Toward A Greater Understanding Of Healthy Food Accessibility In Melbourne: Part II

Margalit Levin, University of Melbourne; Yiqun Chen, University of Melbourne
ABSTRACT: This investigation is derived from the concept of ‘food deserts’ - spaces within cities that do not provide adequate access to affordable, healthy food. The paper builds on previous literature research presented at SOAC 2011. This second and (abridged) final part produces the findings from the original scoping paper that sets out to examine possible barriers to accessing healthy food in metropolitan Melbourne. In building a comprehensive understanding of this field, the research takes a first step by looking at the physical configuration of the urban form, and asks whether there are travel barriers to accessing healthy food. Through empirical data and quantitative methods, the paper examines whether there are disparities in people’s ability to reasonably travel to supermarkets - used as a proxy for healthy food outlets - across the Melbourne Statistical Division (MSD), where such disparities are located, and their relative magnitudes. Given that this field is relatively new, the research devises a methodology for mapping ‘healthy food access’ using ArcGIS. This is done through first layering supermarket locations with walking paths, roads and tram networks, and calculating a gravity index of ‘accessibility’. The index is subsequently overlaid with car ownership rates in order to provide a more realistic picture of people’s actual travel options. Final results indicate that Melbourne does not suffer transit captivity.
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   - South East Melbourne
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## GLOSSARY

### TERMS

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<th>Description</th>
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<tbody>
<tr>
<td>MSD</td>
<td>Melbourne Statistical Division</td>
</tr>
<tr>
<td>GIS</td>
<td>Graphical Information System</td>
</tr>
<tr>
<td>MB</td>
<td>Mesh Block, as applied in the 2011 Australian Census</td>
</tr>
<tr>
<td>SA1</td>
<td>Statistical Area 1, as applied in the 2011 Australian Census</td>
</tr>
<tr>
<td>CR</td>
<td>Car Ownership Rate</td>
</tr>
<tr>
<td>GI</td>
<td>Gravity Index</td>
</tr>
<tr>
<td>PT</td>
<td>Public Transit (Transport)</td>
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<tr>
<td>ASX</td>
<td>Australian Stock Exchange</td>
</tr>
<tr>
<td>EUC</td>
<td>Euclidean Distance</td>
</tr>
<tr>
<td>TER</td>
<td>Travel Distance/Euclidean Distance Ratio</td>
</tr>
<tr>
<td>DIST</td>
<td>Distance</td>
</tr>
<tr>
<td>TRAV</td>
<td>Travel (Distance)</td>
</tr>
<tr>
<td>SPD</td>
<td>Speed</td>
</tr>
<tr>
<td>M</td>
<td>Metres</td>
</tr>
<tr>
<td>KM</td>
<td>Kilometers</td>
</tr>
<tr>
<td>ERC</td>
<td>Eastern Resource Centre Library, University of Melbourne</td>
</tr>
<tr>
<td>UBG</td>
<td>Urban Growth Boundary</td>
</tr>
<tr>
<td>CBD</td>
<td>Central Business District</td>
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### SYMBOLS

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Description</th>
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<tbody>
<tr>
<td>=</td>
<td>Equals to</td>
</tr>
<tr>
<td>≈</td>
<td>Approximately equal to</td>
</tr>
<tr>
<td>/</td>
<td>Divided by</td>
</tr>
<tr>
<td>&gt;</td>
<td>Greater than</td>
</tr>
<tr>
<td>&lt;</td>
<td>Less than</td>
</tr>
<tr>
<td>≥</td>
<td>Greater than or equal to</td>
</tr>
<tr>
<td>≤</td>
<td>Less than or equal to</td>
</tr>
<tr>
<td>*</td>
<td>Multiplied by</td>
</tr>
<tr>
<td>+</td>
<td>Added to</td>
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</tbody>
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1. INTRODUCTION

1.1 Research Outline

This research examines possible barriers to accessing healthy food in metropolitan Melbourne. The investigation is derived from the concept of ‘food deserts’ - spaces within cities do not provide adequate access to affordable, healthy food. In building a comprehensive understanding of this field in Victoria, the research takes a first step by looking at the physical urban form, and asks whether there are travel barriers to accessing supermarkets – used as a proxy for healthy food outlets. This work endeavours to provide an empirical foundation for discussing whether Melbourne suffers from unevenness in core amenities. Final outcomes attempt to shed some light on which areas may lack enough supermarkets or have greater difficulty in accessing them.

The research also becomes important in the context of Melbourne’s on-going debate around alleged two-track urban growth, and associated concerns over polarisation between a wealthier inner-core and a disconnected, under-provisioned outer-ring. (MacroMelbourne Initiative Report, 2009) Future applications of the research will able to test whether lower socio-economic areas are disproportionately represented with inferior travel access, and whether areas of poorer access may be positively correlated to areas with poorer health profiles. It may also help to determine how and whether there are spatial dimensions to serious health issues in the community.

1.2 Research Aims And Questions

The paper is framed around four research questions:

1. Are there transport captive food deserts (TCFD) in the Melbourne Metropolitan Region?
2. Where are they?
3. How severe are they (relative to other areas)?
4. What characteristics might determine the severity of a TCFD?

The research questions are designed to avoid the broad definitional ambiguities around food deserts, such that they are not restricted to investigating food accessibility in areas of socio-economic disadvantage. This is intended to remove the implied positive correlation (or perhaps causation) between higher socio-economic status and better access to healthy food. In this way, the paper uses the food desert metaphor as a conceptual guide rather than an operational term and is framed around strict measures of spatial access as applied through different transport modes.
2. METHOD

2.1 Definitions

‘Healthy food’ is taken to include items such as fruit, vegetables, meat, fish, grains and breads.

