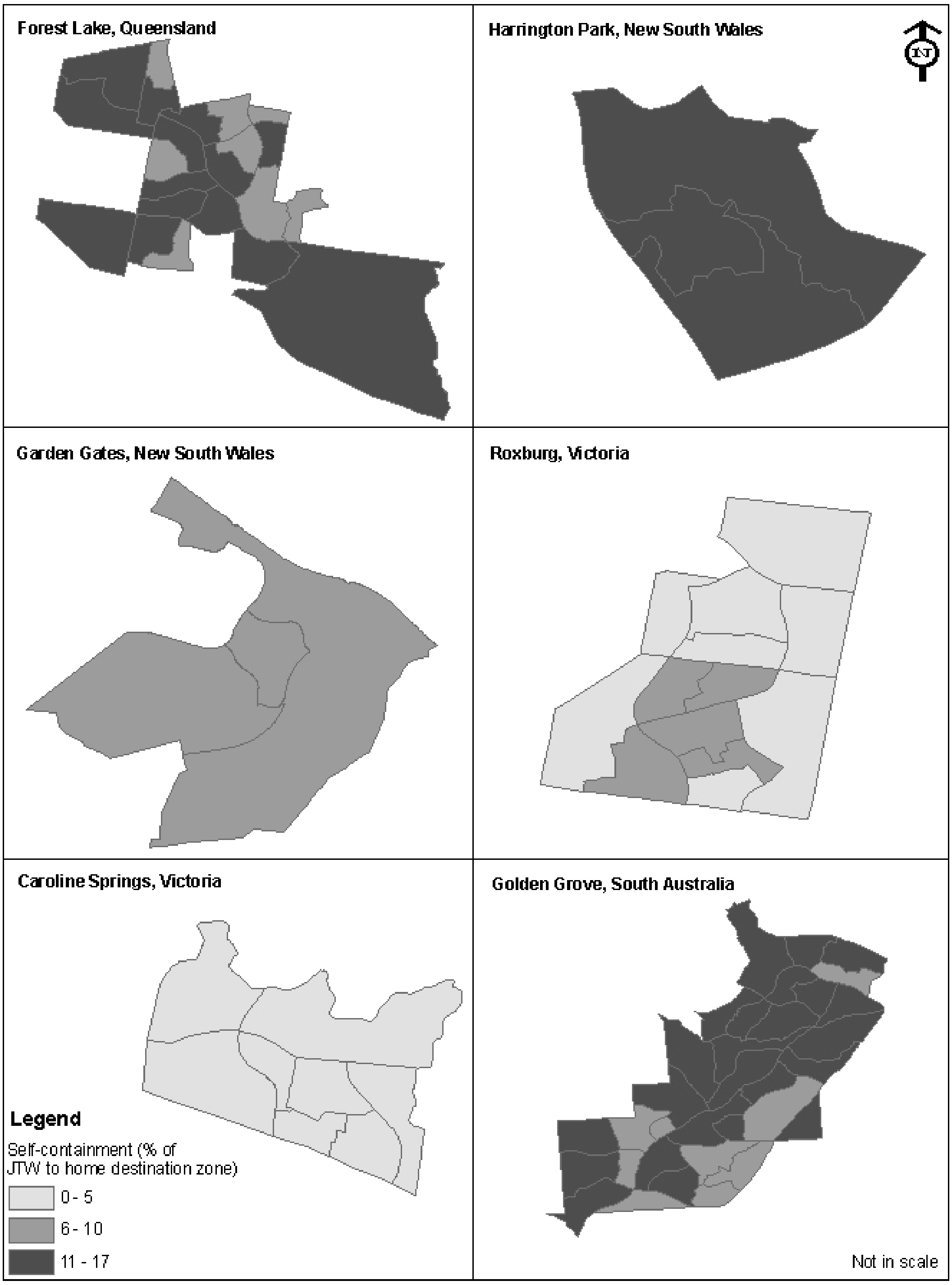

Figure 6: Census CD level travel self-containment rates

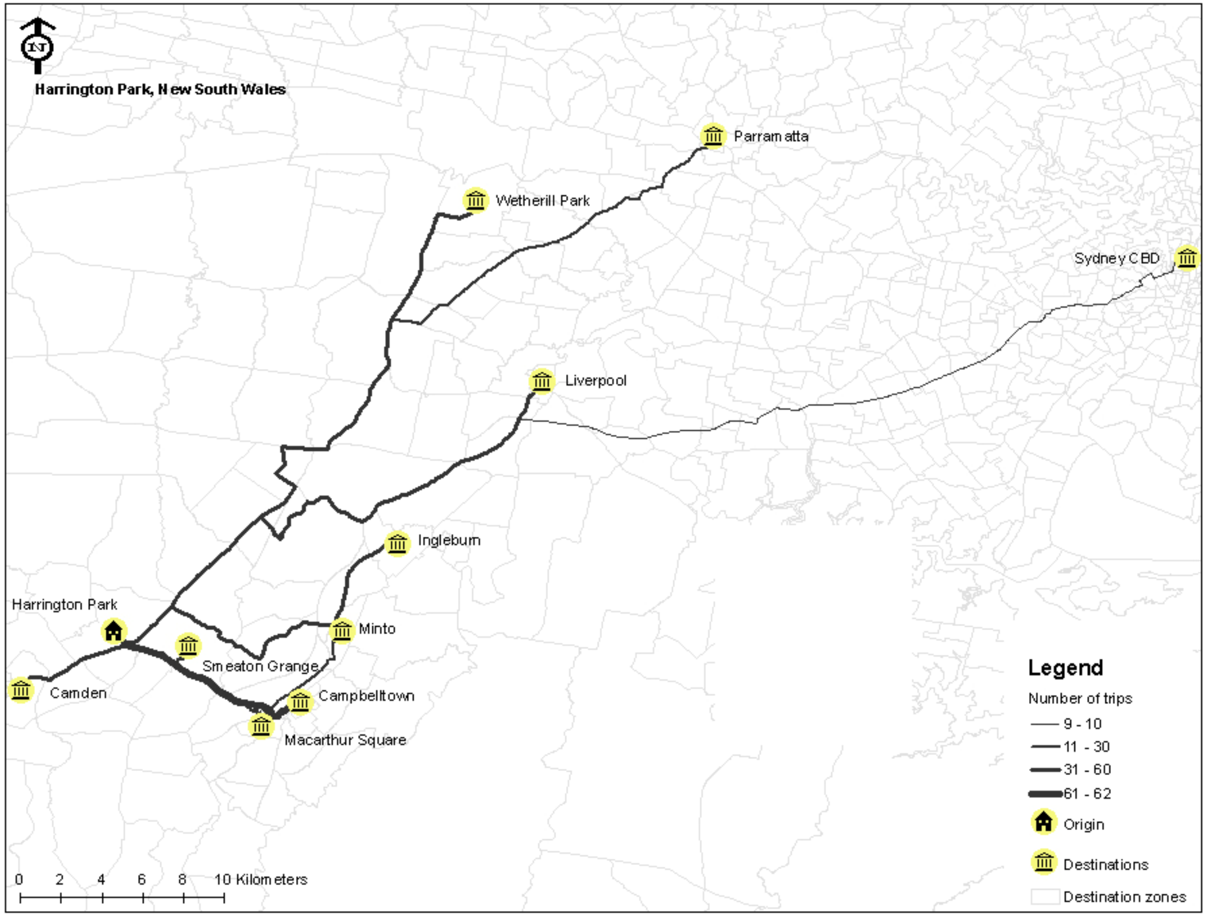

Figure 7: Proximity to CBD and regional employment centres

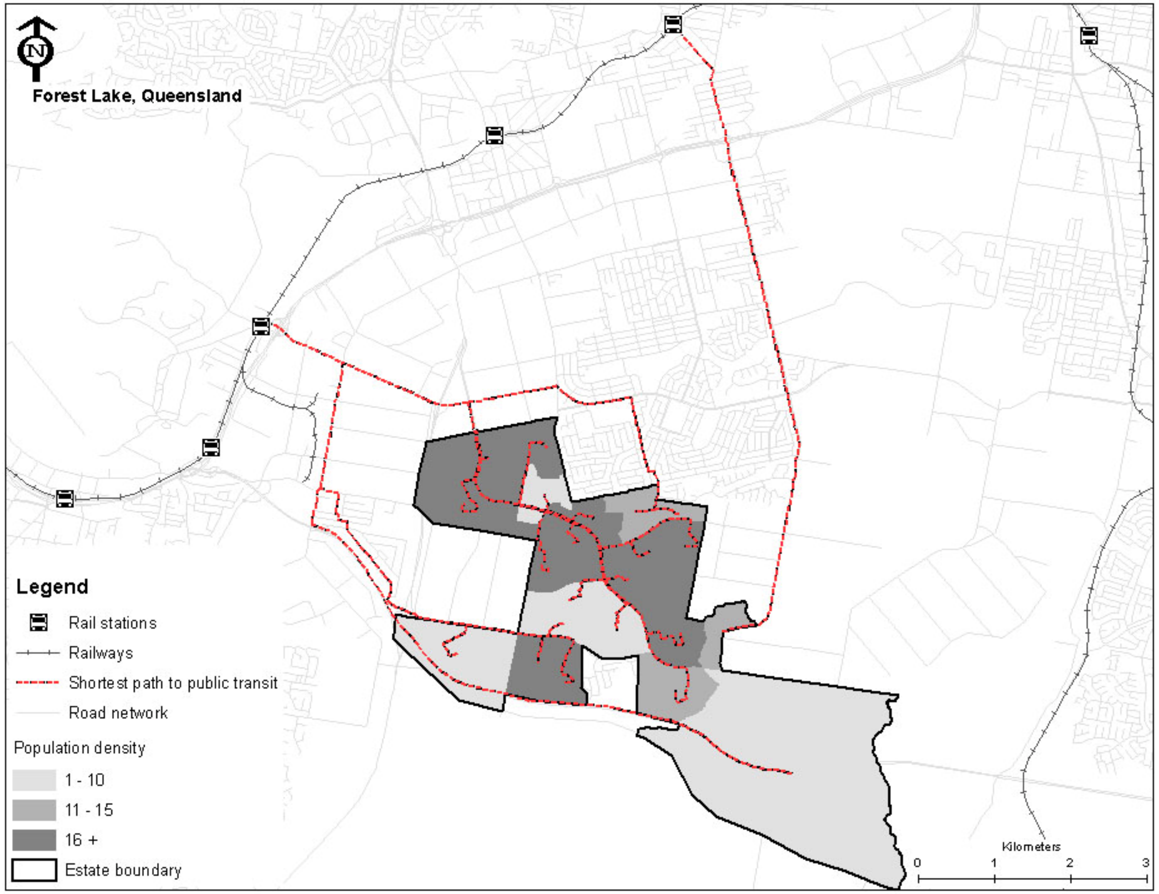

Figure 8: Proximity to public transport

Table 1: Regression analysis variables used in this study

Land Use Varibles	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: The salient characteristics of the MPEs

	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 (persons)	3027	3829	5356	9487	15062	26029
Population density (person/hectare)	8.9	6.5	7.9	18.1	11.8	18.2
Commencement of occupation (year)	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 JTW (%)	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 centres (km)	45	44	33	26	24	12
Average commuting distance (km)	22.5	21.8	16.3	13.2	12.0	12.6
