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Do apartment residents have enough car parking? Assessing car parking adequacy in Australian cities

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1. Introduction

In planning for new apartment development, the amount of off-street car parking proposed is frequently raised as a key concern by surrounding residents (Taylor 2014). In response, minimum residential car parking requirements are used in many cities, including throughout Australia (De Gruyter et al. 2021), to meet parking demand and avoid overspill of parking on to surrounding streets (Willson & Roberts 2011). However, these requirements have been associated with an oversupply of car parking (Gabbe et al. 2020), increased car ownership and use (Guo 2013; Weinberger 2012), and reduced housing affordability (Jia & Wachs 1999).

While previous research has assessed the adequacy of residential off-street car parking provision in cities, this has typically been undertaken in an aggregate manner, either at an area-wide (De Gruyter et al. 2021; Rose et al. 2017) or building level (Gabbe et al. 2020; McCahill 2017; Rogers et al. 2016), with little understanding of the variability and extent to which car parking may be under or oversupplied for individual households. This is particularly relevant where car parking is 'bundled' with the purchase price or rental cost of apartment housing, and therefore allocated individually to households, as is the case in Australia.

This research therefore aims to assess the adequacy of off-street car parking provision for apartment residents, with a focus on the individual household level. It also seeks to understand factors associated with an under/oversupply of off-street car parking. To meet this aim, the research draws on a survey of apartment residents (n=1316) in three major cities of Australia, including Sydney (population of 5.4 million), Melbourne (5.2 million) and Perth (2.1 million). Collectively, these cities provide 65% of all apartment dwellings across Australia (ABS 2016).

An understanding of the adequacy of off-street car parking provision at the household level can better inform the development of parking policies. This is in contrast to area-wide or building-level analyses, which can mask the extent of car parking supply issues where parking is 'bundled' and therefore allocated to individual households.

2. Method

2.1. Resident survey and compilation of variables

As part of a wider study aimed at informing apartment design guidelines (Foster et al. 2019), a survey of apartment residents was undertaken across three Australian cities: Perth, Melbourne and Sydney. These cities were chosen to reflect varying levels of apartment design policy – the Sydney buildings were developed under the most comprehensive policy in Australia (SEPP65), compared with relatively limited guidance in Perth and Melbourne when the building sample was developed (2006-2016). An information pack was posted to randomly selected apartment households inviting them to participate in an online version or hardcopy of the survey.

Survey questions covered a range of topics relating to apartment design, health and well-being, lifestyle, and socio-demographics. Within these topics, residents were asked how many off-street car parking spaces are allocated to their apartment and the number of cars in their household. Other questions asked in the survey that were relevant to the analysis covered housing tenure (own/rent), apartment size (number of bedrooms), household size (number of people), whether children lived in the household, annual household income, importance of car parking in the choice of dwelling, whether parking problems had been experienced in the last 12 months, and the extent to which residents agree that enough visitor and resident car parking is provided at their apartment building.

The survey was conducted from 2017 to 2019. A total of 10,560 households were invited to participate, with 1,316 valid survey responses received across the three cities, corresponding to a response rate of 13.2% after accounting for a 5% rental vacancy rate. A similar number of survey responses were received in Perth (n = 577) and Melbourne (n = 448), with fewer received in Sydney (n = 291).

Various built environment and transport-related characteristics were compiled for each apartment building location, including dwelling density (dwellings/ha), street connectivity (3+ way intersections/sq.km), social infrastructure mix (score out of 16 reflecting local access to various social infrastructure destinations), effective transit service headway (mins), distance to public transport stops/stations (mins), presence of car sharing (yes/no), and travel time to the CBD by car and public transport (mins). These variables were chosen given their established relationships with car ownership, car parking demand and travel behaviour more generally (De Gruyter et al. 2020; Ewing & Cervero 2010).

2.2. Data analysis

A comparison of car parking supply against car ownership for each household was undertaken first to understand the extent to which off-street car parking is undersupplied (spaces < cars), balanced (spaces = cars) and oversupplied (spaces > cars) in each city.

