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Quantifying spatial gaps in public transport supply based on social needs

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ABSTRACT

This paper concerns a research project to identify spatial gaps in public transport provision for people who are socially disadvantaged. The paper outlines the research context for measurement of public transport supply and needs, and then describes the methodology developed for an application in Melbourne, Australia. Results of the application are described including key findings on spatial gaps in services relative to social needs. The research identifies significant gaps between services supplied and social needs for transport services. Consistency of these findings with research in other Australian cities are noted. Implications for policy development are suggested.

1. Introduction

A large number of research studies have identified the suburban fringe of Australian metropolitan areas as a focus of significant transport disadvantage (e.g., Faulkner, 1978; Travers Morgan, 1992; Dodson et al., 2004). More recent research has suggested that rising auto fuel prices and associated increases in home loan interest rates are further exacerbating disadvantage in Australia's urban fringe (Dodson and Sipe, 2006). In the UK research has associated lack of transport and access to wider social disadvantage and social exclusion (Social Exclusion Unit, (SEU), 2003).

The provision of public transport to provide access for socially disadvantaged groups has long been seen as one of several major service development rationales (Larwin, 1999; Veeneman, 2002; Nielsen et al., 2005). However, a number of studies have identified problems with Australian urban public transport systems associated with poor service levels on Australia's urban fringe (e.g., Hurni, 2006). A major problem with social research studies which identify transport needs of this kind is that they are often based on expressed needs, anecdotal and largely qualitative evidence. Hence while there is much recognition of the problem there is only limited quantitative, robust and reliable evidence upon which to objectively review and assess the full range of public transport service delivery in the context of social needs in Australian cities. This has acted to limit policy responses to selected and often tokenistic responses. A systematic and comprehensive approach to matching public transport to social needs requires an objective and systematic approach to identifying gaps between services and social needs.

This paper presents the results of research study aimed at objectively measuring the relative quality of public transport supply and its spatial distribution with respect to transport disadvantage in Metropolitan Melbourne. The project is part of a wider international research program funded by the Australian Research Council[1] which is currently focussing on understanding transport disadvantage in Metropolitan Melbourne.

Section 2 of this paper presents a summary of the research context regarding studies that have measured transport service quality relative to social needs. Section 3 then details the methodology adopted for the study. The results associated with the spatial distribution of public transport supply are then described in Section 4. Section 5 summarises the results concerning the spatial distribution of transport needs. Section 6 then outlines the assessment of relative supply and needs to identify gaps in service levels. Section 7 then concludes the paper by providing a discussion of key findings and an assessment of the implications for future policy and research.

2. Research context

Some of the earliest studies assessing the relative quality of public transport services relative to social needs come from the UK and concern the value for money associated with rural public transport accessibility and associated subsidies (Moseley, 1979; Searle, 1987). The more recent UK interest in transport and social exclusion has driven the adoption of accessibility planning

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techniques which are now a central part of all Local Government Transport Plans in both urban and rural contexts (Department for Transport, 2004). The UK approach measures accessibility in a number of ways including:

- *Core accessibility indicators:* These are specific measures such as the percentage of pupils of compulsory school age within 15–30 min of a primary school by public transport.
- *Local indicators*: These are specific studies of known 'problem' locations and can include a much wider range of measures, e.g., percentage of bus network services with low floor buses.
- *Accessibility modelling:* Using geographical information systems (GIS) to generate transport maps, accessibility maps, e.g., illustrating 'isotims', catchment maps comparing population distribution with access time/cost thresholds and ranking charts (where areas are ranked according to an accessibility indicator on graphs or charts).

Amongst a series of methodological developments in this area are techniques such as 'PTAL' (public transport accessibility level). For example, Wu and Hine (2003) undertook a review of transport and supply needs using GIS mapping to compare the spatial distribution of the outputs of indices of deprivation with relative measures of public transport supply (PTAL) in Belfast, UK. PTAL is a 1–6 rating scale of service quantity supplied which includes measures such as access walk time, frequency and service reliability.

The UK accessibility framework and measures associated with them have been criticised for overly emphasising 'place based' gaps in services when other forms of transport disadvantage can be experienced by social groups with no particular spatial concentration (Hine and Mitchell, 2003). In the context of the spatial assessment of public transport and social needs in Australia, these approaches provide a useful way forward.

A review of international approaches to measuring the relative supply of passenger transport and transport disadvantage was undertaken in 1992 (Currie and Wallis, 1992). This identified an approach using available census and social data from sources such as the Australian Bureau of Statistics to identify relative transport needs at census collector district (CCD) level. Associated approaches to measure supply of services for the transport disadvantaged were also described. Measures such as the relative bus vehicle kms per km^2 were used to illustrate public transport supply. Gaps were identified between public transport and social needs in Adelaide particularly on the urban fringe. Since this time the method has been applied in NSW, West Australia, regional Queensland, Victoria and New Zealand in a range of consultancy studies (see Currie et al., 2003). In general these approaches were adopted for the Melbourne study described in this paper (see later).

A new variation of this approach was developed in Hobart (Currie, 2004). A public transport network model utilising generalised costs was used to represent public transport supply quality across the network. This provided a more detailed refinement of the supply side modelling in previous applications of the approach. However, the transport needs measurement methods were similar to previous applications. In addition the approach was 'rebadged' under the 'needs-gap' name.

The Hobart 'needs-gap' study (Currie, 2004) found consistent spatial gaps between low supply of public transport and high shares of transport need groups in fringe suburban Hobart. The Melbourne 'needs-gap' study described in this paper aimed to find out what the application of these approaches would establish for a larger city in the Australian context.

3. Methodology

3.1. Overview

The methodology aims to identify a measure for social need associated with transport disadvantage for each of Melbourne's 5839 census collector districts (CCDs). It also aims to develop a comparable measure representative of the level of public transport supply available in each CCD. It then compares the two to identify 'need-gaps'.

3.2. Approach to supply measurement

The supply measurement aimed to create a measure of public transport supply for each CCD which was representative of:

- the share of the CCD which had good/bad access distance to public transport,
- the level of service provided by public transport to the areas where public transport was provided.

