

TRANSPORT FINDINGS

Determining Optimum Design Density for 20-minute Neighbourhoods

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Findings

The 20-minute neighbourhood faces a unique challenge: more people are needed to support adequate opportunities to promote living locally whereas more opportunities mean less land for residential use to accommodate more people. This study maps 20-minute neighbourhoods for Melbourne's statistical areas (SA1) and estimates optimum population density for a 20-minute neighbourhood. The results show that, on an average distance to CBD, 19 different types of opportunities and services can be supported at 36 dwellings/ha (optimum). The study reports a range of planning standards at different combinations of density and distance factors.

1. Questions

20-minute neighbourhood is a recent planning concept aims to support 'living locally' — giving people the ability to meet most of their daily needs within a 20-minute (800m) round-trip walk from home, with safe cycling and local transport options (Victoria State Government 2017; The Portland Plan 2012). The concept (or its variants like 15-minutes or 30-minutes) has received wider policy attention recently due to the COVID-19 travel restrictions, and consequent reliance on local opportunities to meet daily needs (Local Government Information Unit 2021; Moreno et al. 2021; Wu et al. 2021). The key criteria for a 20-minute neighbourhood to be successful to support local living are, therefore, the provision of basic opportunities and services locally, and access to quality public transport that connects people to jobs and higher-order services. However, the provision of opportunities required to meet the minimum population threshold to be viable varies between the types of opportunities to be provided. For example, the respective population requirements for a secondary school and a library are 10,000-30,000 and 30,000-60,000 in Australia (Australian Social & Recreation Research Pty Ltd 2009).

Clearly, the more people a 20-minute neighbourhood can accommodate, the greater the variety of opportunities it can support. However, increasing population means more spaces needed to provide some opportunities and services. For example, the standard for the provision of open green spaces is 5m² per person (Pissourios 2014; Umar 2021). This essentially means that the fixed land area of a 20-minute neighbourhood (considering an 800m radius) needs to be negotiated among competing lands uses. Therefore, the 20-minute neighbourhood concept faces a unique challenge: more people are needed to support adequate opportunities whereas more opportunities mean less land for residential use to accommodate more people. This challenge raises the central question for this research: *What is the optimum population*

density for a 20-minute neighbourhood? However, it is understood that there is no one-size-fits-all standard for density levels (Forsyth, Salomon, and Smead 2017; Haider 2019), and like the ‘optimal city size’ debate in the literature (Alonso 1971; Capello and Camagni 2000), it can be hypothesized that the optimal density depends on the spatial organisation of the neighbourhood within an urban system – i.e. there are determinants of urban location advantages other than population size. This raises the second research question of the study: *does the location of the neighbourhood moderate the relationship between density and destination?*

2. Methods

The study explores the answer of the research question using Greater Melbourne as a case, which aims to be a ‘City of 20-Minute Neighbourhoods’ by 2050. Statistical Area level 1 (SA1) was used as the basic unit of analysis (10,288 in total with an average size of 97 hectares). An 800m network buffer was drawn from the centroids of each SA1 to make the unit of analysis comparable with the size of a 20-minute neighbourhood. Total residential population within the buffer was calculated by summing population of meshblocks (the smallest census unit) that were proportionately contained within the buffer. Population density within the buffer was calculated by excluding SA1s with a population of 10 persons or fewer due primarily to their non-residential nature (Higgs et al. 2019), which resulted in 9,856 SA1s as the analytical sample. 20 different types of lower-order community infrastructure were selected as the opportunities and services to support local living from Grodach, Kamruzzaman, and Harper (2019). These were mapped and their types were counted within each buffer ([Table 1](#)).

Due to the count nature of the outcome variable, Poisson regression models were estimated to identify the effects of population density on the type of opportunities supported within the buffer. A quadratic term of population density was included to test and identify optimum population density (Roback and Legler 2021; Su, Wei, and Zhao 2017). Distance to the Melbourne CBD from each SA1 was included in the model to take into account the effects of spatial organisation (locational advantage) (Hong 2017). An interaction term between density and distance was added in the model to identify the moderating effects of locational advantage on density. In addition, a number of other explanatory factors were also tested including accessibility to jobs, betweenness centrality of SA1, and distance to major activity centre. Although these factors were statistically significant (including the interaction term), they did not improve the explanatory power of the model, and therefore, were not retained in the final model.