‘Healthy food outlets’ are represented as supermarkets, which are a common proxy used across the literature. (Apparicio, et al., 2007; Furey, et al., 2001; Hubley, 2010; Larson, Story, & Nelson, 2009; Morland, et al., 2002; Smoyer-Tomic, et al., 2006) The limitations of this proxy are well advised in these studies (Besharov, et al., 2011; Cummins & Macintyre, 2002; Hubley, 2010), in particular that they only represent one type of healthy food distributor and also stock a variety of unhealthy items. Other appropriate outlets not included here are butchers, bakers, green grocers, specialty health food stores and farmers’ markets.

‘Physical access’ is a person’s travel options to healthy food outlets – walking, public transit (tram) and car.

2.2 Field Of Investigation

The field of investigation is the Melbourne Statistical Division (MSD) as defined by the Australian Bureau of Statistic (ABS) in the 2011 Australian Census. This area includes metropolitan Melbourne as set by the Urban Growth Boundary (UGB) and surrounding areas of the Mornington Peninsula, Dandenong Ranges and Yarra Valley. The primary area of interest is metropolitan Melbourne.

2.3 Spatial Units For Analysis

Each gravity index (GI) is computed at mesh block (MB) level as defined in the ABS 2011 census. The MSD comprises 53,771 MBs categorised into nine ‘function’ areas. The research only considers the 40,487 residential MBs, with all others removed from computations.

Car ownership rates (CR) have been collected at SA1 due to the unavailability of data in MBs. The MSD comprises 13287 SA1s comprised of a number of perfectly aggregated MBs.

2.4 Choice Of Travel Modes

The research investigates three transport modes: walking, trams and driving. Each is intended to cover people’s core travel modes to access supermarkets. The study does not include buses or trains, constituting both a limitation and area for further study. The benefit of investigating trams is two-fold. Often different from trains, trams offer a uniquely local public transport option for residents. On the assumption that people are shopping close to home, trams can maintain many more stops and lines in a neighbourhood compared with trains, which maintain a comparative advantage in transport between suburbs. (PTUA, 2012) For buses, the Victorian State Budget (2012-13) presents that comparatively more people use trams. The Public Transport Users Association (2012) argue that, ‘there are as up to four times as many passenger kilometres travelled by tram than by bus, despite similar amounts of total vehicle kilometres and many trams and buses having comparable passenger carrying capacity’. (PTUA, 2012) It also states that Melbourne’s buses rate poorly against similar interstate services. As such, trams are preferred where only one PT mode is considered.

2.5 Part 1: Spatially Locating Potential Deserts And Their Relative Severity

The study investigates relative food accessibility – understood as transport captivity - through the calculation of a gravity index (GI), which computes the relative attractiveness of every supermarket in reference to a specific location (MB centroid), for each mode. Treating modes separately, results for each MB are aggregated over the MSD to provide a relative index of transport accessibility.
2.5.1 Data Sets and Shape Files

Computation of the GI requires a set of data inputs. These are:

1. Shape file of the Melbourne Statistical Division
   Obtained from the Eastern Resources Centre (ERC), University of Melbourne

2. Shape file overlay of mesh blocks

3. Road network: shape file and routes
   Shape file: obtained from the Eastern Resources Centre (ERC).
   Routes: determined using MapQuest API and Google API.

4. Tram network: shape file and routes
   Shape file: obtained from the Victorian Spatial Datamart
   Routes: obtained from the Victorian Spatial Datamart.
   ** All data from the Victorian Spatial Datamart under license from the University of Melbourne

5. Walking network:
   Shape file: obtained from the Eastern Resources Centre (ERC).
   Routes: determined using MapQuest API and Google API.

6. Geo-coded supermarket database (detailed below)
   Store addresses obtained online from supermarkets company websites.

2.5.1.1 Geocoding The Supermarket Database

The database was developed in two stages. First, store addresses were sourced from each supermarket company website detailed below. Where most supermarket companies could not provide these lists directly, and where many municipal councils did not have this information, it was necessary to manually compile the list. (APPENDIX B)


Addresses were then geocoded in two parts, first entered into a location recognition software program using the VIC Map property address datasets that produced 157 successful matches. Where many store addresses (across all chains) were not specific enough to be recognised, the remaining locations were geo-coded using Google API. Once results were exported to Google Earth, they were checked for accuracy, with modifications if necessary. Final results were exported to shape file for analysis. Where corner addresses were specified, markers were placed on the edge of the street intersection. It is possible some of these coordinates are inaccurate by 50 – 200 metres.
2.5.2 Developing The Framework For Public Transport (Tram) Analysis

Where public transit routes were unavailable using MapQuest and Google APIs, network analysis was undertaken through applying a series of travel parameters and core assumptions:

1. Public transit modes are not integrated.
   - The study only investigates tram use as a wholly separate mode, acknowledging this is a likely oversimplification of real life travel patterns.

2. No wait-time between route changes on the same mode and/or no intra route changes.

3. No wait time at a PT stop.
   - Assumes people have planned their journey to arrive at the stop when it is ready to depart.

4. Walking time - MB centroid to PT stop; PT stop to supermarket.
   - Some walking to and from PT stops is inevitable. This route information was obtained through the APIs similar to the walking GI.

5. Walking distance thresholds - MB centroid to PT stop; PT stop to supermarket.
   - Research imposes a 300metre walking distance parameter from PT stop to either MB centroid or supermarket. Anything beyond the threshold is considered inaccessible. The threshold has been determined in reference to the 1000 metre radial parameter used for the walking GI (detailed in section 3.5.3.2). This is on the rationale that it is not reasonable for one to cumulatively walk at least as far to access PT than one could simply walk to access a supermarket.
2.5.3 Devising the GI

Expressed mathematically,

\[
\text{GI} = \frac{\text{store weighting (relative attractiveness)}}{\text{distance between mesh block centroid and supermarket}}
\]

The GI calculates the weighted sum of each store’s size in reference to a specific place (MB centroid), and then depreciates it by a distance decay effect, computed separately for each mode. (Apparicio et al., 2007; Lee & Lim, 2009; Smoyer-Tomic et al., 2006) The ‘gravity’ of each store is added together to provide the overall accessibility for that area, which is then aggregated to create an accessibility index for the MSD, by mode. The benefit of a GI is its ability to engage the relative distance and relative ‘attractiveness’ of different supermarkets. By not assuming all stores are homogenous, this metric shows the diversity of the urban environment (Apparicio et al., 2007). Where the food desert term is a relative measure (Besharov, et al., 2011), the GI’s ability to indicate relative preferences is essential.