The following approach was adopted:

1. A database of bus and tram stops and train stations was obtained. This is current to August 2006. This included the location of each stop/station plus a listing of rail, bus and tram routes using the stops.
2. This database was integrated with a database of public transport service frequencies in Melbourne. A database of bus service levels was obtained from the Bus Association of Victoria (current to November 2005, and includes updates for new 'SmartBus' routes 700 and 900 to August 2006). Current tram and train service frequencies were extracted from the Metlink passenger information website and are current to August 2006.
3. For each stop/station a measure of service frequency was calculated which is the 'total number of service arrivals per week'.
4. Access distance to each stop/station was then measured for each CCD assuming the following thresholds of walk access which are based on typical walk catchments (termed walk 'buffers') for public transport modes:
   - Access to bus stop = 400 m.
   - Access to tram stop = 400 m.
   - Access to rail station = 800 m.
5. A combined measure of service frequency (vehicle trips per week) and access distance was then computed for each CCD using GIS software and the following formulae:

$$SI_{CCD} = \sum N\left(\frac{Area_{B_n}}{Area_{CCD}} * SL_{B_n}\right) \tag{1}$$

where SI_{CCD} is the supply index for the CCD, CCD is the CCD under analysis, N is the number of walk access buffers to stops/stations in each CCD, B_n is the buffer n for each stop/station in each CCD, Area is the square kilometre spatial area of the CCD, SL is the service level measure (number of bus/tram/train vehicle arrivals per week).

This approach accounts for the spatial coverage of a CCD which is covered by walk catchments to public transport and also their relative service levels. It also accounts for overlaps in catchments, e.g., places where walking to bus and rail is possible. In this case the combined service level of bus and rail are 'double counted' which recognises that these areas have a higher service level.

A weakness of this approach is that it allots a measure of supply to each CCD without any knowledge of the spatial distribution of people living within the CCD. In effect it assumes an even spatial distribution of residents within the CCD. This method also does not concern itself with where travel is being supplied to. For example some trips might be cross-corridor rather than to the CBD and hence be more difficult. Overall the approach adopted is simplistic but quantifies broad levels of supply and is relatively easy to measure.

The approach adopted is as not as detailed/refined as that adopted for Hobart (Currie, 2004). The Hobart analysis included measurement of total generalised cost of travel between each zone to the nearest destination for a series of trip purposes including access to doctors, chemists, schools, hospitals and other key activities. The analysis requirement for this is considerable and would be particularly cumbersome given the relative scale of Melbourne compared to Hobart (Melbourne has 5839 zones while Hobart had only 387). Simplification was therefore a major requirement of the revised methodology. However, the use of individual station and tram/bus stops to assess walk catchments and the adoption of GIS approaches to identify overlapping walk 'buffers' with a higher combined service level is new and a refinement of a different nature to the methodology.

3.3. Approach to social disadvantage measurement

A combination of two main measures of the spatial distribution of social disadvantage or 'need' indices were adopted including the following:

1. The Australian Bureau of Statistics Index of Relative Socio-Economic Advantage/Disadvantage (IRSAD).
2. A transport needs index.

Both were considered a valuable means of identifying social disadvantage in relation to transport needs. The IRSAD index is more common in general social research in Australia. The transport index approach is based on Currie (2004) and Travers Morgan (1992) and is adopted because it specifically considers transport related needs using available Australian census and social indicators.

3.4. IRSAD

IRSAD is a measure of advantage and disadvantage in a spatial continuum. Areas with a low index score can be categorised as relatively disadvantaged areas and areas with higher scores can be categorised as relatively advantaged areas. The index includes the variables and weights identified in Table 1.

This index can show where the affluent (as opposed to just high income earning) live; where disadvantaged (as opposed to the unemployed) live: and where the highly skilled and educated (as opposed to the tertiary educated people) live (Adhikari, 2006).

IRSAD was identified as a preferred indicator for the use of identifying advantaged and disadvantaged areas in one of the first working papers of the wider research program of which this paper is a part (Currie et al., 2006).

3.5. Transport needs index

This is based on the previous 'needs-gap' approach (Currie and Wallis, 1992; Travers Morgan, 1992; Currie, 2004). For each CCD the indicators identified in Table 2.

In outline the methodology for producing a needs measure for each CCD involves:

- Assembling transport need indicators for a series of areas.
- Defining a single need score for each area based on the relative indicator values shown in Table 2.
- Accessibility is the only indicator that is not readily available from government statistics. Accessibility measures the natural convenience or difficulty that a person is faced with when trav-

Table 1
List of variables used for the index of relative socio-economic advantage/disadvantage and their weights (Adhikari, 2006, p. 39).

Variable	Weight
% Persons aged 15 years and over with no qualifications	−0.2544
% Persons aged 15 years and over who left school at year 11 or lower	−0.2445
% Couple families with no children with annual income less than $20,800	−0.2003
% Couple families with dependent child(ren) only with annual income less than $36,400	−0.1977
% Employed females classified as 'Labourers and Related Workers'	−0.1918
% Employed males classified as 'Labourers and Related Workers'	−0.1903
% Employed males classified as 'Intermediate Production and Transport Workers'	−0.1861
% Single person household with income less than $15,600	−0.1803
% Males (in labour force) unemployed	−0.1611
% Females (in labour force) unemployed	−0.1579
% Couple families with dependents and non-dependents or with non-dependents only with annual income less than $52,000	−0.1464
% One-parent families with dependent offspring only	−0.1292
% Employed males classified as Tradespersons'	−0.1274
% Employed females classified as 'Intermediate Production and Transport Workers'	−0.1248
% Employed females classified as 'Elementary Clerical, Sales and Service Workers'	−0.0988
% Single parent families with dependents and non-dependents or with non-dependents with annual income less than $26,000	−0.0986
% Dwellings with four or more bedrooms	0.0845
% Employed females classified as 'Advanced Clerical and service Workers'	0.0958
% Single parent families with dependents and non-dependents or with non-dependents with annual income greater than $62,399	0.1271
% Employed males classified as 'Associate Professionals'	0.1354
% Persons aged 15 years and over at university or other tertiary institution	0.1482
% Single parent families with dependent child(ren) only with annual income less than $15,600	0.1674
% Couple families with dependents and non-dependents or with non-dependents only with annual income greater than $103,999	0.1758
% Persons using internet at home	0.1882
% Single person households with income greater than $36,399	0.1974
% Employed females classified as 'Professionals'	0.2086
% Persons aged 15 years and over having an advanced diploma or diploma qualification	0.2111
% Employed males classified as 'Professionals'	0.2269
% Couple families with no children with annual income greater than $77,999	0.2325
% Couple families with dependent child(ren) only with annual income greater than $77,999	0.2381
% Persons aged 15 years and over with degree or higher	0.2440

Table 2
Transport need indicators and weights applied.

