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# Patterns of Social Capital associated with Transit Oriented Development

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## Abstract

In policy circles, transit oriented development (TOD) is believed to enhance social capital, however empirical evidence of this relationship is lacking. This research compares levels of social capital between TOD vs. non-TOD areas in Brisbane, Australia. Using a Two Step cluster analysis technique, three types of neighbourhood groupings were identified based on net employment density, net residential density, land use diversity, intersection density, and public transport accessibility: TODs, transit adjacent development (TADs) and traditional suburbs. Two dimensions of social capital were measured (trust and reciprocity, connections with neighbours) based on factor analysis of eight items representing elements of social capital. Multivariate regression analyses were conducted to identify links between the distributions of the dimensions of social capital on areas defined as TODs, TADs, and traditional suburbs controlling for socio-demographics and environmental factors. Results show that individuals living in TODs had a significantly higher level of trust and reciprocity and connections with neighbours compared with residents of TADs. It appears that TODs may foster the development of social sustainability.

## Keywords

Transit Oriented Development; Transit Adjacent Development; Public Transport Accessibility Level (PTAL); Social Capital; Social Sustainability; Brisbane

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## 1. Introduction

Transit Oriented Development (TOD) has been associated with the three dimensions of sustainability (e.g. environmental, economic, and social) (Glaeser and Gottlieb, 2006; Lund, 2002; Yang, 2008). Robust evidence supports the environmental and economic outcomes, but empirical evidence supporting the impact of TODs on social outcomes is comparatively sparse (Melia et al., 2011). Garnering such empirical evidence is in part hindered by the lack of agreed measures of social sustainability in the literature; researchers have used a wide variety of concepts to measure social sustainability e.g. social equity, engaged governance, social interaction, interpersonal relations, social cohesion, attachment to place, community stability, health and well-being, inclusion, security, and collective efficacy (see, Sharifi and Murayama, 2013). Vallance et al. (2011) have usefully classified social sustainability into three domains:

- a) developmental – addressing basic needs, the creation of social capital and social justice;
- b) bridging – concerning changes in behaviour so as to achieve bio-physical environmental goals; and
- c) maintenance – aspects that need to be preserved/sustained e.g. socio-cultural characteristics in the face of change.

This research focuses on social capital as one potentially measurable aspect of social sustainability, and whether its level differs in TOD and non-TOD areas.

One of the main reasons for investing in the social capital aspects of social sustainability is its importance in the social policy agenda internationally. The UK government, for example, has identified social capital as a key element in addressing a host of social ills, from high crime and under-employment to poor health and low educational attainment (Gray et al., 2006; Roche, 2004). Similar benefits have been echoed in Canadian policy documents (Spinney et al., 2009), and Australia, Canada, and the US are among countries that have included measures of social capital into national population surveys (Australian Bureau of Statistics, 2004, 2010; Johnson et al., 2005). Putnam (2000), whose research has done much to popularise the concept, also contends that the existence of social capital is closely tied to the effective functioning of a democracy. Numerous research studies in different disciplinary and policy areas have investigated the impact of high levels of social capital on a diversity of outcomes, and their findings are mostly positive. These range from associations between social capital and physical activity (Poortinga, 2006), enhanced community disaster recovery and resiliency (Miller and Rivera, 2011; Wood et al., 2013) through to the role of social capital in assisting the development of alternative mechanism for city governance such as the development of community induced trash collection system in Dhaka (Pargal et al., 2000). While there have been some studies investigating links between neighbourhood walkability and social capital (Leyden, 2003; Lund, 2002), there has been very little research into its relationship with TODs more broadly. Yet both social capital and TODs are high on current transport and planning policy agendas (Ganapati, 2008; Gray et al., 2006; Miciukiewicz and Vigar, 2012). As a result, this present research is particularly timely in investigating linkages between the two.

TOD is a relatively recent neighbourhood development concept characterised by moderate to high residential and/or employment density, diverse land use patterns, well-connected street networks (e.g. grid pattern as opposed to cul-de-sac), and centred on fast, frequent and well-connected public transit (PT) stops/stations (Cervero and Kockelman, 1997; Renne, 2009). The concept has emerged as a response to the perceived shortcomings of conventional suburban development (Rohe, 2009), which encourages car dependency due to the separation of homes from other destinations (e.g. work, shops) (Forrest and Kearns, 2001; Lau et al., 2005; Putnam, 2000). TODs, on the other hand, facilitate participation in local activities due to their diversity of land uses, and as a result, reduce the need for motorised travel and reduce greenhouse gas emissions (i.e. environmental sustainability) and congestion (i.e. economic sustainability) (Bertolini et al., 2009; Transportation Research Board, 2001).

A clarification must be made here between TOD and its related but opposite concept 'transit adjacent development (TAD)'. TADs are located close to transit stations/stops, however, unlike TODs, TADs possess suburban street patterns (e.g. cul-de-sac), low densities, and segregated land uses (Duncan, 2011; Renne, 2009). Thus, TADs are often responsible for diluting TOD research due to the difficulty associated with filtering out TADs from TODs (Halbur, 2007). TADs are considered to be the "evil twin" of TODs: when TOD development goes bad, it often morphs into a TAD. Thus, suburban development located adjacent to a train station cannot be labelled a TOD (Belzer and Autler, 2002). Hollenhorst (2007) suggests that while TOD is a desirable development, TAD is what researchers have been dealing with for years and is often passed off as TOD. For example, the Transportation Research Board (2004) has identified that about 97% of rail stations in the USA possess the character of a TAD although they are often regarded as a TOD. Clearly in the context of this present research paper, the patterns of social capital associated with TADs vs. TODs will be of much interest.

Hypothetically, TODs consist of important characteristics that can influence the development of social capital. For example, participation in local activities is facilitated by the diversity of land uses and connectivity of places which can enhance interactions amongst individuals living within a TOD (Bertolini, 1999). In turn this can increase the opportunity for people to be on familiar terms with each other and trust each other which are the building blocks of social capital (Bullen and Onyx, 1998; Mason, 2010). Well-connected street networks are conducive to walking and this can facilitate social interaction and sense of community (Lund, 2002; Wood et al., 2008). Speculation prevails that TODs are attractive places to live because a compact urban form with a mix of uses, better public transport and a greater density fosters a strong sense of community and public safety (Buys et al., 2007; Dempsey et al., 2012; Glaeser and Gottlieb, 2006; Gordon, 2008). Stanley et al. (2010) argue that the existence of public transport services in a neighbourhood enhance the mobility of individuals which consequently helps developing social networks and connections amongst individuals. In addition, "public transport by definition involves travelling with others and hence provides opportunities for social interaction while travelling" (Currie and Stanley, 2008, p.529). Both fast transport services and the local availability of retail and services can save travel time which hypothetically enable individuals to engage in other social activities (Putnam, 2000).

Despite these hypothetical understandings, empirical findings on these individual elements of the built environment are not conclusive so far (discussed in Section 2.2). This raises the question of whether such a hypothetical relationship holds for TOD as a whole given that they are an aggregated built outcome of the individual elements (e.g. density, diversity). An answer to this question is important because TODs are billion dollar investments, and therefore, would be more justifiable when they are associated with policy co-benefits such as improved social capital (Boarnet, 2010).

Section 2 of this paper reviews literature on the concept of social capital and their operational measures. This section also reviews literature on the built environmental impacts of developing social capital in a neighbourhood. Section 3 outlines the geographical and policy contexts in which this study was conducted and Section 4 discusses the data and method used to reach the aim of this research. Section 5 presents the findings which are discussed in policy terms in Section 6. Section 6 also concludes this research.

## **2. Literature review**

### **2.1 Social capital: concept and measures**

Social capital has flourished as a field of research and policy interest over the last 10-15 years, but there is no single agreed definition (Wood et al., 2008). This research adopts the widely used definition of social capital from Putnam (1993, p.35) "similar to the notions of physical and human capital, social capital refers to features of social organisation such as networks, norms and trust that facilitate co-ordination and co-operation for mutual benefit". Social capital is a multifaceted concept (Ziersch et al., 2005), and a number of themes have been identified in the literature including (Bowling and Stafford, 2007; Bullen and Onyx, 1998; Masoud et al., 2011; Roche, 2004):

- a) participation in networks: these can be informal such as neighbourly interactions or via collective forms of participation such as clubs, community based groups, and local association;
- b) reciprocity/altruism: for example, offering help to others, without an explicit expectation of this be returned;
- c) trust: individuals' perceptions of the trustworthiness of others within their community, and a sense of confidence that others will respond as expected and will act in mutually supportive ways;
- d) social norms: 'unwritten rules' and a sense of collectively shared values;
- e) the commons: pooled community resources generated by the combined effect of networks, trust, reciprocity, and norms; owned by no-one but used by all; and
- f) civic engagement and pro-activity: the active and willing engagement of citizens within a participative community.