Separate univariate logistic regression models for each variable were then developed to provide an initial understanding of factors that are associated with an under/oversupply of car parking. Here, two dependent binary variables were used: undersupplied car parking (spaces < cars) and oversupplied car parking (spaces > cars). Independent variables that were significant in the univariate regression models that did not exhibit significant multicollinearity were included in two full binary logistic regression models: one for undersupplied car parking and the other for oversupplied car parking. All regression modelling was performed using SPSS (v26).

3. Results

Figure 1 shows the difference between car parking supply and car ownership among the apartment households, to help illustrate the extent to which off-street car parking is undersupplied (spaces < cars), balanced (spaces = cars) and oversupplied (spaces > cars) in each city. Overall, around two-thirds (65.9%) of households have a ‘balanced’ amount of off-street car parking, with the remainder being oversupplied (20.2% in total) or undersupplied (14.0% in total). Of the households that are over/under supplied, most either have one space too many (19.0% out of 20.2% in total, or 94.1%) or one space too few (13.0% out of 14.0% in total, or 92.9%). A Chi-square test showed that there was no significant difference in the proportion of apartment households that are balanced, oversupplied or undersupplied between the cities (p = 0.62).

Figure 1: Difference between car parking supply and car ownership among resident sample by city

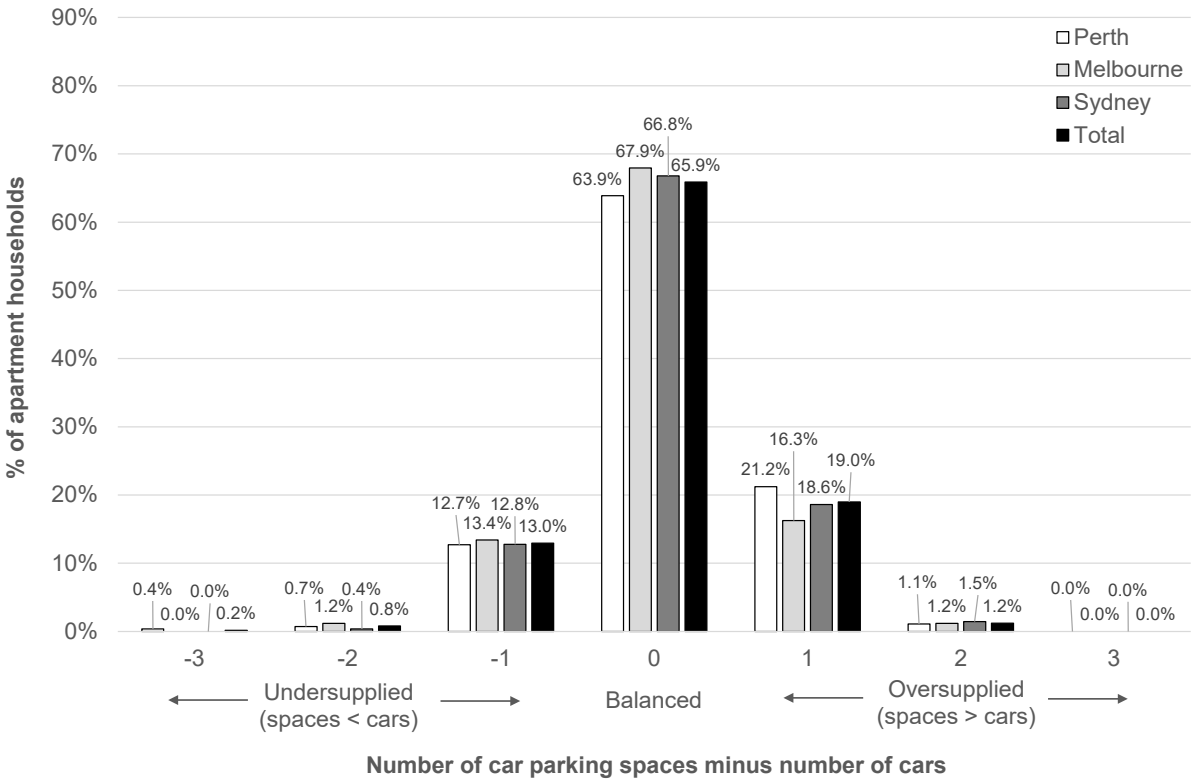

Table 1 provides the results of the binary logistic regression models for undersupplied car parking and oversupplied car parking. To avoid multicollinearity, *travel time to CBD by public transport* was excluded due to a high level of correlation with *travel time to CBD by car*. Other variables – including *dwelling density*, *effective transit service headway* and *distance to public transport stops/stations* – were also excluded as they were not significant in the univariate regression models. Across the two models, variables that were significantly associated with an undersupply or oversupply of car parking included *number of bedrooms in apartment*, *household size*, *children in household*, *importance of car parking in choice of dwelling*, *enough visitor car parking at my building*, *enough resident car parking at my building*, *local street connectivity within 1600 m*, and *car sharing vehicle < 800 m*.

For each additional bedroom in an apartment, there was a 4.6-fold increase in the odds of having an oversupply of car parking (odds ratio = 4.56, $p<0.01$). This result is expected given the generally higher level of car parking provision for larger apartments. However, there was a 4.4-fold increase in the odds of having *undersupplied* car parking for each additional person living in an apartment (odds ratio = 4.39, $p<0.01$), given this can increase the demand for car ownership. Conversely, having children