Need indicator	Source	Weight
Adults without cars	Census 2001[a]	0.19
Accessibility	Distance from Melbourne CBD[b]	0.15
Persons aged over 60 years	Census 2001	0.14
Persons on a disability pension	Centrelink[c]	0.12
Low income households	Census 2001[d]	0.10
Adults not in the labour force	Census 1996[e]	0.09
Students	Census 2001[f]	0.09
Persons 5–9 years	Census 2001	0.12

[a] Based on the number of cars per household and the number of persons aged 18 and over (Census 2001).
[b] Based on the straight line distance to Melbourne central business district (GPO) from the CCD centroid.
[c] Based on the number of persons on a disability pension in a postcode grouping (Centrelink 2006). This was then spread across CCDs based on number of persons in each CCD within that postcode (Census 2001).
[d] Based on the number of households with a weekly household income of $499 or less (Census 2001).
[e] Based on persons over 15 not in labour force in 2001 (Census 2001).
[f] Based on persons enrolled in an educational institution – including primary and secondary school, university and technical and advanced further education.

elling to basic services from their home. It is a measure of locational disadvantage. The accessibility measure used was the straight line distance to the Melbourne CBD.

The formula for calculating needs scores is as follows:

$$NS_{CCD} = \sum (SI1_{CCD} * WI) + (SI2_{CCD} * W2) + \cdots + (SI8_{CCD} * W8) \tag{2}$$

where CCD is the CCD under analysis, SI1 is the standardised indicator 1 = adults without cars, SI2 is the standardised indicator 2 = accessibility, SI3 is the standardised indicator 3 = persons aged over 60 years, SI4 is the standardised indicator 4 = persons on a disability pension, SI5 is the standardised indicator 5 = adults on a low income, SI6 is the standardised indicator 6 = adults not in the labour force, SI7 is the standardised indicator 7 = student, SI87 is the standardised indicator 8 = persons 5–9 years, WI1–WI8 is the weight for indicator I1–8, see Table 2. Weights were sourced from an analysis of low trip making behaviour from the Adelaide Household Travel Survey (Travers Morgan, 1992; Currie, 2004).

A single need score is derived from the indicators by firstly ‘standardising’ each value. This involves re-setting the scores to a value of between 0 and 100 based on the relationship of the score to the highest value in its series. Each standardised value is then weighted and added together and a finalised need index generated. This is then standardised to obtain need scores between 0 and 100 for all areas in the analysis.

3.6. Relative and total need indicators

In practice both the IRSAD and transport need indices come in two forms:

- A total need indicator – which weights the indicators by the size of the population in a CCD.
- A relative need indicator – which weights the indicators by the proportion of the CCD population which is defined in the social need component groups.

These measures represent two separate ways of considering the spatial distribution of statistics both of which have validity to understanding social needs. Population weighting (total need) has obvious significance to understanding the scale of a problem since the number of people in a particular group is representative of the societal predominance of a given statistic. At the same time the proportion of a given indicator is illustrative of the relative predominance of its scale between areas. The approach used in this research adopts both approaches since they both have merit in understanding the scale of need. As such four total indicators are used:

- Total need IRSAD index.
- Relative need IRSAD index.
- Total transport need index.
- Relative transport need index.

3.7. Approach to assessment of multiple indicators

For the purposes of analysis, no judgement was made as to the relative value of the IRSAD or transport need indicator or of their relative and total need variants. Rather CCDs where indicator values are high or low were identified. This highlighted areas of high/low need using each approache. Nevertheless a single indicator was required otherwise the analysis would be overly complex. Hence a combined indicator was generated by adding the scores for each indicator at each CCD together and then standardising the combined score using the approach described above.

4. Results – public transport supply measurement

4.1. Overview

Fig. 1 and Table 3 show the findings of the public transport supply measurement using the methodology described above. The supply index was grouped into seven groups including three above and three below average categories plus a zero supply group. This indicates the following:

- Zero supply is provided for some 85,423 residents or 2.5% of the population which almost exclusively reside in fringe urban Melbourne including the Local Government Areas of Mornington Peninsula, Casey, Cardinia, Yarra Ranges and Nillumbik.
- The very low supply group covers all of outer Melbourne and many parts of the middle suburbs.
- Overall some 74.8% of the population or 2.5M residents have supply index scores which are below the Melbourne average.
- Above average, high and very high supply scores are concentrated in inner and CBD fringe areas.

4.2. Relating supply indices to service quality

Table 4 presents a summary of the individual supply index scores by component divided into areas of Melbourne (inner, middle and outer suburbs). This analysis aims to better understand the final supply index relative to service frequencies (services per week) and spatial coverage.

Table 4 indicates that:

- On average there are 3.1 stops/station per CCD (item iii) with about 291 services per week per stop (item iv or 41 per day). For an average CCD with 3.1 stops/stations and 291 services per week and an even coverage of walk catchments over the entire area a supply score of 902 might be expected (3.1×291). However, the actual services per week average for Melbourne CCDs is 1058 (item v). This is indicative of overlap between walk catchments in many CCDs which is not surprising since the average CCD is only 1.51 km^2 in size.
- On average Melbourne CCDs have an 83% coverage of walk catchments to public transport (viii). However, if the Metropolitan area as a whole is considered, only 18% of Melbourne is spa-

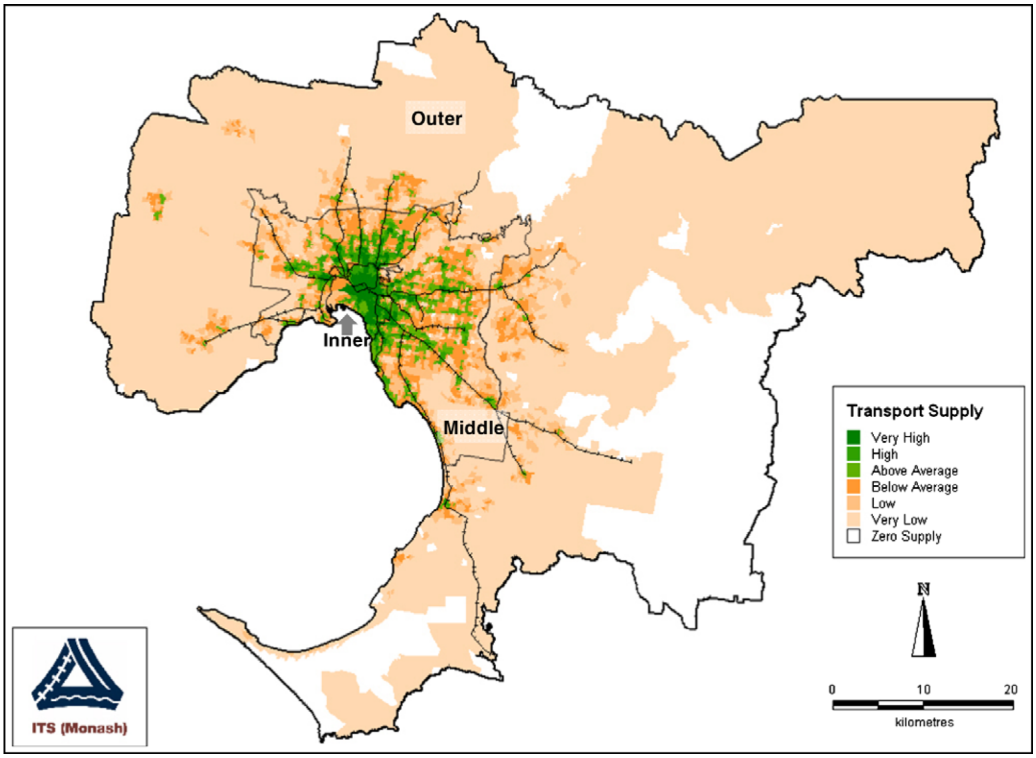

Fig. 1. Distribution of supply measure scores – Metropolitan Melbourne.