2.5.3.1 Numerator: Determining ‘Attractiveness’

‘Attractiveness’ is defined as supermarket size and is a core assumption built into method. Expressed as a relative ‘weighting’, stores maintain a ranking based on their chain’s market share. This logic is derived from the literature where larger chains maintain greater market shares because of their operational size and ability to capitalize on economies of scale, which allows them to provide consumers with better deals. (Furey, et al., 2001; Hubley, 2010; Larson, et al., 2009; Morland, et al., 2002; Smoyer-Tomic, et al., 2006) Rankings are as follows:

<table>
<thead>
<tr>
<th>Ranking</th>
<th>Supermarket Chain</th>
<th>Market Share (Each)</th>
<th>GI Weighting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tier 1</td>
<td>Coles, Woolworths</td>
<td>30 - 40 %</td>
<td>3</td>
</tr>
<tr>
<td>Tier 2</td>
<td>Aldi/IGA</td>
<td>7 - 10%</td>
<td>2</td>
</tr>
<tr>
<td>Tier 3</td>
<td>FoodWorks</td>
<td>1-2 %</td>
<td>1</td>
</tr>
</tbody>
</table>

The necessary creation of ‘weightings’ maintains some unavoidable assumptions, the most consequential being the criteria against which stores are ranked. There are a number of alternatives that could be used including store floor size (Lee & Lim, 2009), parking spaces, supermarket foot traffic or number and size of fresh food deliveries. However, all require further corroborating data that is impracticable over the research area. Where the size of the supermarket chain can likely capture the core dimensions of greater availability of healthy options at potentially equally reasonable prices, this benchmark is justifiable and workable. However, the ranking assumes that prices and food availability are constant across all stores in the same company regardless of location or size, and constitutes a limitation of this process.

A final assumption is the weighting figures that were chosen in the absence precise data on each chain’s market share in Victoria. They represent a ‘best guess’ approach based on available information, endeavouring to keep the GI simple yet realistic. Coles and Woolworths are estimated to each cover around 30 - 40 per cent of Australia’s grocery sector. (Stuart Alexander, 2013; Deloitte Access Economics, 2012) Independent Grocers Australia (IGA) is estimated around 15 per cent of nation-wide market share. (Deloitte Access Economics, 2012) ALDI is considered to have captured part of the independent retailers’ market share to hold at least 7 per cent in Victoria. (Stuart Alexander, 2013; Deloitte Access Economics, 2012; Greenblatt, 2012) Remaining retailers including Foodworks are considered to hold 1-2 per cent of the national market. Costco is excluded as there is limited data on their market share and the nature of the company - few, but large stores - does not compare like with like. A separate limitation is that the weightings change in equal units, where the magnitude between tiers implies an equal difference between stores, though this is not necessarily realistic.
2.5.3.2 Denominator: Determining The ‘Travel Parameters’

The ‘travel parameter’ is expressed in time (minutes) as opposed to distance, as time is usually the more important dimension – time travelling to the supermarket, to park the car, to cook. Small distances may actually represent significant travel time investments depending on the quality of public transit, car traffic or physical barriers for walkers. (Bader et al., 2010:412) The GI also applies radial Euclidean distance parameter, the length of which is specific to each travel mode such that:

Table 2: Radial Distance Parameters, By Mode

<table>
<thead>
<tr>
<th>Travel Mode</th>
<th>Distance Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>1000 metres</td>
</tr>
<tr>
<td>Public Transit</td>
<td>3000 metres</td>
</tr>
<tr>
<td>Driving</td>
<td>5000 metres</td>
</tr>
</tbody>
</table>

The parameter ensures the calculation is manageable considering the size of the MSD and number of MBs and supermarkets. The distance for each mode is informed by the literature and in reference to Melbourne’s urban form. For all modes, the literature almost universally agrees that a 15 min travel time in each direction is the upper limit for ‘acceptable access’. (Algert, Agrawal, & Lewis, 2006; Apparicio, et al., 2007; Bader, et al., 2010; Bertrand, et al., 2008; Clarke et al., 2002; Furey et al., 2001; Hallett & McDermott, 2010; Larsen & Gilliland, 2008; Smoyer-Tomic et al., 2006; N. Wrigley et al., 2003) What varies between authors is the conversion of time into distances (Appendix A). While Euclidean distances cannot perfectly capture actual travel distances, it is not wholly unreasonable to apply here considering Melbourne is flat with good road and path networks. The most important limitation is the impact of the distance parameter on distorting the overall calculation, where anything outside the parameter is excluded from the index. To minimise this, the method applies the literature’s upper limits for all modes. For public transit there is a gap in literature for distance thresholds so this study applied a 3000m radius according to the 16km/hour tram travel speed, (YarraTrams, 2013). This is just lower than the proportional distance of 4000m, as tram speeds drop to 11km/hour in the CBD. Trams also require passengers to carry shopping that can reduce capacity to easily travel further.

2.5.4 Interpreting the GI

Every GI has been divided into six classes that together comprise the accessibility range for that mode to ensure the results indicate a meaningful variation in accessibility without creating overwhelming detail. Classes are ordered according to natural breaks (jenks) as opposed to equal intervals as it more accurately conveys the findings. Initially dividing the accessibility categories into equal intervals did not break the data into useful sub-ranges, where for example, large sections of similar results were split over just two categories rather than being logically grouped together.

2.5.5 Dealing with Problem Records

The following problems were encountered when calculating the GI.