Although social capital is often measured and considered in the context of geographically defined communities, it can in fact inhere in any type of community, and has been studied in a broad range of groups and settings, including families, schools, business corporations and virtual internet affiliations.

Within area based studies of social capital, the unit of focus also varies, and ranges from between or within country comparisons through to neighbourhood or suburb level differentiation (Gray et al., 2006). Three approaches have been operationalised in the literature to measure the level of social capital of individuals living in an area: objective; subjective; and observation (Bowling and Stafford, 2007; Ziersch et al., 2005). Objective approaches are the most commonly used in which demographic and socio-economic data are aggregated to produce indicators. Survey data from multiple sources are used to measure different dimensions of social capital in this way. However, this approach has been criticised because of its inability to facilitate any assessment of the relationships between the dimensions (e.g. correlation between levels of trust and participation) (Roche, 2004). The subjective approaches collect data directly from residents living in an area by asking them to rate features of their local area. The third approach is to directly observe the specific feature of the local area which are of interest (Bowling and Stafford, 2007).

Two types of indicators have been used in the subjective approaches: proxy; and theory driven. Roche (2004) identified that political scientists, such as Putnam and Fukuyama, relied more on the proxy indicators e.g. survey of participation rates in voluntary groups; survey responses to generic questions around levels of trust. The advantage of using proxy indicators is that it is both time and cost-effective. Despite the advantages, Roche (2004) has highlighted that another approach would be to collect dedicated (or original) data using methods which are more explicitly grounded in theoretical understanding of the notion such as those used by Bullen and Onyx (1998). They conducted a large-scale survey measuring social capital in five areas in Australia. Based on an intensive review of social capital literature, the authors identified different dimensions of social capital (e.g. networks, trust, reciprocity, norms) and subsequently developed a variety of questions on each dimension based on the theory. Consequently, many researchers have followed this approach to measure social capital (General Household Survey, 2002; Onyx and Bullen, 2001; Wood et al., 2008).

When social capital is measured based on the network dimension, it is important to distinguish between bonding and bridging networks (Putnam, 2000). Bonding represents linkages within a group that already has some affinity (e.g. ethnicity, neighbourhood, religion, age) whereas bridging refers to linkages between groups, and can connect people to external sources of support. Both types are important but can serve different purposes (Stanley et al., 2010). For example, bridging social capital may provide networks that facilitate the diffusion of information or links to external opportunities that could benefit an individual or a community, whilst bonding social capital helps build community solidarity and networks of reciprocity (Putnam, 2000). Bonding ties are likely to be stronger in a neighbourhood with good social capital, but individuals within that community can also derive other bonding social capital further afield, and from communities that may not be geographically defined, such as the workplace or a community group to which they belong. Neighbourhoods and individuals can also vary in their access to bridging capital, and for either, the relative absence of bridging social capital can be marker of more limited opportunity to 'get ahead'. From a social sustainability and policy perspective, both bonding and bridging capital are vital, as if a community is rich only in

bonding capital, it may lack the assets, linkages and resources that enable the community or its residents to overcome disadvantage (Harriss and De Renzio, 1997).

Although social capital inherently relates to the social realm and citizens of a community, a growing body of research indicates that differences in social capital exist between neighbourhoods even after adjusting for potentially confounding factors such as age, sex, marital status, race, income, education, employment etc (Wood et al., 2008). This has spawned both research and policy interest in identifying the characteristics of neighbourhood environments that need to be invested in or protected to help build social capital. To this end, the supposition that differences in the level of social capital between TOD and non-TOD areas are worthy of investigation.

## **2.2 Built environmental impacts on social capital**

As previously discussed, TODs are an outcome of the synergy and combination of built environmental factors (e.g. density, diversity, connectivity, public transport accessibility). Although scant evidence was found in the literature investigating the overall impact of TODs on social capital, a number of studies have, however, identified the impact of individual environmental factors of the built environment on social capital, with density and walkability two of the most investigated factors.

In relation to density, Dempsey et al. (2012) employed a multi-method approach and collected both quantitative and qualitative data from 3 types of suburbs in terms of density (e.g. outer, intermediate, and inner) located in 5 cities in the UK (Edinburgh, Glasgow, Leicester, Oxford, and Sheffield). Using data from 4381 respondents, this study found that social interaction and social networks were stronger in intermediate neighbourhoods than outer or inner city areas. Nonetheless, the study reported an inverse relationship between housing density and feelings of place attachment measured by the length of stay. Similar findings have been echoed in a US study. Glaeser and Gottlieb (2006) investigated five types of social or civic engagement (i.e., attended church or other place of worship, worked on a community project, wrote a letter to an editor of a magazine or newspaper, contacted a public official, and whether a registered voter) using the DDB (Doyle, Dane, Bernbach) Needham Life Style Survey data collected in various years. This study has shown that with the exception of letter writing, central-city residents had a significantly lower level of all types of social engagement than residents living in non-city areas. In addition, this study compared levels of social capital across different parts in a city based on five indicators: participation in voluntary work, working on community project, going to club meetings, attending church, and trusting people. It found a negative relationship between density and all indicators of social capital, except church attendance.

Buys et al. (2007) selected a case study area characterised by planned mixed-tenure / mixed density (low-medium) development in Gold Coast, Queensland. The study used data from a survey of 209 individuals on 34 items related to social capital based on Bullen and Onyx (1998). The items were grouped into eight dimensions: participation in local community, pro-activity in a social context, feelings of trust and safety, neighbourhood connections, family and friends, tolerance of diversity, value of life, and work connections. The mean scores of all items within the dimensions were then

compared with that of the scores reported in the Bullen and Onyx's (1998) study for five different types of communities (e.g. inner Sydney, rural areas) in New South Wales (NSW). The study reported that the level of social capital was lower in three dimensions (participation in local community, feeling of trust and safety, and neighbourhood connections) in the case study area when compared with rural NSW. In contrast, the case study area had an equal score in the participation in local community and neighbourhood connection dimensions when compared with a traditional neighbourhood in Sydney (Pymont).

A number of studies have investigated neighbourhood walkability and its relationship to social capital. The earliest known paper used both subjective and objective measures of pedestrian environment in assessing the relationship between built environment and sense of community (Lund, 2002). The author used objective criteria (e.g. era of development, street and sidewalk connectivity, housing mix, lot size, housing setbacks etc.) to identify one traditional (pedestrian oriented) and one conventional (modern suburban neighbourhood – automobile-oriented) neighbourhood in Portland. Survey data were collected, together with perceived pedestrian environment data from 106 individuals living in the two neighbourhoods. The questionnaire included 11 items (e.g. comfort, safety, appeal) representing the perceived pedestrian environment scale; and 11 items representing a sense of community scale. The items in both scales were measured using a 5-point Likert scale. The scores of all items within a scale were aggregated to derive a score for each of the scales. Using a hierarchical regression analysis, this study found support that there was a greater sense of community in pedestrian-oriented neighbourhoods than in auto-oriented neighbourhoods, and that the perceived pedestrian environment is significantly associated with sense of community.

In a subsequent study, Lund (2003) assessed the relationship between physical aspects of neighbourhoods (e.g. access to park but no retail, access to retail but no park, access to both park and retail, and location in the inner city) and neighbouring (social) behaviours in Portland. The behaviours were measured in three dimensions: frequency of unplanned interaction (number of times in the previous week respondents waved or said hello to neighbours, stopped and chatted with neighbours, invited neighbours); local social ties (e.g. number of acquaintances within close proximity of home), and supportive acts of neighbouring (frequency with which one gives/receives assistance to/from neighbours). This study found a significant but weak relationship between the neighbourhood environment and social behaviour.