Table 3
Distribution of supply index scores and resident population.

Supply index category	Number of CCDs	Resident population	
		Number	% Total
Zero supply	189	85,423	2.5
Very low	1314	793,046	23.6
Low	1310	865,330	25.7
Below average	1294	774,521	23.0
Above average	608	324,546	9.6
High	535	260,411	7.7
Very high	589	263,832	7.8
Total	5839	3,367,109	100
Subtotal below average	4107	2,518,320	74.8

tially within a walk catchment to public transport (ix). The apparent conflict between these two statistics is explained by the wide variations in sizes of CCDs with very small CCDs with good walk catchment coverage being numerically dominant but a small number of very large CCDs (usually on the urban fringe) dominating the spatial coverage of Metropolitan Melbourne.

- Table 4 illustrates a significant contrast in public transport service levels between outer and inner/middle Melbourne.
  – Inner Melbourne stops/stations have an average of 630 services per week (iv) or 2149 per CCD (item v). Spatial coverage is excellent (98% in item viii). The overall average inner CCD supply score is 10,923 (item x) which is substantially higher than the amount of services per week per CCD (2149, item v). This illustrates substantial overlap between walk catchments to stops/stations and hence a wide range of choice between routes, stops and services.
  – In contrast outer Melbourne has only 156 services per stop per week, 75% less than inner Melbourne and 50% less than middle Melbourne. Only 66% of outer Melbourne CCDs are covered by public transport (32% less than inner Melbourne

Table 4
Supply index scores and elements of component service level measures.

Indicators	Inner Melbourne	Middle Melbourne	Outer Melbourne	Total
i. Number of CCDs	614	3189	2036	5839
ii. Total number of stops/stations	1514	10,226	6466	18,206
iii. Average number of stops in each CCD	2.5	3.2	3.2	3.1
iv. Average number of services per week per stop	630	313	156	291
v. Average total services per week per CCD	2149	1120	631	1058
vi. Average area of individual CCDs (km^2)	0.14	0.33	3.77	1.51
vii. Area of all CCDs (km^2)	85.9	1061.5	7683.8	8831.2
viii. Average proportion of each CCD covered by stop/station walk catchment	98%	91%	66%	83%
ix. Average proportion of all CCDs covered by stop/station walk catchment	90%	73%	10%	18%
x. Average supply score	10,922.7	2694.9	764.3	2886.9

Middle Melbourne enclosed the following LGA's (Banyule, Bayside, Boroondara, Brimbank, Darebin, Glen Eira, Greater Dandenong, Hobsons Bay, Kingston, Manningham, Maribyrnong, Monash, Moonee Valley, Moreland, Stonnington (part) and Whitehorse). Outer Melbourne (Cardinia, Casey, Frankston, Hume, Knox, Mornington Peninsula, Maroondah, Melton, Nillumbik, Whittlesea, Wyndham and Yarra Ranges). Inner is the other LGA's.

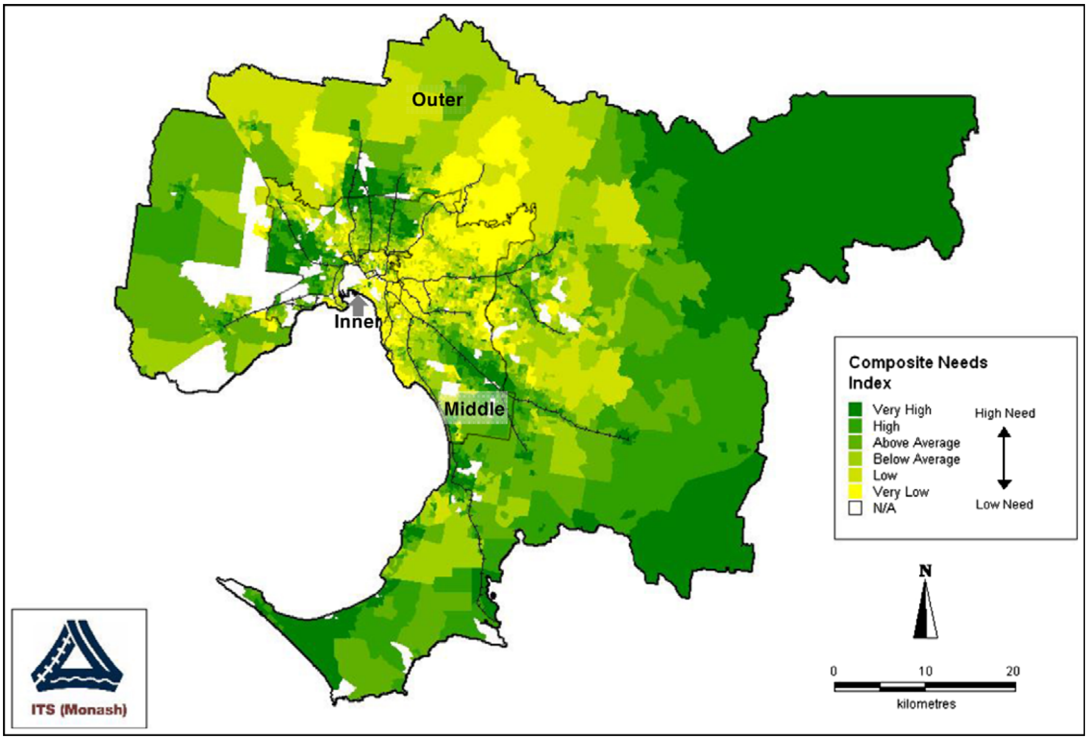

Fig. 2. Distribution of categories of composite social need index scores.

and 25% less than middle Melbourne). Overall only 10% of the spatial area of outer Melbourne has public transport walk catchment coverage compared to 90% of inner Melbourne.