1. Travel Time (TRV_TIME) = -1
   When the APIs fail to find a valid route between two locations.

2. Travel Time (TRV_TIME) = 0
   When the API treat the two locations (MB centroid and supermarket) as identical. This can be the result of the locations actually being too close to each other, or being recognised as too close after the Google API geo-coding.

3. Euclidean Distance > Travel Distance (EUC_DIST > TRV_DIST)
   When the APIs are unable to find a path between the centroid and supermarket, either because:
   i. While EUC_DIST is always based on original coordinates, if the API cannot find a route it may alter coordinates in order to calculate the route. This may make TRV_DIST (from revised coordinates) appear shorter than EUC_DIST (from original coordinates), which is conceptually impossible, or
ii. API could not find a path between the coordinates.

4. Travel Distance/Euclidean Distance ≥ 3 (TRV_DIST / EUC_DIST)
   TRV_DIST / EUC_DIST Ratio (TER) indicates the appropriateness of routes taken between the two locations. The smaller the TER, the closer the route is to the Euclidean distance - the shortest route. A large TER - anything greater than 3 - suggests a distortion of the real TRV_DIST. (Figure 2) This may be attributed to:
   i. Reverse-geocoding process that hasn’t quite captured the correct coordinates, or
   ii. Deficiency of the APIs.

For all valid records where EUC_DIST ≤ TRV_DIST, the average TER was 1.519842.

Figure 2: Possible Travel Routes Between Two Locations

2.5.5.1 Correction Process
Correcting walking and driving records are handled separately due to each mode’s different travel characteristics. To ensure there were no values where TRV_TIME = 0 for either mode after corrections, all records were increased by 30 seconds. The alternative was to only increase the TRV_TIME = 0 records, by 30 seconds, which was considered to disrupt the relativity of measure.

Correction Process For Walking
1. Find valid records, where EUC_DIST ≤ TRV_DIST and TRV_DIST/ EUC_DIST < 3
2. Calculate the TER for valid records:
   TER_valid = 1.446815, very reasonable
3. Calculate the average travel speed for valid records:
   SPD_valid = 1.122728 meter/second ≈ 4km/hr, very reasonable
4. Find invalid records, where EUC_DIST > TRV_DIST and TRV_DIST/ EUC_DIST ≥ 3
5. Recalculate TRV_DIST for invalid records, such that:
   TRV_DIST = EUC_DIST * TER_valid
6. Recalculate TRV_TIME for invalid records, such that:
   TRV_TIME = TRV_DIST / SPD_valid
Correction Process For Driving

1. Find valid records, where EUC_DIST <= TRV_DIST and TRV_DIST/ EUC_DIST < 3

2. Calculate the TER for valid records:
   \[ \text{TER\_valid} = 1.456145, \text{ very reasonable} \]

3. Calculate the average travel speed for valid records:
   \[ \text{SPD\_valid} = 10.93206\text{meters/second} \approx 40\text{km/hr}, \text{ very reasonable} \]

4. Find invalid records, where EUC_DIST > TRV_DIST and TRV_DIST/ EUC_DIST \geq 3

5. Recalculate TRV_DIST for invalid records, such that:
   \[ \text{TRV\_DIST} = \text{EUC\_DIST} \times \text{TER\_valid} \]

6. Recalculate TRV_TIME for invalid records, such that:
   \[ \text{TRV\_TIME} = \text{TRV\_DIST} / \text{SPD\_valid} \]
Part 2: Car Captivity - Is The ‘Desert-I-Ness’ A Problem?

Part 2 asks whether transit captivity, as shown in the first set of results, is actually a problem by matching car ownership rates (CR) with the food accessibility index, for each mode. CRs were acquired from the ABS, according to census (2011) question 54: ‘how many registered motor vehicles owned or used by residents of this dwelling were garaged or parked at or near this dwelling on Census Night? Include vans and company vehicles kept at home. Exclude motorbikes and motor scooters. The inference is that if one owns a car, the initial measure of transit captivity may not provide a meaningful representation of overall inaccessibility. This is to say it might not matter if one lacks ‘adequate’ walking or public transport access (however determined) if one has car access. Equally, good car access will not matter if one does not have use of a car.

This approach cannot capture those that do not own a car but via some arrangement - relatives, friends, other organisations - still maintain access to a private vehicle for food shopping. Car ownership also arguably implies the ability to use that vehicle, which in some cases may not be true. It also does not assume a correlation between socio-economic status and car ownership as is often cited in the literature. (Bader et al., 2010; Caraher et al., 1998; Coveney & O'Dwyer, 2009; Furey et al., 2001; Rose & Richards, 2004) Where Melbourne’s urban form broadly reflects a wealthier, better public transit provisioned inner core that gradually decreases towards the urban growth boundary (MacroMelbourne Initiative Report, 2009), those living further out may own a car despite a relatively lower income.

2.6.1 Data Set

Car ownership rates were collected at SA1, as it is not available in MB. To incorporate CRs with the original GI, every MB was assigned the car rate for the SA1 it belongs to. The data was obtained using TableBuilder Basic (ABS), and the distribution is shown in Figure 3. Initial CRs for each SA1 are detailed in Appendix C.