Leyden (2003) subjectively assessed neighbourhood walkability and examined the relationships between walkability and social capital in Galway, Ireland. First, eight neighbourhoods were selected based on a subjective classification (city centre/near city centre; older, mixed-use; and modern, automobile-dependent). Second, 279 respondents were surveyed and asked to indicate whether they could walk without trouble to nine destinations: a corner shop/newsagent, church, park, school, community centre, child care, chemist, pub, and work. The respondents also completed items forming four social capital scales: familiarity with neighbours, political participation, trust, and social engagement. This research showed that the city centre and mixed-use neighbourhoods had higher

levels of social capital. Moreover, respondents living in walkable neighbourhoods were significantly more likely to know their neighbours, participate politically, trust others, and be socially engaged.

du Toit et al. (2007) developed a composite index of neighbourhood walkability and then assessed the relationships between walkability and social capital in Adelaide, Australia. The walkability index was developed for each census collection district (CCD) by summing four environmental indicators: dwelling density, street connectivity, land use mix, and net retail area. The index was subsequently reclassified into quartiles. Overall, 2194 respondents completed items measuring four dimensions of social capital: local social interaction, sense of community, informal social control, and social cohesion. This study found no significant relationship between walkability and three of the indicators of social capital (local social interaction, informal social control, and social cohesion) but a weak positive relationship with the sense of community.

Mason (2010) evaluated the impact of community design on social capital using questionnaire data collected from 721 individuals living in 34 neighbourhoods in the city of Boise, USA. The study evaluated only one social capital indicator (i.e. "trust") because the author argued that despite multiplicity of factors contributing to social capital production, trust is the cornerstone. This study found a positive association between perceptions of trust and access to cul-de-sacs, sidewalks, and parks or open spaces.

Hypotheses about the influence of a more walkable street network design on social capital were examined in a mixed methods study undertaken in Perth, Australia (Wood et al., 2012). The study selected three suburbs with different types of street network design (e.g. traditional – pre-dominantly grid layout, conventional – cul-de-sac and curve layout, and hybrid – mix of cul-de-sacs and grid). Survey data on 31 items from 339 individuals were used to measure seven social capital dimensions: trust, community concern, reciprocity, civic engagement, friendliness, support, and networks. In contrast to their hypothesis, the study found that respondents who lived in the conventional suburb had a higher level of social capital compared with respondents in traditional neighbourhood; with the authors concluding that other neighbourhood factors such as perceptions of safety and incivilities may importantly impact on the relationship between neighbourhood design and social capital.

Despite investigations of various land use elements and social capital, little empirical understanding exists about the relationship between social capital and the availability of public transport services. Currie and Stanley (2008, p.529) suggest that "measuring the influence of improved mobility options on SC [social capital] in disadvantaged communities would be a worthwhile research area". In an empirical study in Melbourne, Stanley et al. (2012) found that enhancing the ability to make an additional trip for an individual who is at risk of social exclusion is equivalent to providing \$17.34. The study also showed that a unit increase in the person's sense of community was worth \$22,000 annually. However, no direct link was established between trip making and sense of community. Nevertheless, the study confirmed that lower levels of social capital increased the risk of social exclusion (Stanley et al., 2012).

A number of observations can be made from the above reviews:

1. empirical findings rarely support the notion that increased density, diversity, and street connectivity would increase social capital: rather, with few exceptions an opposite relation has commonly been reported;
2. researchers have utilised both aggregated (between areas) and disaggregated (individuals living in different areas) approaches in identifying the level of social capital;
3. different studies have investigated different dimensions of social capital, using different items within a dimension which are also aggregated using various methods (e.g. average, summation, factor analysis);
4. environmental factors were derived subjectively, objectively, or both; and
5. researchers mainly used regression analysis (e.g. ordinary logistic, hierarchical) to investigate the differences in social capital between different groups.

### **3. Study context**

This study was conducted in Brisbane, Queensland, Australia. Concerted transport and land use policy development have been taken at all levels of Government in Queensland in order to achieve a number of sustainable development targets. For example, at the state level, Queensland Government (2008) aims to cut one-third of its existing carbon emissions. The government (2008) also recognised that congestion is hurting Queensland's economy due mainly to car-based travel. As a result, the government intends to: double the share of active transport trips (such as walking and cycling) from 10% to 20% of all trips; double the share of public transport from 7% to 14% of all trips, and reduce the share of trips taken by private motor vehicles from 83% to 66% (Queensland Government, 2010a). The Queensland Government (2010a) is prepared to spend \$227 billion on a variety of priority areas in the transport sector between 2011 and 2031 to meet the targets. At the regional level, one such policy is to facilitate development in a more compact way through locating self-contained activities in well-defined nodes along existing and planned transport corridors. These nodes or activity centres are identified as prime candidate locations for the application of TOD principles (Queensland Government, 2009). A number of principles have been devised to guide development in TOD precincts. The precinct boundary has been defined as a comfortable walking distance – 5 to 10 minutes from transit nodes depending on the nature of the topography (Queensland Government, 2009, 2010b). The key principles include the availability and connectivity (intermodal) of public transport services; land use mix (diversity); residential density; land use intensity for employment; and pedestrian connectivity (Queensland Government, 2009). These principles will be applied in various combinations depending on their locations (see Table 1). In addition, to achieve the above policy targets, the government anticipates that developments like TODs would “enable residents, business people and workers to meet and interact, build social capital, and create networking and business opportunities” (Queensland Government, 2009, p.100). Many of these regional planning principles have been echoed in a recent state planning policy document (Queensland Government, 2013). One of the state planning codes highlights the need for integrated approaches between land use and transport planning and states that the principle “is to ensure development within close proximity [400m] of

existing or future public passenger transport facilities” (Queensland Government, 2013, p.75). The above statement indicates the government’s intention to extend the TOD principles to the state level.

Guided by the above policy documents, a comprehensive approach has been taken to facilitate the implementation of TODs within Brisbane (Brisbane City Council, 2013). Some examples of TODs that have been constructed, or are being constructed within Brisbane, include: Yeerongpilly, Coorparoo, Bowen Hills, Northshore, Hamilton, Fitzgibbon and Woolloongabba (Queensland Government, 2010a). As a result, this present research, which examines the extent to which TODs contribute to the social sustainability goal of the government using Brisbane as a case study, is particularly timely.

## **4. Methodology**

The aim of this study is to investigate whether individuals living in TODs have a higher level of social capital compared with residents of traditional suburbs and areas defined as TADs. This investigation uses data from the HABITAT study (**H**ow **A**reas in **B**risbane **I**nfluence **H**eal**T**h and **A**c**T**ivity). The HABITAT is a panel survey conducted in Brisbane in 2007, 2009, and 2011. 11036, 7866, and 6901 questionnaires were collected from purposefully drawn samples (aged between 40 and 70 years) living within 200 census collection districts (CCDs) in Brisbane in respective years. Clustered random sampling technique was used to operationalise the surveys. Details about sampling, survey design framework, and the representativeness of the baseline sample to the wider population have been published elsewhere and are not discussed here in detail (Burton et al., 2009; Turrell et al., 2010). This research used the 2011 version of the surveys given that TODs are a recent built environmental phenomenon in Brisbane. An analytical sample of 5606 individuals was retained in this study after excluding missing cases. The analytical samples include only those individual who did not move home between the survey periods in order to ensure that they had a considerable length of stay at current address allowing the opportunity to build social capital.

### **4.1 Dependent variables**

Social capital measures were drawn from the work of Buckner (1988) . Respondents were asked to indicate whether they agreed/disagreed to 8 items on a 5-point Likert scale (1 – strongly disagree to 5 – strongly agree) representing different aspects of social capital (Table 2). Factor analysis (principle axis factoring) was then conducted in order to reduce the data into two meaningful dimensions (scales) of social capital. The items within a scale were also found to have good reliabilities. The factor analyses were conducted based on polychoric correlations matrix in order to take into account the ordinal nature of the variables. A special SPSS program developed by Basto and Pereira (2012) was used to conduct the factor analyses.

The two factors were selected using the latent root criteria for the number of factors (eigenvalues larger than 1) (Table 2). These two factors statistically contributed to the explanation of the total variance of the data by more than 71% - a level considered to be good for this type of analysis (Kamruzzaman and Hine, 2011). The factor loadings were also found to be acceptable as they explained more than 10% of the variance in the data (De Vos et al., 2012). The two factors can

respectively be interpreted as reflecting connectedness with neighbours and trust and reciprocity of people in the neighbourhood. The generated factor scores were used as dependent variables in order to investigate the impacts of TODs on these. The social capital dimensions (scales) were moderate-to-highly correlated (0.608). Given the nature of social capital and the factor extraction method applied, inter-relationship between factors is congruent with common understandings (Kamruzzaman et al., 2013b).