Vehicle Kilometres Travelled (Daily JTW) (km)	21510	24926	26949	45245	82838	98062
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: Definitions, means and standard deviations of variables

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

DV: Dependent variable *IV: Independent variable*

Table 4: Results of Regression Analysis of MPE Travel Characteristics

	Column A: Urban Structure Variables only		Column B: Socio-economic Variables only		Column C: Travel Behaviour Variables only		Column D: All Variables	
Independent Variables	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance	Coefficient	Significance
Population density	0.004	0.889	_	_	_	_	0.012	0.541
Age of estate	**0.603**	**0.000**	_	_	_	_	0.151	0.325
Proximity to CBD	0.063	0.175	_	_	_	_	**0.384**	**0.000**
Proximity to public transport	**0.794**	**0.008**	_	_	_	_	0.084	0.685
Income level	_	_	**0.008**	**0.032**	_	_	-0.004	0.107
Employment level	_	_	**-0.493**	**0.001**	_	_	-0.140	0.101
Education level	_	_	**0.130**	**0.022**	_	_	0.016	0.629
Car ownership	_	_	-5.379	0.226	_	_	**11.830**	**0.000**
Travel method	_	_	_	_	**-0.170**	**0.000**	**-0.200**	**0.000**
Proximity to employment centres	_	_	_	_	**-0.212**	**0.002**	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: OLS Regression model for travel self-containment

Independent Variables		Coefficient - B	Significance
Population Density		0.001	0.960
Proximity to CBD		**0.186**	**0.000**
Proximity to public transport		0.108	0.625
Income level		**0.004**	**0.019**
Employment level		**-0.245**	**0.006**
Education level		*0.059*	*0.090*
Travel method		**-0.196**	**0.000**
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.