![Figure 3: Number Of Cars Per Household Across The Msd](image-url)
### 2.6.2 Integrating Car Ownership Rates

Integrating CRs with the GI data is undertaken through ‘matching’ accessibility between the indexes, by assigning each GI class a ranking from 1 to 6, in ascending order. Walking GI results and CRs are as follows:

#### Table 3: Walking GI and Accessibility Ranking

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>GI CLASS</th>
<th>LEVEL OF ACCESSIBILITY</th>
<th>GI RANKING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.0017</td>
<td>Very low</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.0017 - 0.0052</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>0.0052 - 0.0098</td>
<td>Good</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>0.0098 - 0.0172</td>
<td>Very Good</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>0.0172 - 0.0354</td>
<td>High</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>0.0354 - 0.0645</td>
<td>Very High</td>
<td>6</td>
</tr>
</tbody>
</table>

#### Table 4: Car Rate and Accessibility Ranking

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CLASS</th>
<th>LEVEL OF ACCESSIBILITY</th>
<th>RANKING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.7821</td>
<td>Very low</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0.7821 - 1.1231</td>
<td>Low</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1.1231 - 1.3961</td>
<td>Good</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>1.3961 - 1.6509</td>
<td>Very Good</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>1.6509 - 1.9536</td>
<td>High</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1.9536 - 2.7955</td>
<td>Very High</td>
<td>6</td>
</tr>
</tbody>
</table>

Each SA1 receives an integrated accessibility ranking that is the product of its GI and CR ranking, receiving a total out of 12. This data is then recoded in ArcGIS to produce final ‘integrated’ accessibility maps for each mode. The new index range applies natural breaks and is presented as follows:

#### Table 5: Final Accessibility Ranking

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CUMULATIVE ACCESSIBILITY RANKING</th>
<th>LEVEL OF ACCESSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GI ACCESSIBILITY + CAR RATE ACCESSIBILITY</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>Class 1</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>Class 2</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>Class 3</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>Class 4</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>Class 5</td>
<td>Very High</td>
</tr>
</tbody>
</table>

The assumption in the both accessibility rankings is that allocating each class a number from 1 to 6 implies the same difference of utility between levels, which will not necessarily be realistic. The marginal benefit between owning no cars to one car may be much larger than the marginal benefit between three to four cars. Similarly, it seems reasonable to assume the benefit of some walking and tram accessibility rather than none might be more important than the difference between high and very high accessibility. Ranking the classes in equal intervals does not allow the research to consider these ideas of decreasing marginal utility and constitutes a limitation.
3. RESEARCH FINDINGS

3.1 Transit Captivity By Mode

3.1.1 Walking

Walking access is visualized in figures 5-9 (Appendix D - supplementary maps) and indicate three immediate findings. First, accessibility is fragmented with very few continuous tracts of even low accessibility. Second, highest accessibility is located around the CBD, dispersing out across the MSD. Third are the pockets of 'inaccessibility' around the urban fringe.

The maximum GI for walking is 0.0645. While seemingly very low, it should be interpreted in reference to the maximum GIs for trams and driving at 0.1756 and 0.5405 respectively. The distribution of results can be seen in table 6 and figure 4.

Table 6: Distribution Of Gravity Results For Walking

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>GI CLASS</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.0017</td>
<td>17090 (42.2%)</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>0.0017 - 0.0052</td>
<td>10321 (25.9%)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>0.0052 - 0.0098</td>
<td>6696 (16.5%)</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>0.0098 - 0.0172</td>
<td>4211 (10.4%)</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>0.0172 - 0.0354</td>
<td>1695 (4.1%)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>0.0354 - 0.0645</td>
<td>474 (1.1%)</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Figure 4: Distribution Of Gravity Results For Walking

The data indicates around two-thirds (67.7%) of MBs in the MSD have low or very low walking accessibility. Although the literature does not provide a percentage threshold for what constitutes adequate or good walking access, it seems reasonable to argue this is low. The extent of low accessibility is not immediately obvious when looking at the visual data due to its fragmented layout. There are however some distinct spatial patterns, with the largest supermarket concentration in and around the CBD and surrounding eastern suburbs.

Moving out from the centre, walking accessibility becomes patchy with exceptions around Murrumbena and to a lesser extent from Balaclava through Carnegie to Bentleigh, and from Northcote to Preston (figure 5). Other areas that maintain somewhat extended accessibility are St Kilda,
Brunswick and Coburg. Notwithstanding, supermarkets appear to be mostly evenly spread across Melbourne’s urban core and reflect no obvious areas that are completely devoid of walking accessibility inside the UGB. In what may best be described as ‘consistent fragmentation’, this result highlights the inappropriateness of food desert definitions that only investigate urban centres. This is obviously not the case for Melbourne and can attributed to the city’s urban development.

Areas that overall suffer poorer access inside the UGB are on or near Melbourne’s outer suburbs and include Montmorency, Warrandyte, Donvale, Croydon Hills, Chirnside Park, Greensborough, Wantirna, Lysterfield and Mooroolbark in the north east; Narre Warren North and South and Casey South in the south east; Whittlesea-Wallan, Tullamarine-Broadmeadows in the North; Taylors Lakes, Tarneit and Rockbank in the West. This fragmentation appears to be the result of supermarket clustering across the urban core (figure 6), where the data indicates these concentrations comprise stores from different chains.

**Figure 5: Walking Accessibility - Inner City: Continuous ‘Accessibility’ Tracts**

![Map showing walking accessibility in the inner city of Melbourne.](image)
Some areas that maintain a supermarket cluster still do not rank in the upper two most accessible categories, though the size of the MBs are not any larger, which may have contributed (figures 7, 8). This may be the result of a cluster situated in a non-residential area. Alternatively, supermarkets outside the cluster that were included in the calculation for those MBs were quite far away, reducing the overall size of the GI for that area. This may be the case for cluster B (figure 7) and cluster D (figure 8). It may also be the consequence of having increased all travel times by 30 seconds when the method corrected for invalid records. While this increase is seemingly small, it is possible it had a disproportionately adverse impact on the travel distances for clusters, which are actually closer. Notwithstanding, lower accessibility in outer suburbs should be read carefully. Many areas showing lowest accessibility contain much larger MBs (figure 9). Where most residential MBs contain approximately 30 – 60 dwellings (ABS, 2013), it seems reasonable to infer that these maintain much larger residential plots, and are characteristically less suited to higher walking accessibility. This is contrasted to the many more and smaller MBs in the inner city that support smaller dwellings (apartments) and highlights one way in which urban form and housing trends may affect accessibility.
Figure 7: Supermarket Clusters - North East Melbourne

Figure 8: Supermarket Clusters - North West Melbourne
Figure 9: Walking Accessibility – Outer Metropolitan Suburbs

SCALE: 1:200000

Melton
Sunbury
Werribee
Pakenham
Cranbourne
3.1.2 Trams

Results for trams are generally intuitive and can be seen in figures 10-12 (Appendix D - supplementary maps). With the concentration of supermarkets and tramlines in the city centre, there is very high accessibility at the urban core that decreases along the routes into the suburbs. The maximum GI is 0.1756, with the distribution of results in table 7 and figure 10.