## 4.2 Independent variables

The purpose of this study was to investigate whether individuals living in TODs had a higher level of social capital. As a result, individuals' living environments were classified into TOD and non-TOD areas. A further specification of respondents' living environment was needed to distinguish between TODs and TADs in order to disentangle the impact of TADs while identifying the impact of TODs on social capital. A two stage processes was used to make these distinctions. The TwoStep cluster analysis technique was applied in both stages.

In the first stage, the cluster analysis identified natural groupings of individuals' living environment based on six environmental factors (Cerin et al., 2007). The six factors were selected based on the TOD literature in this context and included: public transport accessibility levels (PTALs), net residential density, net employment density, land use diversity, intersection density, and cul-de-sac density (Kamruzzaman et al., 2013b, 2014). These are also the key elements used to define a neighbourhood as a TOD, or a TAD, or a non-TOD as discussed earlier. All of these factors were derived based on a 400m network distance buffer from each respondent's home. Note that there is no agreed size of a TOD precinct in the literature, and the size varies between contexts (Kamruzzaman et al., 2014). However, despite the variations, almost all studies, including the Queensland policy documents discussed earlier, consider that a 400m should be the minimum precinct size. As a result, the 400m distance (5 minutes walking distance) was used in this research. Note that the buffer method was not used for the calculation of the net employment density indicator rather this was calculated based on CCD boundaries. This is due to the fact that unlike individual work location data, the places of work data were available only in an aggregated format. All spatial analyses were conducted using ArcGIS 10 software. Spatial datasets required to conduct the analyses were download from Queensland Government (<http://dds.information.qld.gov.au/dds/>), Australian Bureau of Statistics (<http://www.abs.gov.au/>), and Australian Government websites (<http://data.gov.au/>). Additional spatial datasets (e.g. land use) were collected from Brisbane City Council. In addition, public transport time table data for Brisbane were downloaded from the *Translink* website (<http://translink.com.au/>).

The well-known PTAL approaches were used to derive public transport accessibility level for each individual (see, Transport for London, 2010; Wu and Hine, 2003). The procedure has been described elsewhere, and is not discussed in detail here (Kamruzzaman et al., 2013b). Briefly, the method took into account spatial accessibility (whether PT services are located within the 400m buffer) of bus and train services, their morning peak hour frequencies, directional connectivity (e.g. different routes

available to travel), and reliability. Net residential density was calculated by counting the number of residential units located within a unit area of residential zoned land (e.g. number/hectare) of the buffer. Net employment density was calculated based on the number of jobs located within a unit area of employment generating land uses (e.g. commercial, industrial) located within respondents' CCD of residence (e.g. number of jobs/hectares). Land use diversity was calculated using the Simpson's diversity index (Simpson, 1949), and has been applied in transport research (Kamruzzaman and Hine, 2013). Five types of land uses were taken into account: residential, commercial, recreational, institutional, and industrial. The index varies between 0 (no diversity – e.g. a single land use is present) to 1 (fully diverse – all types of land uses exist with equal amount). Although both intersection and cul-de-sac density represent street connectivity level (Stangl and Guinn, 2011), the former is supportive for TODs whereas the latter is unfavourable for TODs (Cervero and Gorham, 1995; Lund, 2006). Intersection density was measured based on the number of 3 or more way intersections located within a unit area of the buffer (e.g. number/hectares) whereas cul-de-sac density was calculated using the number of dead-end streets located within a unit area of the buffer (e.g. number/hectares). However, a correlation analysis showed that the cul-de-sac density indicator was negatively associated with the intersection density indicator, hence, only the intersection density indicator was retained in the final analysis.

The first stage of the cluster analysis generated a 4 cluster solution (Figure 1). The overall cluster quality was found to be in the fair range. Amongst the four clusters, two clusters (Cluster 3 and Cluster 4) comprising of 576 individuals were clearly identified to be labelled as living in TOD types of areas (see, Figure 1 and Table 1). In contrast, further exploration revealed that the environmental characteristics of the remaining two clusters (Cluster 1 and Cluster 2) (5030 individuals) do not qualify for a TOD, and as a result, these were labelled as non-TOD type of areas.

The second stage cluster analysis was conducted only for those individuals who were identified to live in non-TOD areas in the first stage. The cluster analysis was conducted based on only the PTALs factor in order to identify natural groupings of neighbourhood environment for the non-TOD individuals. The analysis resulted in a two cluster solution with a good quality cluster (Figure 2). Clearly Cluster 1 in Figure 2 reveals that about 32.5% of non-TOD individuals had very good PTALs. Figure 2 shows that the average PTAL score (3.78) of these individuals were close to those who were identified as living in some type of TOD areas (see, Cluster 3 in Figure 1). This means that these individuals were classified as living in non-TOD areas due to land use patterns (e.g. low density, diversity, connectivity) – not due to transport services. As a result, these individuals can clearly be classified as living in TADs according to the definition adopted in this research. The remaining individuals were, therefore, classified as living in traditional suburban areas. As a result, a three category independent factor was developed classifying respondents as living in: a) traditional suburban neighbourhood (3396 respondents – 61%); b) TADs (1634 respondents – 29%); and c) TODs (576 respondents – 10%). Figure 3 shows the location of TODs, and TADs in Brisbane.

### 4.3 Adjustment for potential confounders

Researchers have identified two types of factors that act as confounders in assessing the relationship between the built environment and social capital including residential self-selection and socio-demographics (Kim and Kaplan, 2004; Lund, 2002; Mason, 2010). Residential self-selection refers to the inclination of a respondent to choose a particular neighbourhood as a place to live according to their preferences (Guo and Chen, 2007; Pinjari et al., 2007). In the context of social capital, this means, for example, that “residents live neighbourhoods with people more like themselves than not, thus making it more likely that they trust one another” and also more likely to be socially connected with each other (Mason, 2010, p.462). Thus, any observed differences in the level of social capital between neighbourhoods could be spurious if residential self-selection effects are not taken into account. However, few studies to date have considered residential self-selection effects in investigating the links between social capital and the built environment. Kim and Kaplan (2004) asked respondents to indicate whether a sense of community played any role in their decision to move into their current neighbourhood. They used the answer to this statement as a factor to control for self-selection effects. Mason (2010), in contrast, asked respondents whether people in their neighbourhood shared the same values. Using ANOVA, the author found that the answer did not vary significantly between respondents’ neighbourhood types. As a result, the author concluded that the differences in the level of social capital (e.g. trust) between the neighbourhoods are not due to a self-selection effect.

In this research, a similar method to Kim and Kaplan (2004) was utilised to control for self-selection effects. In the HABITAT survey, respondents were asked to indicate the level of importance that ‘sense of community’ had in their decision to choose their current neighbourhood as a place to live. Importance was measured on a 5-point Likert scale ranging from 1 (not at all important) to 5 (very important). A preliminary analysis using ANOVA confirmed the evidence of self-selection processes in the context of this research: in particular, respondents with a higher sense of community were significantly more likely to choose TODs and traditional suburbs as a place to live compared to TADs. As a result, answers to the “sense of community” question were used as a controlling factor in assessing the relationship between the three types of neighbourhoods and social capital in this research.

In addition to controlling for residential self-selection effect, a number of socio-demographic factors were also taken into account as potential confounders in this study based on the literature. Factors that significantly affect social capital included respondents’ age, gender, dependent children at home (du Toit et al., 2007; Leyden, 2003; Mason, 2010), and level of education (du Toit et al., 2007; Leyden, 2003; Mason, 2010). Note also that the effects of income, marital status, years in residence (i.e. length of stay in current neighbourhood), and home ownership status variables on social capital are inconclusive. These variables were collected as a part of the HABITAT survey and were included in this research (see, Table 3). However, given that a higher proportion of missing values were found to exist in the income data (Table 3), a ‘missing’ category was included in order to maximise sample sizes. In addition to these socio-demographic factors, environmental indicators (e.g. residential

density, diversity, PTALs, intersection density, and cul-de-sac density) were also included in the analysis as independent factors so that minor environmental variations are controlled for when measuring the impact of TODs on social capital.

#### **4.4 Data analysis**

Due to the correlation between dependent variables as indicated earlier, multivariate multiple regression (simultaneous equation model) analyses were conducted. This analysis, takes into account the correlations of the dependent variables (Kamruzzaman and Hine, 2013). The regression analyses estimate two models in total, one for each of the dimensions of social capital. Only the statistically significant ( $p < 0.05$ ) explanatory factors for at least one outcome variable were retained in the models upon refinement of an initial starter specification that included all explanatory factors. Analyses were conducted using STATA (version 11.2).