3. Findings

[Table 2](#) presents the outcomes of six different Poisson regression models estimated with various combination of explanatory factors. Model 1 confirms that population density has a positive association with the types of

Table 1. Number of SA1 with access to different community infrastructures

List	Community infrastructure type	Sources of data	Name of sourced data	Number of SA1 having access	%
1	Neighbourhood parks	DATA VIC	Parks and Conservation Reserves	9,144	92.78
2	Local shops	Open Street Map	Amenity Points	4,816	48.86
3	Local sports facility	DATA VIC	Vicmap Features of Interest	3,667	37.21
4	Community centre	AURIN	PSMA	1,232	12.50
5	Childcare centre	DATA VIC	Vicmap Features of Interest	7,022	71.25
6	Government primary schools	DATA VIC	2015 All Schools Listing	2,971	30.14
7	Kindergarten	AURIN	PSMA	4,806	48.76
8	Medical & allied health services	AURIN	PSMA	2,557	25.94
9	Post office	AURIN	PSMA	1,226	12.44
10	Church	AURIN	PSMA	3,536	35.88
11	Maternal & child health centre	DATA VIC	Vicmap Features of Interest	561	5.69
12	Catholic primary school	DATA VIC	2015 All Schools Listing	1,395	14.15
13	Tennis courts	DATA VIC	Vicmap Features of Interest	2,092	21.23
14	District/metropolitan park	DATA VIC	Parks and Conservation Reserves	152	1.54
15	Community health centre	DATA VIC	Vicmap Features of Interest	107	1.54
16	Government secondary schools	DATA VIC	2015 All Schools Listing - Feb	880	8.93
17	Aged care	DATA VIC	Vicmap Features of Interest	2,221	22.53
18	Bus stop	DATA VIC	PT. a collection of PTV datasets	9,029	91.61
19	Tram stop	DATA VIC	PT. a collection of PTV datasets	1,838	18.65
20	Train station	DATA VIC	PT. a collection of PTV datasets	1,617	16.41

opportunities available within the buffer. The effect of quadratic term of density in Model 2 shows an expected negative sign meaning that the positive association is expected up to a certain level and beyond which the effect declines, which also suggests the existence of a density that supports the maximum types of opportunities. Model 3 outlines that there exists an inverse relationship between distance to CBD and the availability of destination types. Models 4, 5, and 6 indicate that the addition of quadratic term for distance and/or the interaction term does not improve the explanatory power of the models and are not considered further to keep the model relatively simple. As a result, Model 3 is considered as the operational model for this study, which explains about 11.3% variations in the outcome variable.

Table 2. Poisson regression analysis results showing the effects of density on destinations

Explanatory factors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Density (person/ha)	0.01103*	0.03128*	0.01804*	0.01675*	0.01366*	0.02139*
Squared density (quadratic term)		-0.00017*	-0.00010*	-0.00010*	-0.00009*	-0.00012*
Distance to CBD (km)			-0.01540*	-0.02871*	-0.03556*	-0.01173*
Squared distance to CBD (quadratic term)				0.00025*	0.00032*	
Interaction: Density X Distance					0.00014*	-0.00017*
Constant	1.49041*	1.08217*	1.70449*	1.87123*	1.97432*	1.63650*
R ²	0.058	0.088	0.113	0.115	0.116	0.113
Log likelihood	-24561.63	-23770.67	-23135.78	-23067.70	-23061.87	-23118.78
LR Chi ²	3025.93*	4607.86*	5877.62*	6013.78*	6025.44*	5911.63*
N	9,856	9,856	9,856	9,856	9,856	9,856

* significant at the 0.05 level

The low explanatory power of the model is expected due to the distribution of opportunities across different density settings ([Figure 1](#)). Based on the estimated model, the value for density (92 person/ha \approx 36 dwellings/ha), at which the maximum number of opportunities exists, was obtained by taking the first derivative (partial) of the regression equation from Model 3. On average, each 20-minute neighbourhood have access to 6.18 opportunity types. However, at the 'optimum' density level, each 20-minute neighbourhood is expected to support 18.9 opportunity types (at the average distance to CBD of 21.6km). [Figure 2](#) shows the expected types of destinations to be supported in different 20-minute neighbourhoods based on their distance and density factors. Clearly, at zero population density, nearly zero types of opportunities are expected to be supported irrespective of the location of the 20-minute neighbourhoods. However, [Figure 2](#) shows that, at 100 persons/ha, the types of opportunities to be supported would be about 30, 26, 22, 19, 16, and 14 if a 20-minute neighbourhood were respectively located 0km, 10km, 20km, 30km, 40km, and 50km away from the CBD.