- Overall the average outer Melbourne CCD supply score is 764 compared to 10,922 inner and 2695 middle. This is illustrative of lower service levels, sparser spatial coverage and limited walk catchment overlap compared to inner and middle Melbourne.

5. Results – social transport needs measurement

Appendix A to this paper shows the top 100 ranked CCDs with the highest need indicators. Fig. 2 illustrates the spatial distribution of composite needs scores divided into three above average and three below average need score groups.

This illustrates that:

- While there is trend to the very high transport/social needs scores being located in outer/fringe urban Melbourne this is not entirely the case. Nevertheless sections of Casey, Mornington Peninsula, Cardinia and Yarra Ranges show large areas with 'very high' levels of transport need.
- More inner/middle Melbourne distributions of 'very high' and 'high' needs can be seen in the East/South Eastern suburbs of Dandenong and Frankston, in the Northern Suburbs of Broadmeadows, Fawkner, Thomastown, and Reservoir and the Western suburbs of St Albans, Deer Park and Sunshine.
- The Bayside suburbs of Melbourne and the CBD and inner suburbs plus the North Eastern suburbs of Doncaster up to Eltham have 'very low' composite need categories.

6. Results – needs-gap analysis

Table 5 shows the distribution of CCD supply and needs scores in each category for Metropolitan Melbourne.

The most important groups identified from Table 5 are those with very high needs and zero or low public transport service levels:

- Some 89 CCDs representing 37,699 Melbourne residents (1.1% of the population) live in areas with no public transport but have the 'very high' social/transport needs score.
- Of those with 'very high' need scores, 101,305 residents live in areas with 'very low' public transport supply and 137,735 with 'low' public transport supply. Hence overall 8.2% of Melbourne residents have 'very high' needs but 'zero', 'low' or 'very low' public transport supply.

Fig. 3 illustrates the relative distribution of need and supply scores plus the relative thresholds for the categories used. The supply scores in this example have been converted to log values (excluding zero values) to aid visual assessment of the results.

Fig. 3 illustrates the relative distributions of scores in each group. There is no obvious link between supply and need, rather overall scores are scattered with a concentration of values in the 'low', 'below average', 'above average' and 'high' groups of both log supply and normalised composite need indicators.

Fig. 4 shows the spatial distribution of CCDs with 'very high' need scores and 'zero' or 'very low' public transport service levels. Table 6 lists the top 20 of these CCDs by the rank of composite need score with the associated rank of supply score.

These indicate that:

- The top 20 areas of highest need and low/zero supply are in Mornington Peninsula, Cardinia, Frankston and Yarra Ranges.
- Sections of the suburbs around Rosebud and Hastings are amongst the areas of greatest concern.
- Looking at the wider group of high need and low/zero supply areas (Fig. 4):
  - Mornington Peninsula, Yarra Ranges and Cardinia are highlighted as areas with large amounts of high need low/zero supply.

Table 5
Number of CCDs and resident population by social/transport need and public transport supply categories.

Supply indicator	Composite need indicator								
	Very high			High			Above average		
	CCDs	Pop.	% Pop.	CCDs	Pop.	% Pop.	CCDs	Pop.	% Pop.
Zero	89	37,699	1.1	32	14,338	0.4	16	7985	0.2
Very low	190	101,305	3.0	212	131,554	3.9	230	140,757	4.2
Low	209	137,735	4.1	214	141,273	4.2	256	169,648	5.1
Below average	189	120,934	3.6	205	119,981	3.6	191	113,281	3.4
Above average	74	41,702	1.2	61	33,000	1.0	81	43,622	1.3
High	53	27,149	0.8	66	33,314	1.0	62	30,694	0.9
Very high	53	24,692	0.7	39	16,563	0.5	43	20,393	0.6
Total	857	491,216	14.7	829	490,023	14.7	879	526,380	15.8

Supply indicator	Composite need indicator											
	Below average			Low			Very low			Total		
	CCDs	Pop.	% Pop.	CCDs	Pop.	% Pop.	CCDs	Pop.	% Pop.	CCDs	Pop.	% Pop.
Zero	18	9416	0.3	25	13,263	0.4	6	2722	0.1	186	85,423	2.6
Very low	245	154,876	4.6	218	140,874	4.2	164	118,926	3.6	1259	788,292	23.6
Low	221	146,209	4.4	217	148,078	4.4	176	119,906	3.6	1293	862,849	25.8
Below average	261	153,874	4.6	237	140,390	4.2	206	126,061	3.8	1289	774,521	23.2
Above average	121	62,783	1.9	116	60,952	1.8	147	79,117	2.4	600	321,176	9.6
High	92	42,802	1.3	98	48,912	1.5	161	76,597	2.3	532	259,468	7.8
Very high	75	35,865	1.1	146	61,719	1.8	205	90,181	2.7	561	249,413	7.5
Total	1033	605,825	18.1	1057	614,188	18.4	1065	613,510	18.4	5720	3,341,142	100.0

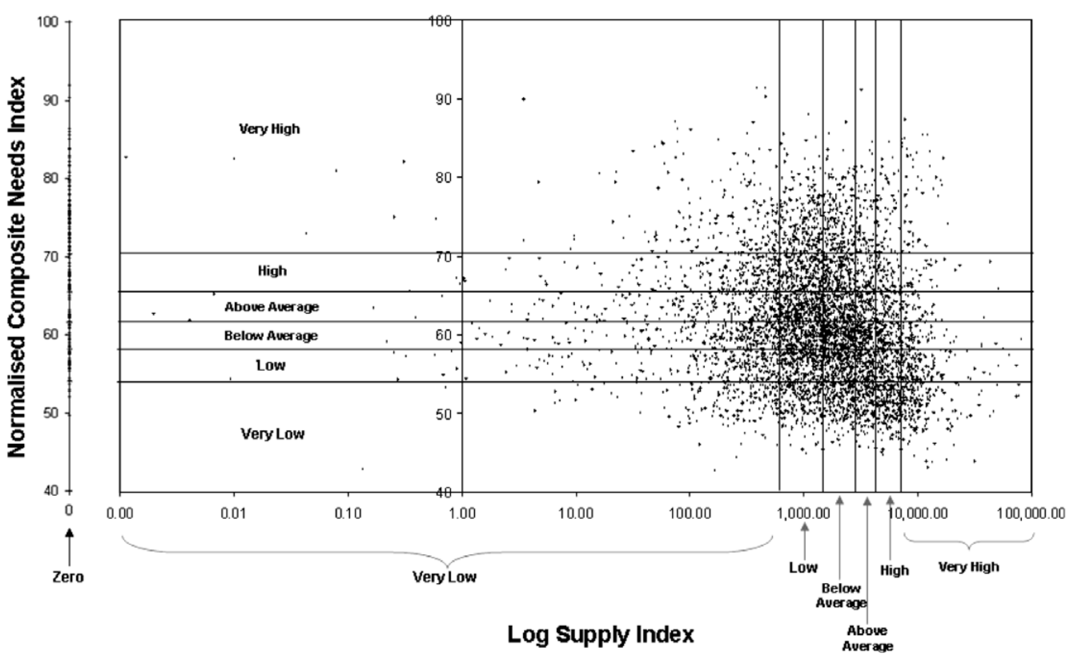

Fig. 3. Log supply score and need index values – Melbourne needs-gap study.