#### **5. Results**

Table 4 shows the results obtained from the multivariate multiple regression models. The tests for the overall model indicate that the multivariate model was statistically significant, regardless of the type of multivariate criteria used (e.g. Wilks' lambda) (Table 4). In addition, each of the two univariate models (e.g. trust and reciprocity, connectedness with neighbours) was also found to be statistically significant. The explanatory powers of the models were also found to be representative of previous studies on this topic (see, du Toit et al., 2007; Lund, 2002; Mason, 2010).

Table 4 clearly shows that the development of social capital was strongly influenced by the residential self-selection effect (i.e. positive attitudes and preferences). Despite the stronger role of residential self-selection, Table 4 also shows that the neighbourhood types had an independent impact on the development of social capital. The trust and reciprocity model in Table 4 shows that controlling for all other factors, individuals who lived in TODs had a significantly higher level of trust and reciprocity than those who lived in TADs. Similarly, the "connected with neighbours" model shows that individuals who lived in TODs were significantly more likely to be connected with their neighbours than those who lived in TADs. In addition, individuals living in traditional suburbs had a higher level of social capital for both dimensions compared to those living in TADs.

In addition to the above area level factors (e.g. TOD/TAD), Table 4 also shows that some of the environmental indicators (e.g. PTALs, net residential density, land use diversity) had significant independent impacts on social capital. Surprisingly, despite TOD having a positive association with building trust and reciprocity, and connectedness with neighbours; the independent effects of PTALs, land use diversity, and net residential density had a negative relationship with both of these social capital dimensions. The findings are similar to that reported in other contexts. For example, Dempsey et al. (2012) reported a lower level of social interaction in high density areas in five UK towns. Similarly, Gottlieb (2006) has shown that central city residents possess a lower level of social engagement in the US. The findings suggest that when all the environmental factors act together to form a TOD, they influence both trust and reciprocity, connection with neighbours in a positive way.

But improvement only in a single environmental factor might have an opposite impact, as evident for TADs. No independent impacts of the other environmental factors (e.g. intersection density, employment density, cul-de-sac density) were evident in the models.

## **6. Discussion and conclusion**

This research appears to be the first of its kind to simultaneously investigate the relationship between three types of neighbourhood (e.g. TODs, TADs, and traditional suburbs) and two dimensions of social capital (e.g. trust and reciprocity, and connected with neighbours). Previous studies have reported inconsistent findings about the relationship between a particular built environment feature (e.g. density, land use diversity, street connectivity, and public transport accessibility level - PTAL) and social capital. The above neighbourhood types are the joint outcome of various combinations of these individual environmental features which triggered this research to investigate their joint impact on social capital. A neighbourhood with a higher value of all the features was referred to as a TOD whereas a neighbourhood associated with a lower value of all the features was referred to as a traditional suburb. In contrast, when a neighbourhood has a relatively higher PTAL but a lower value in other features, it was referred to as a TAD.

Conditional on the above definition for different types of neighbourhood, the findings of this research generally support the hypothesis that individuals living in TODs possess a significantly higher level of social capital when compared with those who lived in TADs in Brisbane. In addition, the level of social capital for those who lived in traditional suburbs was also significantly higher than individuals living in TADs. The findings verify that TADs are the “evil twin” of TODs because they possess some attributes of a TOD (e.g. high PTAL) which required a substantial investment but failed to generate all of the desired outcomes (Halbur, 2007). Further post-hoc analysis revealed that individuals living in TODs had a similar level of trust and reciprocity as well as connectedness with neighbours to those who lived in traditional suburbs. This is a significant finding which is due to the fact that most previous studies have reported higher levels of social capital in suburbs than high density / central city (traditional) neighbourhoods as discussed in Section 2.2 (see for example, Dempsey et al., 2012; Glaeser and Gottlieb, 2006; Mason, 2010; Wood et al., 2012). Partitioning of the neighbourhoods into TODs and TADs therefore helped to identify the true association between TODs and social capital which otherwise would have been diluted due to the significantly lower impact of TADs. However, given that TADs have met some criteria for a TOD, they could be converted into a TOD in order for full benefits to be realised. For example, Renne (2009) has demonstrated the transition of a train station (Subiaco) from a TAD to a TOD in Western Australia. However, such transitions are difficult to achieve in reality.

Previous research in this context has shown that individuals living in TODs are significantly more likely to use public transport services (e.g. bus, train), and active transport (e.g. walking, and cycling); and are significantly less likely to use the car (Kamruzzaman et al., 2013a; 2013b). These findings suggest that TODs are associated with both economic (e.g. by lowering congestion) and environmental (e.g. by reducing CO<sup>2</sup> emissions) sustainability in Brisbane. The findings of this

research, therefore, compliment the previous research demonstrating that TODs in Brisbane contribute to social sustainability. The findings justify the investment for TODs in Brisbane because they are associated with multiple policy co-benefits (Boarnet, 2010).

The HABITAT dataset used in this research was unique in many respects. Whereas most previous studies have used data from only few case study neighbourhoods in investigating the links between built environment factors (e.g. density) and social capital, the dataset used in this research represents the entire Brisbane city. As a result, the findings reported in this research are more generalisable. It also used data from a larger sample compared to previous studies. It is, however, important to note that our sample was purposefully drawn from adults aged between 40 and 70 years. Future research should seek to investigate this relationship involving a sample from all age groups. For example, this paper has not investigated the links between TODs and child behaviour, although previous research has indicated that there are some common characteristics between child oriented development (COD) and TOD (Freeman and Tranter, 2011). In particular, Freeman and Tranter (2011, p.221) have stated that “children still languish on the outer fringe of urban design consciousness”. However, relatively little research has been done in this area, and therefore, this issue should be explored further. Note also that this paper has not operationalised the network dimension of social capital; rather social capital is treated in terms of residential locality (e.g. trust and reciprocity in TOD/non-TOD neighbourhood areas) which could include both bonding and bridging networks amongst residents. Moreover, this research investigates only one dimension of social sustainability of TODs i.e. social capital. There are many other dimensions of social sustainability contained within the concept of TODs that have been debated/contested in the literature e.g. gentrification, affordability, health and well-being, social inclusion, and security (Bartholomew and Ewing, 2011; Bowes and Ihlanfeldt., 2001; Kamruzzaman et al., 2013c). Future research should seek to investigate these dimensions further. In addition, despite the TODs having a positive association with social capital, individual built environmental factors (e.g. density, PTALs) that form the TODs were found to have a negative association with the dimensions of social capital (e.g. trust). Further qualitative studies should seek to clarify these complex relationships.

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## **8. References**

- Australian Bureau of Statistics, 2004. Measuring Social Capital: An Australian Framework and Indicators. Information Paper, ABS Catalogue No. 1378.0, Canberra.
- Australian Bureau of Statistics, 2010. Sport and social capital, Australia.  
<http://www.abs.gov.au/ausstats/abs@.nsf/mf/4917.0>. 06.09.2013
- Bartholomew, K., Ewing, R., 2011. Hedonic Price Effects of Pedestrian- and Transit-Oriented Development. *Journal of Planning Literature* 26, 18-34.