in a household was associated with reduced odds of having undersupplied car parking (odds ratio = 0.27, $p<0.01$) which is likely to be due to children living in larger apartments with a higher level of car parking provision. This is confirmed by a separate analysis which showed that apartment households with children had 2.2 bedrooms on average compared to 1.6 bedrooms on average for apartment households with no children. The results also show that income has an association with an undersupply of car parking. Households earning $100,001 – $150,000 per year were more than 2.5 times likely to experience an undersupply of car parking, compared to those earning less than $30,000 per year (odds ratio = 2.57, $p = 0.05$).

Table 1: Binary logistic regression model results

Variable	Undersupplied car parking (spaces < cars)					Oversupplied car parking (spaces > cars)				
	Estimate	Std. error	Odds ratio	Confidence interval (95%)	p-value	Estimate	Std. error	Odds ratio	Confidence interval (95%)	p-value
Number of bedrooms in apartment	-0.70	0.23	0.50	0.32 - 0.77	<0.01***	1.52	0.19	4.56	3.14 - 6.63	<0.01***
Household size	1.48	0.20	4.39	2.95 - 6.54	<0.01***	-1.02	0.19	0.36	0.25 - 0.52	<0.01***
Children in household	-1.33	0.42	0.27	0.12 - 0.60	<0.01***	0.41	0.39	1.50	0.71 - 3.19	0.29
Household income										
Under $30,000	Ref.					Ref.				
$30,001 - $60,000	0.88	0.51	2.41	0.88 - 6.58	0.09*	-0.06	0.36	0.95	0.46 - 1.93	0.88
$60,001 - $100,000	0.29	0.48	1.34	0.52 - 3.44	0.54	-0.45	0.34	0.64	0.33 - 1.25	0.19
$100,001 - $150,000	0.94	0.47	2.57	1.01 - 6.50	0.05**	-0.32	0.35	0.73	0.37 - 1.43	0.36
Over $150,000	0.74	0.48	2.09	0.81 - 5.36	0.13	-0.19	0.35	0.83	0.42 - 1.64	0.59
Importance of car parking in choice of dwelling										
Not at all important / unimportant	Ref.					Ref.				
Neither unimportant nor important	1.34	0.55	3.82	1.31 - 11.15	0.01**	-1.17	0.35	0.31	0.16 - 0.62	<0.01***
Important / very important	1.10	0.48	3.01	1.17 - 7.74	0.02**	-2.47	0.31	0.09	0.05 - 0.16	<0.01***
Parking problems with residents in last 12 months	0.31	0.26	1.36	0.82 - 2.27	0.23	0.25	0.25	1.29	0.80 - 2.08	0.30
Enough visitor car parking at my building										
Strongly disagree / disagree	Ref.					Ref.				
Neither agree / disagree	0.26	0.42	1.30	0.57 - 2.94	0.54	0.57	0.28	1.76	1.02 - 3.04	0.04**
Agree / strongly agree	0.96	0.29	2.60	1.49 - 4.56	<0.01***	0.19	0.23	1.20	0.77 - 1.89	0.42
Enough resident car parking at my building										
Strongly disagree / disagree	Ref.					Ref.				
Neither agree / disagree	-1.70	0.37	0.18	0.09 - 0.38	<0.01***	0.37	0.33	1.45	0.75 - 2.79	0.27
Agree / strongly agree	-2.57	0.31	0.08	0.04 - 0.14	<0.01***	0.87	0.27	2.39	1.40 - 4.08	<0.01***
Local street connectivity within 1600 m	0.01	0.01	1.01	1.00 - 1.02	0.03**	-0.01	0.00	0.99	0.98 - 1.00	<0.01***
Average social infrastructure mix score	-0.01	0.06	0.99	0.88 - 1.12	0.87	0.05	0.05	1.05	0.94 - 1.16	0.39
Car sharing vehicle < 800 m	-0.90	0.38	0.41	0.20 - 0.86	0.02**	0.44	0.32	1.55	0.83 - 2.87	0.17
Travel time to CBD by car	0.01	0.01	1.01	1.00 - 1.02	0.10	-0.01	0.01	0.99	0.98 - 1.01	0.24