– Closer to the middle areas of Metropolitan Melbourne the following areas are highlighted:
– In Melbourne's North West – parts of Deer Park, Albion/Ginifer, Keilor Plains, Meadow Heights, Dallas, Campbellfield and Laylor.
– In Melbourne's South – parts of Frankston East, Seaford, Bonbeach, Cranbourne South, Dandenong, Clayton South and Keysborough.

7. Discussion and conclusions

This paper has presented the results of research aimed at objectively measuring the relative quality of public transport supply and its spatial distribution with respect to transport disadvantage in Metropolitan Melbourne. The approach adopted includes the development of measures of public transport supply and associated measures of social needs applied to CCDs in Melbourne. It is an extension on earlier work carried out on settlements and cities of much smaller size.

In general the approach was found to be easy to transfer to the context of a larger metropolitan city. The simplification of the supply side analysis assisted in this regard since the analysis tasks are significantly larger for 5839 zones in Melbourne compared to the 387 zones in an earlier study in Hobart.

Overall the analysis has identified significant differences between the levels of service of public transport supply between outer and inner/middle Melbourne. On average outer Melbourne has

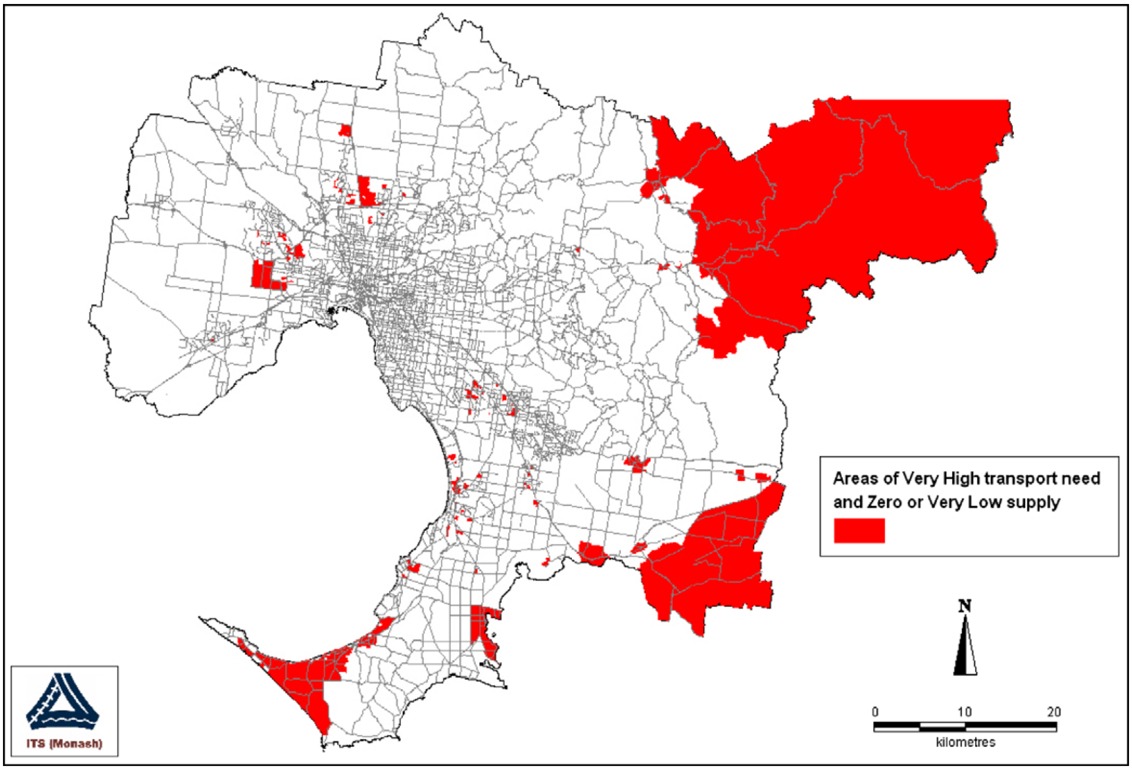

Fig. 4. Melbourne needs-gap – very high transport need areas with zero or very low public transport supply.

Table 6
Top 20 CCDs ranked by composite transport need and relative rank of public transport supply.

Suburb	CD code	SLA CCD name	Population	Public transport supply rank	Composite needs indicator (rank)
Rosebud West	2,211,609	Mornington P'sula (S) – South	1216	1	1
Rosebud	2,211,512	Mornington P'sula (S) – South	421	1	2
Hastings	2,212,405	Mornington P'sula (S) – East	528	1041	3
Frankston South	2,220,311	Frankston (C) – West	1190	920	4
Rosebud	2,211,401	Mornington P'sula (S) – South	376	1	6
Rosebud	2,211,410	Mornington P'sula (S) – South	241	1040	7
Rosebud	2,211,507	Mornington P'sula (S) – South	297	52	8
Hastings	2,212,407	Mornington P'sula (S) – East	956	271	11
Rosebud	2,211,402	Mornington P'sula (S) – South	243	849	13
Lang Lang	2,342,008	Cardinia (S) – South	921	1	14
Rosebud West	2,211,510	Mornington P'sula (S) – South	183	278	15
Rosebud	2,211,214	Mornington P'sula (S) – South	482	1	16
Hastings	2,212,402	Mornington P'sula (S) – East	576	327	17
Rosebud	2,211,511	Mornington P'sula (S) – South	329	1	18
Hastings	2,212,406	Mornington P'sula (S) – East	480	773	19
Rosebud	2,211,508	Mornington P'sula (S) – South	611	1	25
Pakenham	2,341,803	Cardinia (S) – Pakenham	300	488	28
Millgrove	2,190,302	Yarra Ranges (S) – Central	629	279	30
Hastings	2,212,409	Mornington P'sula (S) – East	692	234	33
Rosebud West	2,211,606	Mornington P'sula (S) – South	575	236	35

Note: All ranks are out of 5839.

only 156 services per stop per week 75% less than inner Melbourne and 50% less than middle Melbourne. Only 66% of outer Melbourne CCDs are covered by public transport (32% less than inner Melbourne and 25% less than middle Melbourne). Overall only 10% of the spatial area of outer Melbourne has public transport walk catchment coverage compared to 90% of inner Melbourne, Overall the average outer Melbourne CCD supply score is 764 compared 10,922 inner and 2695 middle. This is illustrative of lower service levels, sparser spatial coverage and limited walk catchment overlap compared to inner and middle Melbourne.