- Basto, M., Pereira, J.M., 2012. An SPSS R-Menu for Ordinal Factor Analysis. *Journal of Statistical Software* 46, 1-29.
- Belzer, D., Autler, G., 2002. Transit oriented development: moving from rhetoric to reality. Brookings Institution Center on Urban and Metropolitan Policy, Washington DC.
- Bertolini, L., 1999. Spatial Development Patterns and Public Transport: The Application of an Analytical Model in the Netherlands. *Planning Practice & Research* 14, 199-210.
- Bertolini, L., Curtis, C., Renne, J.L., 2009. Introduction, In: Curtis, C., Renne, J.L., Bertolini, L. (Eds.), *Transit Oriented Development: Making it Happen*. Ashgate Publishing Limited, Surrey.
- Boarnet, M.G., 2010. Planning, climate change, and transportation: Thoughts on policy analysis. *Transportation Research Part A: Policy and Practice* 44, 587-595.
- Bowes, D.R., Ihlanfeldt., K.R., 2001. 2001. Identifying the impacts of rail transit stations on residential property values. *Journal of Urban Economics* 50, 1-25.
- Bowling, A., Stafford, M., 2007. How do objective and subjective assessments of neighbourhood influence social and physical functioning in older age? Findings from a British survey of ageing. *Social Science & Medicine* 64, 2533-2549.
- Brisbane City Council, 2013. *Planning for the Future: the Draft New City Plan*, Brisbane.
- Buckner, J.C., 1988. The development of an instrument to measure neighborhood cohesion. *American Journal of Community Psychology* 16, 771-791.
- Bullen, P., Onyx, J., 1998. Measuring Social Capital in Five communities In New South Wales: with Neighbourhood and Community Centres. <http://www.mapl.com.au/A2.htm>. 30.06.2013
- Burton, N.W., Haynes, M., Wilson, L.-A.M., Giles-Corti, B., Oldenburg, B.F., Brown, W.J., Giskes, K., Turrell, G., 2009. HABITAT: A longitudinal multilevel study of physical activity change in mid-aged adults. *BMC Public Health* 9, 76.
- Buys, L., Godber, A., Summerville, J., Barnett, K., 2007. Building Community: collaborative Individualism and the Challenge for Building Social Capital. *Australasian Journal of Regional Studies* 13, 287-298.
- Cerin, E., Leslie, E., Toitc, L.d., Owen, N., Frank, L.D., 2007. Destinations that matter: Associations with walking for transport. *Health & Place* 13, 713–724.
- Cervero, R., Gorham, R., 1995. Commuting in transit versus automobile neighborhoods. *Journal of the American Planning Association* 61, 210.
- Cervero, R., Kockelman, K., 1997. Travel demand and the 3Ds: density, diversity, and design. *Transportation Research Part D: Transport and Environment* 2, 199–219.
- Currie, G., Stanley, J., 2008. Investigating Links between Social Capital and Public Transport. *Transport Reviews* 28, 529-547.
- De Vos, J., Derudder, B., Van Acker, V., Witlox, F., 2012. Reducing car use: changing attitudes or relocating? The influence of residential dissonance on travel behavior. *Journal of Transport Geography* 22, 1-9.
- Dempsey, N., Brown, C., Bramley, G., 2012. The key to sustainable urban development in UK cities? The influence of density on social sustainability. *Progress in Planning* 77, 89-141.

- du Toit, L., Cerin, E., Leslie, E., Owen, N., 2007. Does Walking in the Neighbourhood Enhance Local Sociability? *Urban Studies* 44, 1677-1695.
- Duncan, M., 2011. The Impact of Transit-oriented Development on Housing Prices in San Diego, CA. *Urban Studies* 48, 101-127.
- Forrest, R., Kearns, A., 2001. Social Cohesion, Social Capital and the Neighbourhood. *Urban Studies* 38, 2125-2143.
- Freeman, C., Tranter, P.J., 2011. *Children and their urban environment : changing worlds*. Earthscan, Washington, DC, London.
- Ganapati, S., 2008. Critical Appraisal of Three Ideas for Community Development in the United States. *Journal of Planning Education and Research* 27, 382-399.
- General Household Survey, 2002. *Living in Britain: Results from the 2000/01*. Office for National Statistics.
- Glaeser, E.L., Gottlieb, J.D., 2006. Urban Resurgence and the Consumer City. *Urban Studies* 43, 1275-1299.
- Gordon, I., 2008. Density and the built environment. *Energy Policy* 36, 4652-4656.
- Gray, D., Shaw, J., Farrington, J., 2006. Community transport, social capital and social exclusion in rural areas. *Area* 38, 89-98.
- Guo, J.Y., Chen, C., 2007. The built environment and travel behavior: making the connection. *Transportation* 34, 529-533.
- Halbur, T., 2007. TOD's Evil Twin: Transit-Adjacent Development. *Mass Transit*, 4-7.
- Harriss, J., De Renzio, P., 1997. 'Missing Link' or Analytically Missing? The Concept of Social Capital. *Journal of International Development* 9, 919-937.
- Hollenhorst, J., 2007. Thinking "Green". *Mass Transit*, 3.
- Johnson, D., Headey, B., Jensen, B., 2005. *Communities, social capital and public policy: literature review*. Australian Government: Department of Family and Community Services, Policy Research Paper No. 26, Canberra.
- Kamruzzaman, M., Baker, D., Turrell, G., 2013a. Short and medium term travel behavioural outcomes of residential dissonance: implications for TOD, World Conference on Transport Research (WCTR), Rio-de-Janeiro.
- Kamruzzaman, M., Baker, D., Washington, S., Turrell, G., 2013b. Residential dissonance and mode choice. *Journal of Transport Geography* 33, 12-28.
- Kamruzzaman, M., Baker, D., Washington, S., Turrell, G., 2014. Advance transit oriented development typology: Case study in Brisbane, Australia. *Journal of Transport Geography* 34, 54-70.
- Kamruzzaman, M., Hine, J., 2011. Participation index: a measure to identify rural transport disadvantage? *Journal of Transport Geography* 19, 882-899.
- Kamruzzaman, M., Hine, J., 2013. Self-proxy agreement and weekly school travel behaviour in a sectarian divided society. *Journal of Transport Geography* 29, 74-85.
- Kamruzzaman, M., Washington, S., Baker, D., Turrell, G., 2013c. Does residential dissonance impact residential mobility? *Transportation Research Record* 2344, 59-67.

- Kim, J., Kaplan, R., 2004. Physical and Psychological Factors in Sense of Community: New Urbanist Kentlands and Nearby Orchard Village. *Environment and Behavior* 36, 313-340.
- Lau, S.S.Y., Giridharan, R., Ganesan, S., 2005. Multiple and intensive land use: case studies in Hong Kong. *Habitat International* 29, 527-546.
- Leyden, K.M., 2003. Social capital and the built environment: the importance of walkable neighborhoods. *American Journal of Public Health* 93, 1546–1551.
- Lund, H., 2002. Pedestrian Environments and Sense of Community. *Journal of Planning Education and Research* 21, 301-312.
- Lund, H., 2003. Testing the claims of New Urbanism. American Planning Association. *Journal of the American Planning Association* 69, 414-429.
- Lund, H., 2006. Reasons for Living in a Transit-Oriented Development, and Associated Transit Use. *Journal of the American Planning Association* 72, 357-366.
- Mason, S.G., 2010. Can community design build trust? A comparative study of design factors in Boise, Idaho neighborhoods. *Cities* 27, 456-465.
- Masoud, M., Rastbin, S., Ardahaey, F.T., 2011. Evaluation of Social Capital, Considering Sociability and Walkability in Urban Fabrics: The Case of Isfahan City, Iran. *Asian Social Science* 7, 216-228.
- Melia, S., Parkhurst, G., Barton, H., 2011. The paradox of intensification. *Transport Policy* 18, 46-52.
- Miciukiewicz, K., Vigar, G., 2012. Mobility and Social Cohesion in the Splintered City: Challenging Technocentric Transport Research and Policy-making Practices. *Urban Studies* 49, 1941-1957.
- Miller, D.S., Rivera, J.D., 2011. Introduction: The Unique Opportunities and Challenges from a Social Scientific Perspective, In: Miller, D.S., Rivera, J.D. (Eds.), *Community Disaster Recovery and Resiliency: Exploring Global Opportunities and Challenges*. CRC Press, London New York, pp. XXXV-li.
- Onyx, J., Bullen, P., 2001. Measuring social capital in five communities. *Journal of Behavioural Science* 36, 23–42.
- Pargal, S., Gilligan, D., Huq, M., 2000. PRIVATE PROVISION OF A PUBLIC GOOD: SOCIAL CAPITAL AND SOLID WASTE MANAGEMENT IN DHAKA, BANGLADESH. DOI: 10.1596/1813-9450-2422, World Bank eLibrary.
- Pinjari, A., Pendyala, R., Bhat, C., Waddell, P., 2007. Modeling residential sorting effects to understand the impact of the built environment on commute mode choice. *Transportation* 34, 557-573.
- Poortinga, W., 2006. Perceptions of the environment, physical activity, and obesity. *Social Science & Medicine* 63, 2835-2846.
- Putnam, R., 1993. *Making Democracy Work*. Princeton University Press, Princeton, NJ.
- Putnam, R., 2000. *Bowling Alone: the collapse and revival of American community*. Simon & Schuster, New York.
- Queensland Government, 2008. *Toward Q2: Tomorrow's Queensland*, Brisbane.
- Queensland Government, 2009. *South East Queensland Regional Plan 2009–2031*. Queensland Department of Infrastructure and Planning, Brisbane.