**Table 7: Distribution Of Gravity Results For Trams**

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>GI CLASS</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.0080</td>
<td>33859 (83.6%)</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>0.0080 - 0.0237</td>
<td>2479 (6.1%)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>0.0237 - 0.0401</td>
<td>1953 (4.8%)</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>0.0401 - 0.0605</td>
<td>1262 (3.1%)</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>0.0605 - 0.0931</td>
<td>770 (1.9%)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>0.0931 - 0.1756</td>
<td>163 (0.4%)</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Where the tram network does not cover most of Melbourne, it is not concerning that approximately 90% of the distribution comprises low to very low accessibility. High accessibility drops off to intermediate levels on the outskirts of the inner city suburbs, including in St Kilda East, South Yarra, Richmond and Carlton (figure 12), which may be of note considering these suburbs are all within a 5km radius of the CBD.

The data also indicates about a one per cent difference between very good and high tram accessibility (table 7). While this is very small in absolute terms, its relative importance should be considered in the context of the broader distribution, where good to very high accessibility covers only 10 per cent. However, where the physical tram network only covers approximately 125km (YarraTrams, 2013) of Melbourne - about 1.5 per cent of Greater Melbourne - that 8 per cent of people maintain good to very good access appears reasonable. It is also possible the data may be somewhat distorted due to methodological assumptions that only allow commuters to walk up to 300 metres from tram stop to home or supermarket. As such, the radial distance parameter may fail to accurately capture all tram accessibility.
Figure 11: Tram Accessibility And Supermarket Locations - Inner City

Figure 12: Tram Accessibility - Inner City
3.1.3 Driving

Driving accessibility is visualized in figures 13-16 (Appendix D – supplementary maps) and indicate two immediate findings. First, there is continuous accessibility across the MSD with highest access concentrated at the urban core. Second, and contrasted to the other modes, higher accessibility extends out further into the inner city suburbs. The maximum GI is 0.5405, with the distribution of results in table 8 and figure 13.

Table 8: Distribution Of Gravity Results For Driving

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>GI CLASS</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.0598</td>
<td>8856 (21.9%)</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>0.0598 - 0.1111</td>
<td>11679 (28.9%)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>0.1111 - 0.1691</td>
<td>10116 (25%)</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>0.1691 - 0.2383</td>
<td>5587 (13.8%)</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>0.2383 - 0.3300</td>
<td>3085 (7.6%)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>0.3300 - 0.5405</td>
<td>1164 (2.8%)</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Figure 13: Distribution Of Gravity Results For Driving

It is striking that 50 per cent of the distribution is in the two lowest classes. In addition, despite consistent supermarket clustering across the MSD, there are almost no high accessibility areas in and around the outer metropolitan suburbs. Areas inside the UGB that exhibit particularly poor access include Werribee, Melton, Sunbury, Taylors Hill, Craigieburn, Roxurgh Park, Rockbank, Melton, Sunbury and South Morang in the north-northwest; Montmorency, parts of Eltham, Donvale, Templestowe and parts of Ringwood in the northeast; and Rowville, Hallam, Endeavour Hills, Narre Warren, Berwick, Hampton Park, Cranbourne, Pakenham, Carrum Downs, Frankston and Hoppers Crossing in the southeast. Other suburbs in similar areas that do better are Croydon, Bayswater, Thomastown, Bundoora, Mill Park, Kingsbury, Glenroy, Broadmeadows, Airport West, and Keilor East.

Within the inner suburbs, Kew, Balwyn Glen Iris and Camberwell in the inner northeast overall maintain only good car access. While these findings do not appear particularly adverse, it is worth noting that the inner southeast suburbs of Malvern, Caulfield, Ormond and Carnegie, which are approximately the same distance from the CBD, all maintain very high accessibility. Overall, the eastern suburbs maintain higher accessibility rates than the west.
Figure 14: Driving Accessibility Across The MSD

Figure 15: Driving Accessibility And Supermarket Locations
Nearly all areas on or outside of the UGB maintain low or very low accessibility. While this is a seemingly very adverse result, it may be important to consider other issues when interpreting the findings, including that the study only considers access to supermarkets. A greater proliferation of corner stores, independent grocers, specialty health food stores or farmers markets in these regions may mask greater accessibility. It is possible the radial distance parameter (5000m) applied to the driving GI may not be appropriate for the outer suburbs, such that different radial parameters should be applied to different areas which reflect the urban characteristics of each region. Outer suburb residents who live in more spread out urban environment may be willing (or acclimatised) to driving further to access supermarkets and amenities.
3.2 Integrating Car Ownership Rates With Accessibility

3.2.1 Identifying Car Ownership Across the MSD

The integration of car ownership rates is intended to provide a more realistic picture of what modes people can actually use. Where driving maintains the highest accessibility indicators by distribution, and is the only mode that does not require carrying shopping, it can be assessed as a superior mode against these two criteria. Car ownership rates in the MSD are shown in figures 17-19 (Appendix D - supplementary maps). The maximum CR is 2.7955 and the distribution is seen in table 9 and figure 17.