The social/transport needs indicator analysis has identified that there are also spatial concentrations of 'very high' needs in outer Melbourne. Sections of the City of Casey, Mornington Peninsula, Cardinia and Yarra Ranges show large areas with high levels of transport need. However, needs of this kind are not exclusive to outer Melbourne. In inner/middle Melbourne distributions of 'very high' and 'high' needs can be seen in the East/South Eastern suburbs of Dandenong and Frankston, in the Northern suburbs of Broadmeadows, Fawkner, Thomastown, and Reservoir and the Western suburbs of St. Albans, Deer Park and Sunshine.

The needs/gap comparison has identified some 89 CCDs representing 37,699 Melbourne residents (1.1% of the population) who live in areas with no public transport but have the 'very high' social/transport needs score. In addition, of those with 'very high' need scores, 101,305 residents live in areas with 'very low' public transport supply and 137,735 with 'low' public transport supply. Overall 8.2% of Melbourne residents have 'very high' needs but 'zero', 'low' or 'very low' public transport supply.

The study results show much consistency with the findings of the Hobart 'needs-gap' study (Currie, 2004) and also earlier studies of Adelaide (Currie and Wallis, 1992). Although the approaches used in these studies are different, a remarkably clear mismatch between public transport supply and social needs is apparent in Australian cities. Although this has been widely commented on in social research (e.g., Hurni, 2006), the approach adopted in this study has been quantitatively based utilising GIS techniques to objectively assess relative needs and service levels. The findings should therefore be an excellent basis for planning to address the gaps identified as well as to monitor performance in addressing these gaps.

The service gaps identified are of clear concern from a social planning perspective, however, should not be too surprising from a public transport perspective. The concentration of supply in inner and middle suburbs results from other public transport objectives such as addressing urban traffic congestion and CBD access functions (Nielsen et al., 2005). In addition the suburbs associated with outer Melbourne are characterised with low density dispersed settlement patterns where public transport is generally a bus. Much evidence characterises these environments as difficult for effective bus operations. While the physical layout of roads in many cases constrains effective bus service delivery, in addition, low density itself means the productivity of the service that are provided is poor. It is a sad fact that while needs are high in the urban fringe, the limited bus services provided carry relatively few people and have many empty seats. This is not a constructive basis upon which to increase bus services levels to address needs.

Nevertheless transport policy in Melbourne has seen the rise of the 'social transit agenda' where increases in bus service levels are seen as justifiable from a viewpoint of addressing transport-based social exclusion. This has driven a recent investment of some $Aust1.4B over 10 years in new bus services in recent policy announcements in Melbourne (Department of Infrastructure, 2006 (DOI)). The research summarised in this report should assist in better focussing this investment around the social needs which is its 'raison d'etre'.

A major policy and research question which remains concerns the value of social benefits which result from filling the fringe public transport gaps. If the 'social transit agenda' is to expand further in Melbourne, or to find its way into other Australian cities there is clearly a need to justify the considerable investments which will be required. The research program of which this paper is a part aims to quantify the social benefits of improved accessibility through household surveys tied to econometric modelling. These analysis will be reported in future research papers. Hence there is some hope for this aspect of the Australian public transport 'needs-gap' problem. It will also be prudent to revisit current approaches to effective service delivery in the urban fringe to ensure the efficient use of the considerable amounts of investment that will be required.

The techniques described are relatively easy to develop and apply and can be powerful in identifying spatial gaps in public transport service provision in an open and defendable quantitative manner. However, they are far from perfect and need careful interpretation. The transport needs measured in this approach are only a broad indicator of the aggregate volume of residents who might be associated with transport disadvantage. The service supply measures are also simplistic although it is possible to improve their detail with further resourcing. There are clearly methodology trade-offs between simplification, ease of application and representing need gaps in greater detail. However, the approaches described are substantially more useful than the presentation of anecdotal evidence which is the most common means of identifying transport needs in local transport studies throughout the world.

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Appendix A

Transport need indicator-top 100 indicators with highest needs score rank.

Composite need indicator (rank)	CCD code	SLA name	CCD population	Supply rank	Supply category	Metropolitan region
1	2,211,609	Mornington P'sula (S) – South	1216	1	Zero	Outer
2	2,211,512	Mornington P'sula (S) – South	421	1	Zero	Outer
3	2,212,405	Mornington P'sula (S) – East	528	1041	Very low	Outer
4	2,220,311	Frankston (C) – West	1190	920	Very low	Outer
5	2,331,511	Darebin (C) – Preston	962	4100	Above average	Middle
6	2,211,401	Mornington P'sula (S) – South	376	1	Zero	Outer
7	2,211,410	Mornington P'sula (S) – South	241	1040	Very low	Outer
8	2,211,507	Mornington P'sula (S) – South	297	52	Very low	Outer
9	2,371,808	Gr. Dandenong (C) – Dandenong	623	2213	Low	Middle
10	2,281,302	Port Phillip (C) – West	489	5210	Very high	Inner
11	2,212,407	Mornington P'sula (S) – East	956	271	Very low	Outer
12	2,140,502	Hume (C) – Broadmeadows	751	3598	Below average	Outer
13	2,211,402	Mornington P'sula (S) – South	243	849	Very low	Outer

(continued on next page)

Appendix A (*continued*)