'Undersupplied' car parking model: n = 874, model significant at p<0.001 (chi-square = 182.41, degrees of freedom = 18, pseudo R^2 = 0.34), *** p<0.01, ** p<0.05, * p<0.10.
'Oversupplied' car parking model: n = 874, model significant at p<0.001 (chi-square = 168.79, degrees of freedom = 18, pseudo R^2 = 0.28), *** p<0.01, ** p<0.05, * p<0.10.

Residents who considered car parking in the choice of their dwelling as either important or very important had a 3-fold increase in the odds of having an undersupply of car parking (odds ratio = 3.01, p=0.02), compared to those who considered it as not at all important or unimportant. However, those who considered it as neither important nor unimportant also had an increased odds of having an undersupply of car parking (odds ratio = 3.82, p=0.01). The converse was seen for those with oversupplied car parking (odds ratio = 0.09 and 0.31 respectively, p<0.01).

Residents who agreed or strongly agreed that there was enough visitor car parking at their building were more likely to experience an undersupply of car parking (odds ratio = 2.60, p<0.01). However, those who agreed or strongly agreed that there was enough resident car parking were far less likely to experience an undersupply of car parking (odds ratio = 0.08, p<0.01) and more likely to have an oversupply of car parking (odds ratio = 2.39, p<0.01).

The results also show that residents living in areas with greater street connectivity were slightly more likely to experience an undersupply of car parking (odds ratio = 1.01, p=0.03) while those in areas with lower street connectivity were slightly more likely to experience an oversupply of car parking (odds ratio = 0.99, p<0.01). Finally, residents living within 800 m of a car sharing vehicle had a reduced odds of having undersupplied car parking (odds ratio = 0.41, p=0.02).

4. Discussion and conclusions

Drawing on a survey of apartment residents in Perth, Melbourne and Sydney, this research found that around two-thirds (65.9%) of households have a 'balanced' amount of off-street car parking, where the number of cars owned is equal to the number of allocated off-street car parking spaces. The remaining households either experience an oversupply of off-street car parking (20.2% of all households) or an undersupply of off-street car parking (14.0% of all households). Of the households that are over/under supplied, over 90% either have only one car parking space too many or one too few. Another key finding was that a range of factors are associated with an undersupply and oversupply of off-street car parking among apartment households. These factors were found to be largely related to household characteristics (e.g. number of bedrooms) and residents' perceptions of parking issues, rather than the more typical measures used in studies of travel and the built environment (Ewing & Cervero 2010).