Table 9: Distribution Of Car Ownership Rates

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CLASS</th>
<th>RANKING</th>
<th>LEVEL OF ACCESSIBILITY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.0000 - 0.7821</td>
<td>1975 (4.8%)</td>
<td>Very low</td>
</tr>
<tr>
<td></td>
<td>0.7821 - 1.1231</td>
<td>6729 (16.6%)</td>
<td>Low</td>
</tr>
<tr>
<td></td>
<td>1.1231 - 1.3961</td>
<td>9269 (22.8%)</td>
<td>Good</td>
</tr>
<tr>
<td></td>
<td>1.3961 - 1.6509</td>
<td>10341 (25.5%)</td>
<td>Very Good</td>
</tr>
<tr>
<td></td>
<td>1.6509 - 1.9536</td>
<td>8368 (20.6%)</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td>1.9536 - 2.7955</td>
<td>3806 (9.4%)</td>
<td>Very High</td>
</tr>
</tbody>
</table>

Figure 17: Distribution Of Car Ownership Rates

Results broadly indicate a normal distribution with good to very good access comprising almost 50 per cent of the data. This is generally intuitive considering the normal distribution of cars per household (figure 3). Spatially represented, car ownership rates generally reflect Melbourne’s urban growth pattern of a denser, inner core - with fewer cars per household - that expands outwards and is matched by higher ownership rates. Figures 18 and 19 indicate lower ownership at the urban centre around the Bay that is juxtaposed to the highest levels of ownership predominately on the outskirts of the metro region. The other noticeable feature is the difference in CR patterns between the eastern and western suburbs (figure 19), where ownership rates remain quite low in the inner west and western suburbs including in Sunshine, Moonee Ponds, Essendon, Coburg, Pascoe Vale, Glenroy, Broadmeadows, Preston, Reservoir, Northcote and parts of Heidelberg and West Footscray. This is contrasted to the eastern suburbs that maintain higher and more fragmented rates of car ownership, though few areas have very high rates.

Results should be interpreted in reference to public transit provision in these areas, as well as other key indicators including income, job-housing location and family structure. While further research is needed, it is apparent that car ownership cannot be automatically linked to greater socioeconomic advantage as is argued for other cities and in other studies. (Bader, et al., 2010; Caraher, et al., 1998; Coveney & O'Dwyer, 2009; Furey, et al., 2001)
Figure 18: Car Ownership Across The MSD

Figure 19: Car Ownership - Inner City
3.2.2 Walking

The revised accessibility ranking for walking is detailed in table 10 and figure 20. The change in distribution is stark, moving from an originally declining linear relationship in figure 4 to a normal distribution below. This is largely the product of shift in very low accessibility to very good and high accessibility, increasing from 14 per cent to just over 50 per cent.

Table 10: Distribution Of Cumulative Accessibility Ranking For Walking

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CUMULATIVE ACCESSIBILITY RANKING</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
<th>% CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 2</td>
<td>2424 (6%)</td>
<td>Very low</td>
<td>-36.2</td>
</tr>
<tr>
<td></td>
<td>3 - 4</td>
<td>5387 (13.3%)</td>
<td>Low</td>
<td>-12.6</td>
</tr>
<tr>
<td></td>
<td>5 - 6</td>
<td>9897 (24.4%)</td>
<td>Good</td>
<td>+7.9</td>
</tr>
<tr>
<td></td>
<td>7 - 8</td>
<td>11892 (29.4%)</td>
<td>Very Good</td>
<td>+19</td>
</tr>
<tr>
<td></td>
<td>9 - 10</td>
<td>8292 (20.5%)</td>
<td>High</td>
<td>+16.4</td>
</tr>
<tr>
<td></td>
<td>11 - 12</td>
<td>2595 (6.4%)</td>
<td>Very High</td>
<td>+5.3</td>
</tr>
</tbody>
</table>

Figure 20: Distribution Of Cumulative Accessibility Ranking For Walking

Spatially, many areas that experienced poor walking accessibility now rank with at least good access. For example, much of Narre Warren, Montmorency, Warrandyte, Cranbourne, Berwick, Sunbury and Lysterfield have all moved from the lowest two classes into the highest two. Areas that still maintain low accessibility are Ringwood East and Mooroolbark. Werribee, Pakenham and Melton have improved though still retain patches of lower accessibility, mostly around the fringes.

Areas that still maintain very low or low accessibility, have both low walking access and low car ownership with some adversely affected areas in Ardeer, parts of West Footscray and Pascoe Vale in the west; Reservoir and parts of Thornbury in the North; Ashwood-Chadstone, parts of Kew, parts of Noble Park North, Doveton and Dandenong in the east.
Figure 21: Revised Walking Accessibility – Western Melbourne

Figure 22: Revised Walking Accessibility – Eastern Melbourne
Figure 23: Revised Walking Accessibility – South Eastern Melbourne

SCALE: 1:100000

Dandenong

Chadstone
3.2.3 Trams

The revised accessibility ranking for trams is detailed in table 11 and figure 24. Again the data has shifted to a normal distribution with almost an entire reallocation of very low accessibility to every other class, in particular to the highest three categories.

**Table 11: Distribution Of Cumulative Accessibility Ranking For Trams**

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CUMULATIVE ACCESSIBILITY RANKING</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
<th>% CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 - 2</td>
<td>1132 (2.8%)</td>
<td>Very low</td>
<td>-80.8</td>
<td></td>
</tr>
<tr>
<td>2 – 3</td>
<td>3793 (9.4%)</td>
<td>Low</td>
<td>+3.3</td>
<td></td>
</tr>
<tr>
<td>3 - 4</td>
<td>8515 (21%)</td>
<td>Good</td>
<td>+16.2</td>
<td></td>
</tr>
<tr>
<td>4 - 5</td>
<td>11646 (28.8%)</td>
<td>Very Good</td>
<td>+25.7</td>
<td></td>
</tr>
<tr>
<td>5 - 6</td>
<td>10336 (25.5%)</td>
<td>High</td>
<td>+23.6</td>
<td></td>
</tr>
<tr>
<td>6 - 12</td>
<td>5065 (12.5%)</td>
<td>Very High</td>
<td>+12.1</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 24: Distribution Of Cumulative Accessibility Ranking For Trams**