Composite need indicator (rank)	CCD code	SLA name	CCD population	Supply rank	Supply category	Metropolitan region
14	2,342,008	Cardinia (S) – South	921	1	Zero	Outer
15	2,211,510	Mornington P'sula (S) – South	183	278	Very low	Outer
16	2,211,214	Mornington P'sula (S) – South	482	1	Zero	Outer
17	2,212,402	Mornington P'sula (S) – East	576	327	Very low	Outer
18	2,211,511	Mornington P'sula (S) – South	329	1	Zero	Outer
19	2,212,406	Mornington P'sula (S) – East	480	773	Very low	Outer
20	2,371,801	Gr. Dandenong (C) – Dandenong	612	2959	Below average	Middle
21	2,340,910	Casey (C) – Hallam	448	1438	Low	Outer
22	2,292,408	Yarra (C) – North	451	5505	Very high	Inner
23	2,291,407	Yarra (C) – North	458	5468	Very high	Inner
24	2,371,806	Gr. Dandenong (C) – Dandenong	1006	2443	Low	Middle
25	2,211,508	Mornington P'sula (S) – South	611	1	Zero	Outer
26	2,291,811	Yarra (C) – Richmond	495	5216	Very high	Inner
27	2,291,803	Yarra (C) – Richmond	474	5153	Very high	Inner
28	2,341,803	Cardinia (S) – Pakenham	300	488	Very low	Outer
29	2,340,909	Casey (C) – Hallam	668	2119	Low	Outer
30	2,190,302	Yarra ranges (S) – Central	629	279	Very low	Outer
31	2,290,102		126	4469	Above average	Inner
32	2,311,007	Moonee Valley (C) – Essendon	303	4897	High	Middle
33	2,212,409	Mornington P'sula (S) – East	692	234	Very low	Outer
34	2,311,403	Moonee Valley (C) – Essendon	490	5166	Very high	Middle
35	2,211,606	Mornington P'sula (S) – South	575	236	Very low	Outer
36	2,370,811	Gr. Dandenong (C) – DanOenong	714	1390	Low	Middle
37	2,211,411	Mornington P'sula (S) – South	345	1	Zero	Outer
38	2,311,409	Moonee Valley (C) – Essendon	401	5173	Very high	Middle
39	2,190,701	Yarra Ranges (S) – Central	589	218	Very low	Outer
40	2,211,408	Mornington P'sula (S) – South	351	1	Zero	Outer
41	2,342,208	Casey (C) – Hallam	551	1467	Low	Outer
42	2,211,413	Mornington P'sula (S) – South	343	952	Very low	Outer
43	2,291,405	Yarra (C) – North	459	5245	Very high	Inner
44	2,361,008	Whitehorse (C) – Nunawading W.	796	2881	Below average	Middle
45	2,211,503	Mornington P'sula (S) – South	197	1125	Very low	Outer
46	2,121,309	Wyndham (C) – North	478	3518	Below average	Outer
47	2,311,414	Moonee Valley (C) – Essendon	523	4391	Above average	Middle
48	2,211,805	Mornington P'sula (S) – South	328	169	Very low	Outer
49	2,292,410	Yarra (C) – North	431	5521	Very high	Inner
50	2,311,406	Moonee Valley (C) – Essendon	467	5401	Very high	Middle
51	2,211,009	Mornington P'sula (S) – South	193	1	Zero	Outer
52	2,211,807	Mornington P'sula (S) – South	169	759	Very low	Outer
53	2,211,414	Mornington P'sula (S) – South	151	625	Very low	Outer
54	2,212,408	Mornington P'sula (S) – East	854	300	Very low	Outer
55	2,141,207	Hume (C) – Broadmeadows	838	4459	Above average	Outer
56	2,211,504	Mornington P'sula (S) – South	251	1525	Low	Outer
57	2,291,810	Yarra (C) – Richmond	492	5310	Very high	Inner
58	2,211,514	Mornington P'sula (S) – South	308	791	Very low	Outer
59	2,311,405	Moonee Valley (C) – Essendon	499	5246	Very high	Middle
60	2,311,411	Moonee Valley (C) – Essendon	399	5277	Very high	Middle
61	2,140,508	Hume (C) – Broadmeadows	644	2582	Low	Outer
62	2,211,212	Mornington P'sula (S) – South	386	1	Zero	Outer
63	2,342,207	CaseyJC) – Hallam	700	2913	Below average	Outer
64	2,211,708	Mornington P'sula (S) – South	237	2	Very low	Outer
65	2,190,706	Yarra Ranges (S) – Central	405	274	Very low	Outer
66	2,221,002	Frankston (C) – West	373	4979	High	Outer
67	2,190,703	Yarra Ranges (S) – Central	591	268	Very low	Outer
68	2,291,403	Yarra (C) – North	487	5576	Very high	Inner
69	2,221,308	Frankston (C) – West	623	2076	Low	Outer
70	2,190,710	Yarra Ranges (S) – Pt B	263	7	Very low	Outer
71	2,290,101		476	4718	High	Inner
72	2,370,806	Gr. Dandenong (C) – Dandenong	593	2877	Below average	Middle
73	2,211,701	Mornington P'sula (S) – South	220	1	Zero	Outer

Appendix A (*continued*)

Composite need indicator (rank)	CCD code	SLA name	CCD population	Supply rank	Supply category	Metropolitan region
74	2,311,404	Moonee Valley (C) – Essendon	476	5357	Very high	Middle
75	2,211,412	Morninqton P'sula (S) – South	492	1	Zero	Outer
76	2,211,406	Mornington P'sula (S) – South	300	19	Very low	Outer
77	2,211,608	Mornington P'sula (S) – South	183	1466	Low	Outer
78	2,341,802	Cardinia (S) – Pakenham	303	869	Very low	Outer
79	2,211,607	Mornington P'sula (S) – South	265	1	Zero	Outer
80	2,211,908	Mornington P'sula (S) – South	151	664	Very low	Outer
81	2,211,610	Mornington P'sula (S) – South	217	238	Very low	Outer
82	2,211,803	Mornington P'sula (S) – South	165	1	Zero	Outer
83	2,211,806	Mornington P'sula (S) – South	182	1	Zero	Outer
84	2,260,907	Stonnington (C) – Prahran	531	5519	Very high	Inner
85	2,291,809	Yarra (C) – Richmond	478	4721	High	Inner
86	2,211,506	Mornington P'sula (S) – South	149	1261	Very low	Outer
87	2,371,902	Gr. Dandenong (C) – Dandenong	474	4108	Above average	Middle
88	2,311,415	Moonee Valley (C) – Essendon	549	5355	Very high	Middle
89	2,131,501	Brimbank(C) – Sunshine	321	3906	Below average	Middle
90	2,221,303	Frankston (C) – West	621	2372	Low	Outer
91	2,140,507	Hume (C) – Broadmeadows	703	2638	Below average	Outer
92	2,302,005	Maribyrnong (C)	575	3719	Below average	Middle
93	2,140,608	Hume (C) – Broadmeadows	841	2209	Low	Outer
94	2,371,802	Gr. Dandenong (C) – Dandenong	600	3090	Below average	Middle
95	2,220,705	Frankston (C) – West	669	3865	Below average	Outer
96	2,212,404	Mornington P'sula (S) – East	644	602	Very low	Outer
97	2,311,006	Moonee Valley (C) – Essendon	389	4443	Above average	Middle
98	2,211,703	Mornington P'sula (S) – South	109	11	Very low	Outer
99	2,211,705	Mornington P'sula (S) – South	217	1	Zero	Outer
100	2,291,804	Yarra (C) – Richmond	760	5093	Very high	Inner

Note: Supply rank 1 = lowest supply to 5839 = highest rank.

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