- Queensland Government, 2010a. Connecting SEQ 2031 – An Integrated Regional Transport Plan for South East Queensland. Transport and Main Roads, Brisbane.
- Queensland Government, 2010b. Transit oriented development: guide for practitioners in Queensland. The Department of Infrastructure and Planning, Brisbane.
- Queensland Government, 2013. State Planning Policy. The Department of State Development, Infrastructure and Planning, Brisbane.
- Renne, J.L., 2009. From transit-adjacent to transit-oriented development. *Local Environment* 14, 1-15.
- Roche, M., 2004. Social Policy and Social Capital: A Clear Case of Putting Merit before Method? *Social Policy and Society* 3, 97-111.
- Rohe, W.M., 2009. From Local to Global: One Hundred Years of Neighborhood Planning. *Journal of the American Planning Association* 75, 209-230.
- Sharifi, A., Murayama, A., 2013. Changes in the traditional urban form and the social sustainability of contemporary cities: A case study of Iranian cities. *Habitat International* 38, 126-134.
- Simpson, E.H., 1949. Measurement of diversity. *Nature* 163, 688.
- Spinney, J.E.L., Scott, D.M., Newbold, K.B., 2009. Transport mobility benefits and quality of life: A time-use perspective of elderly Canadians. *Transport Policy* 16, 1-11.
- Stangl, P., Guinn, J.M., 2011. Neighborhood design, connectivity assessment and obstruction. *Urban Design International* 16, 285–296.
- Stanley, J., Stanley, J., Hensher, D., 2012. Mobility, Social Capital and Sense of Community: What Value? *Urban Studies* 49, 3595-3609.
- Stanley, J., Stanley, J., Vella-Brodrick, D., Currie, G., 2010. The place of transport in facilitating social inclusion via the mediating influence of social capital. *Research in Transportation Economics* 29, 280-286.
- Transport for London, 2010. Measuring Public Transport Accessibility Levels (PTALs): Summary, London.
- Transportation Research Board, 2001. Making transit work: insight from Western Europe, Canada, and the United States. Transportation Research Board Special Report 257.
- Transportation Research Board, 2004. Transit-Oriented Development in the United States: Experiences, Challenges, and Prospects. TCRP Report 102.
- Turrell, G., Haynes, M., Burton, N., Giles-Corti, B., Oldenburg, B., Wilson, L.-A.M., M.Giskes, K., Brown, W.J., 2010. Neighborhood disadvantage and physical activity : baseline results from the HABITAT multilevel longitudinal study. *Annals of Epidemiology* 20, 171-181.
- Vallance, S., Perkins, H.C., Dixon, J.E., 2011. What is social sustainability? A clarification of concepts. *Geoforum* 42, 342-348.
- Wood, L., Boruff, B., Smith, H., 2013. When Disaster Strikes...How Communities Cope and Adapt: A Social Capital Perspective, In: Johnson, C.D. (Ed.), *Social Capital: Theory, Measurement and Outcomes*. Nova, New York.
- Wood, L., Giles-Corti, B., Bulsara, M., 2012. Streets apart: does social capital vary with neighbourhood design? *Urban Studies Research* <http://dx.doi.org/10.1155/2012/507503>.

- Wood, L., Shannon, T., Bulsara, M., Pikora, T., McCormack, G., Giles-Corti, B., 2008. The anatomy of the safe and social suburb: An exploratory study of the built environment, social capital and residents' perceptions of safety. *Health & Place* 14, 15-31.
- Wu, B.M., Hine, J., 2003. A PTAL approach to measuring the changes in bus service accessibility. *Transport Policy* 10, 307-320.
- Yang, Y., 2008. A Tale of Two Cities: Physical Form and Neighborhood Satisfaction in Metropolitan Portland and Charlotte. *Journal of the American Planning Association* 74, 307.
- Ziersch, A.M., Baum, F.E., MacDougall, C., Putland, C., 2005. Neighbourhood life and social capital: the implications for health. *Social Science & Medicine* 60, 71-86.

## **9. Figure captions**

Figure 1: The TwoStep Cluster Analysis generated four types of neighbourhoods in the first stage

Figure 2: The second stage PTALs based cluster analysis of non-TOD individuals resulted in a two cluster solution

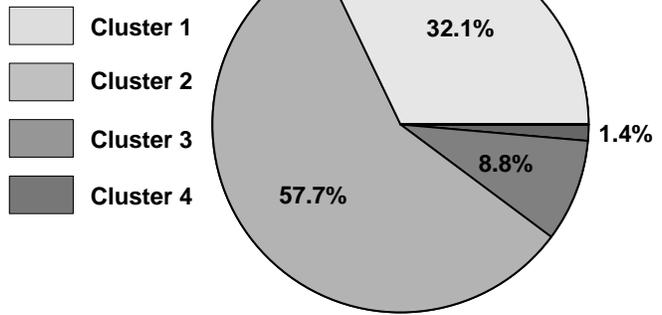
Figure 3: Classification of respondents' living environment into TODs and TADs and their spatial distribution

**Model summary**

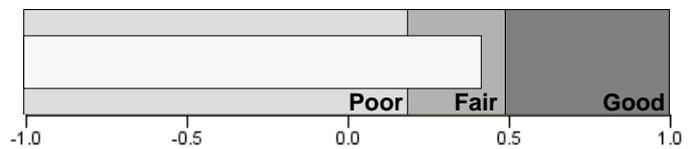
<b>Algorithm</b>	TwoStep
<b>Inputs</b>	5
<b>Clusters</b>	4

<b>Size of smallest cluster</b>	80 (1.4%)
<b>Size of largest cluster</b>	3233 (57.7%)
<b>Ratio of sizes: largest to smallest cluster</b>	40.41

**Cluster sizes**



**Cluster quality**



Silhouette measure of cohesion and separation

**Input (predictor) importance**



Cluster	1	2	3	4
<b>Label</b>	Non-TOD	Non-TOD	TOD	TOD
<b>Size</b>	32.1% (1797)	57.7% (3233)	8.8% (496)	1.4% (80)
<b>Inputs</b>	Employment density 7.70 Land use diversity 0.16 PTALs 1.24 Residential density 12.16 Intersection density 0.54	Employment density 33.33 Land use diversity 0.47 PTALs 1.82 Residential density 15.58 Intersection density 0.66	Employment density 123.04 Land use diversity 0.44 PTALs 5.80 Residential density 27.69 Intersection density 0.88	Employment density 75.22 Land use diversity 0.58 PTALs 13.12 Residential density 116.58 Intersection density 0.95

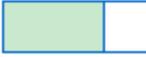
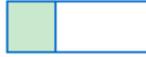
### Model summary

Algorithm	TwoStep
Inputs	1
Clusters	2

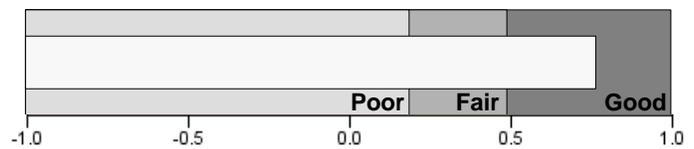
Size of smallest cluster	1634 (32.5%)
Size of largest cluster	3396 (67.5%)
Ratio of sizes: largest to smallest cluster	2.08