A key implication from this research is that there appears to be a strong case for 'unbundling' off-street car parking from the purchase price or rental cost of apartment housing. A similar proportion of apartment households were found to experience an oversupply and undersupply of off-street car parking (20.2% and 14.0% respectively) and this almost always involved having one parking space too many or one too few. Another implication is that factors associated with an undersupply and oversupply of parking deserve greater consideration in the development of residential off-street car parking requirements. For example, the results showed that apartments with more bedrooms were more likely to experience an oversupply of off-street car parking, suggesting that off-street car parking requirements may be too high for larger apartments. In addition, apartment households were less likely to experience an undersupply of parking if they were located within 800 metres of a car sharing vehicle, suggesting that the provision of car sharing could be incorporated within off-street car parking requirements. More generally, the findings can be used to inform the development of updated off-street car parking requirements to help limit the extent of parking oversupply in new apartment buildings.

This research contributes to the literature by providing an understanding of the adequacy of off-street car parking for apartment households and the factors associated with an under/oversupply of parking. However, it is also subject to some limitations: the research is based on a cross-sectional sample of apartment households only, results were not weighted to represent the full

population of apartment households, and the adequacy of off-street bicycle parking considered. These limitations should be addressed in future research.

References

ABS 2016, *Census of Population and Housing Data*, Australian Bureau of Statistics (ABS), Canberra, Australia, <http://www.abs.gov.au/census>.

De Gruyter, C, Davies, L & Truong, LT 2021, 'Examining spatial variations in minimum residential parking requirements in Melbourne', *Journal of Transport Geography*, vol. 94, pp. 1-20.

De Gruyter, C, Truong, LT & Taylor, EJ 2020, 'Can high quality public transport support reduced car parking requirements for new residential apartments?', *Journal of Transport Geography*, vol. 82, no. 102627, pp. 1-11.

Ewing, R & Cervero, R 2010, 'Travel and the Built Environment: A Meta-Analysis', *Journal of the American Planning Association*, vol. 76, no. 3, pp. 265-94.

Foster, S, Maitland, C, Hooper, P, Bolleter, J, Duckworth-Smith, A, Giles-Corti, B & Arundel, J 2019, 'High Life Study protocol: a cross-sectional investigation of the influence of apartment building design policy on resident health and well-being', *BMJ Open*, vol. 9, pp. 1-15.

Gabbe, CJ, Pierce, G & Clowers, G 2020, 'Parking policy: The effects of residential minimum parking requirements in Seattle', *Land Use Policy*, vol. 91, no. 104053, pp. 1-8.

Guo, Z 2013, 'Does residential parking supply affect household car ownership? The case of New York City', *Journal of Transport Geography*, vol. 26, pp. 18-28.

Jia, W & Wachs, M 1999, 'Parking requirements and housing affordability: a case study of San Francisco', *Transportation Research Record: Journal of the Transportation Research Board*, no. 1685, pp. 156-60.

McCahill, C 2017, 'Factors affecting residential parking occupancy in Madison, Wisconsin', *Transportation Research Record: Journal of the Transportation Research Board*, no. 2651, pp. 71-9.

Rogers, J, Emerine, D, Haas, P, Jackson, D, Kauffmann, P, Rybeck, R & Westrom, R 2016, 'Estimating parking utilization in multifamily residential buildings in Washington, D.C.', *Transportation Research Record: Journal of the Transportation Research Board*, no. 2568, pp. 72-82.

Rose, G, De Gruyter, C, Pollard, G & Richter, K 2017, 'Car ownership versus parking supply in residential apartments: A case study of Melbourne, Australia', paper presented to World Symposium on Transport and Land Use (WSTLUR), Brisbane, Australia.

Taylor, E 2014, '"Fight the towers! Or kiss your car park goodbye": How often do residents assert car parking rights in Melbourne planning appeals?', *Planning Theory and Practice*, vol. 15, no. 3, pp. 328-48.

Weinberger, R 2012, 'Death by a thousand curb-cuts: Evidence on the effect of minimum parking requirements on the choice to drive', *Transport Policy*, vol. 20, pp. 93-102.

Willson, R & Roberts, M 2011, 'Parking demand and zoning requirements for suburban multifamily housing', *Transportation Research Record: Journal of the Transportation Research Board*, no. 2245, pp. 49-55.