The new data composition shows a reversal of the distribution, with the lowest two categories now comprising about 10 per cent of results, and very good and high accessibility comprising 55 per cent. While the new data are somewhat spatially fragmented (figures 25 – 27), what can loosely be seen are three bands, or zones of accessibility that move out in concentric semi-circles from the core, with high accessibility in the centre and inner-east, lower access through the middle and returning to higher accessibility on the fringe. This appears to be a logical matching of the data, with higher car ownership on the fringe and lower rates in the west together with the high tram GI at the core, inner east and north appear to have produced this spatial configuration.
Figure 25: Revised Tram Accessibility – Western Melbourne

SCALE: 1:100000

Figure 26: Revised Tram Accessibility – Eastern Melbourne

SCALE: 1:100000
Figure 27: Revised Tram Accessibility – South Eastern Melbourne
3.2.4 Driving

The revised accessibility ranking for driving is detailed in table 12 and figure 28. The data has shifted to become mostly positively skewed. Most noticeable is the reduction in the lowest two classes, previously comprising 50 per cent of the distribution now to just 8 per cent.

Table 12: Distribution Of Cumulative Accessibility Ranking For Driving

<table>
<thead>
<tr>
<th>COLOUR</th>
<th>CUMULATIVE ACCESSIBILITY RANKING</th>
<th>DISTRIBUTION</th>
<th>LEVEL OF ACCESSIBILITY</th>
<th>% CHANGE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1 - 3</td>
<td>1448 (3.6%)</td>
<td>Very low</td>
<td>-18.3</td>
</tr>
<tr>
<td></td>
<td>3 - 4</td>
<td>1895 (4.7%)</td>
<td>Low</td>
<td>-24.2</td>
</tr>
<tr>
<td></td>
<td>4 - 5</td>
<td>5707 (14%)</td>
<td>Good</td>
<td>-11</td>
</tr>
<tr>
<td></td>
<td>5 - 6</td>
<td>11007 (27.2%)</td>
<td>Very Good</td>
<td>+13.4</td>
</tr>
<tr>
<td></td>
<td>6 - 7</td>
<td>12882 (31.9%)</td>
<td>High</td>
<td>+24.3</td>
</tr>
<tr>
<td></td>
<td>7 - 12</td>
<td>7548 (18.6%)</td>
<td>Very High</td>
<td>+15.8</td>
</tr>
</tbody>
</table>

Figure 28: Distribution Of Cumulative Accessibility Ranking For Driving

The revised driving accessibility is spatially represented in figures 29 – 33. The only area that exhibits consistently low accessibility is the Mornington Peninsula, though this may be the result of home ownership patterns, where houses are more likely to be secondary/holiday homes with low modal accessibility and low (if any) car ownership. Notwithstanding, Sunbury (including Sunbury South) and Chelsea are the only two suburbs that maintain pockets (30 – 60 MBs) of low accessibility.

Other areas within the UBG that maintain limited patches (5 -17 MBs) of low accessibility are Frankston, Dandenong, Lilydale and Croydon in the east; Epping in the North; and Caroline Springs, Melton, Altona and Laverton in the west. The remaining areas of these same suburbs maintain at least good if not high accessibility in close by or adjacent MBs.
Figure 29: Revised Driving Accessibility – Western Melbourne

SCALE: 1:100000

Figure 30: Revised Driving Accessibility – Eastern Melbourne

SCALE: 1:100000
Figure 31: Revised Driving Accessibility – South Eastern Melbourne
4. DISCUSSION AND CONCLUSION

4.1 Broad Findings

The data reveals two board findings: that car ownership is important, and that after taking this into account, there is no significant transit captivity.

After applying CRs, only Chelsea in the southeast exhibits ‘some’ level (20/232 MBs) of low accessibility in the same areas for driving and walking. The data further shows there was no suburb that maintained low accessibility in two or modes in five or more of the same MBs. Where suburbs generally maintain between 100 to 350 MBs, it seems reasonable to interpret fewer than 5 MBs as not significant. As such, Melbourne does not appear to suffer from transit captivity. In regards to Chelsea, further work is needed to determine what factors may have contributed this unique result.

The immense increase in modal accessibility after applying CRs highlights the significance of car access to supermarkets and healthy food. This finding is consistent with Bader et al., (2010) and Coveney and O’Dwyer (2009) who argue that having access to a car for shopping is one of the most - if not the most - important determinants of access to healthy food, and appears to be particularly true for Melbourne. Areas out towards the urban fringe that initially exhibited the lowest access across all modes instead experienced levels of accessibility at least as good as the inner city. These findings validate a core premise of the research that it is not enough to look at strict accessibility, but also to understand what travel modes people have available to them. This finding also speaks to Melbourne’s urban form. The research indicates no significant travel accessibility barriers to supermarkets, because those that lack walking or tram access have cars. This is likely in large part attributed to the urban settlement patterns and the combination of lower density housing out towards the fringe with fewer public transit options (MacroMelbourne, 2009).

4.2 Conclusion and Future Research

Where there appears to be no (or very limited) transport captivity due to the prevalence of CRs, policy makers need to decide if this is a result they are comfortable with. Where the broad objective has been to gain a greater insight into the connection between healthy food and the city, the paper has presented a set of core data and findings that will contribute to this growing field.

Further research will benefit from mixed methods, where greater information is needed around where people shop, particularly outside of supermarkets and especially if not from home; who is shopping; and what transport modes are used and preferred. Greater investigation is also needed into factors that determine access. Where each suburb maintains unique characteristics, research is needed to understand what variables – income, age, demographics – are significant in producing accessibility. Overlaying the SEIFA measures onto the data may also help qualify whether areas of lower access also experience lower socio-economic advantage to help to highlight whether different barriers, for example affordability, may be more or less important depending on residential location. Lastly, this work hopes to contribute additional core data and spatial results to on-going work in community health outcomes, helping to establish important connections between physical wellbeing and urban form.