### Input (predictor) importance

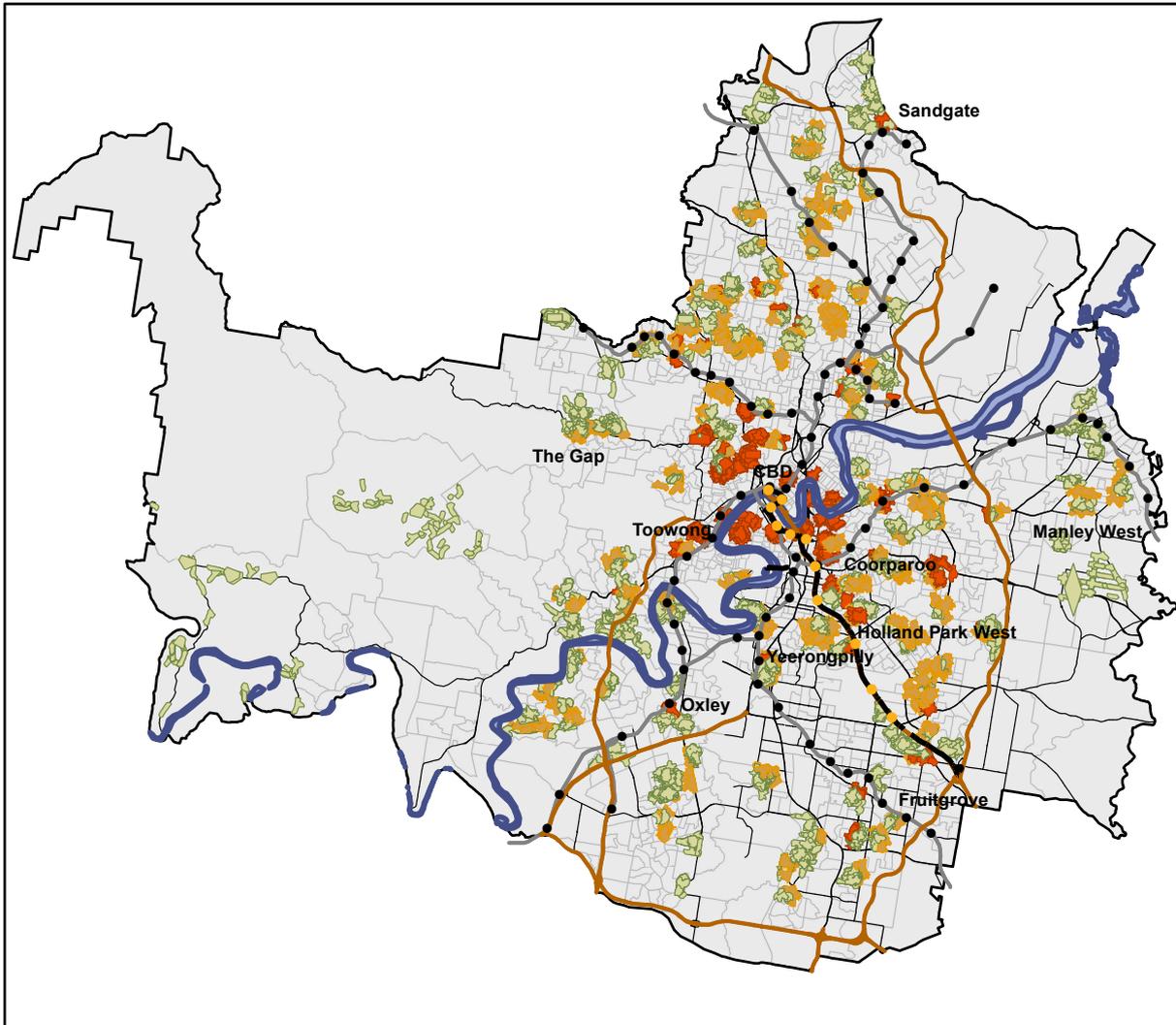
Legend: 1.0 (dark blue), 0.8 (medium blue), 0.6 (light blue), 0.4 (very light blue), 0.2 (lightest blue), 0.0 (white)

Cluster	1	2
Label	Non-TOD	TAD
Size	 67.5% (3396)	 32.5% (1634)
Inputs	PTALs 0.58	PTALs 3.76

### Cluster quality



Silhouette measure of cohesion and separation



<b>Neighbourhood types</b>	● Bus stop
■ TOD	— Dedicated busway
■ TAD	● Train stations
■ Traditional suburbs	— Motorway
■ Brisbane CCDs	— Railway
— MainRoads	■ Brisbane River

## 10. Tables

Table 1: Suggested design parameters for different types of TODs in Queensland (Queensland Government, 2010b)

TOD type	Dwelling density (dwelling units/hectare)	Land use diversity	Commercial plot ratio	Transit
City centre	100+ / 300+	Residential 30%, commercial 40%, retail 20%, community 10%	5:1	-Peak hour frequency: 15 minutes
Activity centre	40+ / 140+	Residential 50%, commercial 25%, retail 15%, community 10%	3:1	-Off-peak frequency: not more than 30 minutes
Specialist activity centre	40+ / 120+	At least 20% residential, at least 10% retail, commercial or community	2:1	-18-24 hour transit services
Urban	60+ / 180+	Residential 60%, commercial 25%, retail 10%, community 5%	3:1	-Dedicated routes
Suburban	30-80 / 100+	Residential 70%, commercial 10%, retail 15%, commercial 5%	2:1	
Neighbourhood	30-60 / 80+	Residential 90%, commercial 2.5%, retail 5%, community 2.5%	1:1	

Table 2: Items and social capital scales (sorted pattern matrix)

Items	Scales (factors)	
	Connectedness with neighbours	Trust and reciprocity
I have little to do with most people in my suburb	-0.878	0.048
I am good friends with many people in my suburb	0.850	-0.002
If I no longer lived here, hardly anyone around here would notice	-0.743	-0.036
I have a lot in common with many people in my suburb	0.471	0.274
Generally speaking, people in my suburb can be trusted	-0.126	0.908
Most of the time, people in my suburb try to be helpful	0.084	0.804
I generally trust my neighbours to look out for my property	0.187	0.515
Most of the time, people in my suburb just look out for themselves	-0.335	-0.502
Sum of squared loadings (rotated)	3.906	3.716
% of variance explained	54.881	7.211
Reliability (Standardised Cronbach's alpha)	0.820	0.788
Kaiser-Meyer-Olkin (KMO) MSA		0.901
Factor extraction method: Principle Axis Factoring		
Rotation method: Oblimin Quartimin with Kaiser normalisation		
Correlation matrix: Polychoric		
N		5606

Table 3: Socio-demographic status of the respondents participated in the survey

Socio-demographics	Frequency	%	Mean	Standard deviation
<b>Gender</b>				
Male	2396	42.7		
Female	3210	57.3		
<b>Employment status</b>				
Not working	1664	29.7		
Working part time	1316	23.5		
Working full time	2626	46.8		
<b>Level of education</b>				
Up to year 12	2076	37.0		
Diploma/certificate	1615	28.8		
Bachelor and above	1915	34.2		
<b>Current living arrangement</b>				
Living alone with no children	913	16.3		
Single parent with >=1 children	321	5.7		
Single and living with friends/relatives	248	4.4		
Couple living with no children	1923	34.3		
Couple living with >=1 children	2114	37.7		
Other	87	1.6		
<b>Income percentile</b>				
First (lower)	1113	19.9		
Second	1085	19.4		
Third	1374	24.5		
Fourth (upper)	1193	21.3		
Missing	841	15.0		
<b>Country of birth</b>				
Australia	4315	77.0		
Other	1291	23.0		
Length of stay at current address (year)			17.3	10.6
Age			56.4	7.1
Average household size			2.7	1.3
<b>N</b>				<b>5606</b>

Table 4: Multivariate multiple regression analyses results showing relationships between neighbourhood types and different dimensions of social capital.<sup>a</sup>

Explanatory factors	Dependent variables: dimensions/scales of social capital			
	Connectedness with neighbours		Trust and reciprocity	
	Coef.	<i>t</i>	Coef.	<i>t</i>
Neighbourhood classification: (ref: TAD)				
TOD				
Traditional suburbs	0.54	3.08	0.28	2.09
Reason for choosing neighbourhood: sense of community	0.26	2.39	0.22	2.75
PTALs (continuous)	0.91	26.43	0.48	18.39
Net residential density (continuous)	-0.04	-2.27	-0.02	-1.42
Land use diversity	-0.01	-1.85	-0.01	-2.99
Length of stay (years) (continuous)	-0.33	-1.52	-0.33	-2.03
Gender: female (ref: male)	0.02	5.03	0.00	0.49
Level of education: graduate and over (ref: up to year 12)	0.15	1.71	0.13	1.97
Country of birth: other (ref: Australia)	0.03	0.36	0.33	4.67
Employment status: full time working (ref: non-working)	-0.26	-2.65	-0.21	-2.77
Living arrangement (ref: single)	-0.39	-4.17	-0.08	-1.13
Single parent with >=1 children	0.55	2.82	0.04	0.28
Couple with no children	0.30	2.59	0.21	2.35
Couple with children	0.80	6.60	0.22	2.40
Household income (ref: First/lowest quartile)				
Third quartile	0.06	0.51	0.31	3.77
Fourth quartile	0.20	1.62	0.30	3.23
Constant	9.67	45.89	13.19	82.85
<i>F</i>		59.56		32.21
<i>R</i> <sup>2</sup>		0.15		0.09
Wilks' lambda ( <i>F</i> )				33.08
Lawley–Hotelling trace ( <i>F</i> )				33.99
Pillai's trace ( <i>F</i> )				32.17
Roy's largest root ( <i>F</i> )				60.12
N				5606

<sup>a</sup>Dimmed coefficients are not significant at the 0.05 level.