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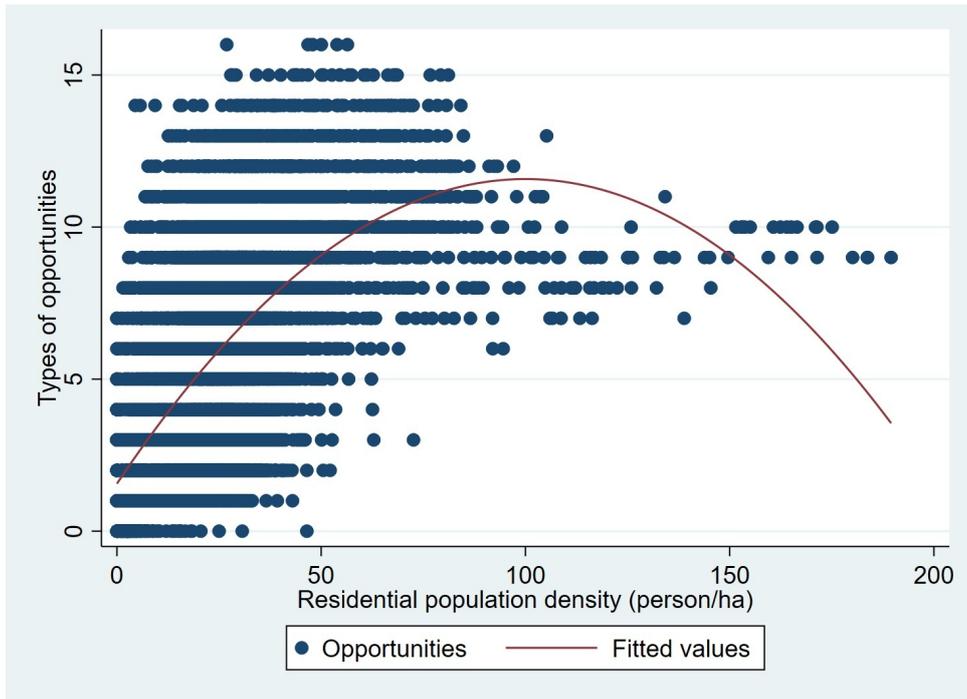


Figure 1. The relationship between population density and types of opportunities

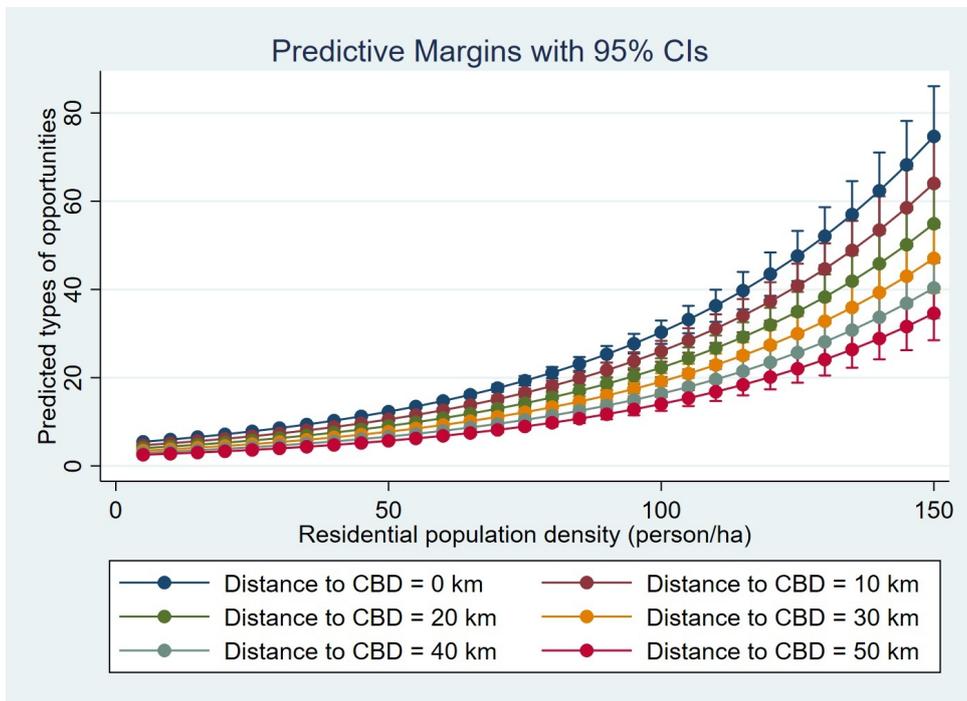


Figure 2. Types of destinations is expected at different distance and density thresholds



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