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# Introduction

* Estimates suggest that 30% of inner city traffic is motorists cruising for parking (Shoup 2006) and simulations suggest a similar proportion (Sykes et al. 2010).
* Planning practitioners and policy makers are required to accommodate a broadening array of modal choices (e.g. private vehicles, public transit, micro-mobility, e-vehicles, ride-sharing, ride-hailing, and soon autonomous vehicles) while remaining constrained to the same urban footprint to support urban consolidation attempts and to avoid generating further urban sprawl. “Peak Mobility” may have already passed in OECD countries where young adults are delaying when they start driving and purchasing private vehicles (Goodwin & van Dender 2013).
* Excessive parking supply has the potential to burden future generations with urban sprawl blanketed with artificial surfaces (Steele 2018).
* Laying all parking flat would blanket more than 10 percent of the typical US city (Scharnhorst 2018) or as much as 30 percent for Los Angeles County (Chester et al 2015).
* Parking is often framed as the ‘life blood’ of businesses since enlarges the customer catchments area by providing spot accessibility for motorists (Box 2000).
* Customers regard parking availability as a key criteria when choosing between businesses and particularly grocery customers (Recker & Kostyniuk 1978; Shobeirinejad et al. 2013).
* Parking inequalities emerge since local councils can provide parking to generate commercial activity and the state transport authority can lose public transport ridership and be relegated to a responsive role (Barter 2015) entailing road-widening and flyovers to minimise the resultant traffic congestion (Young & Miles 2015; McCahill & Garrick 2014).
* It is a classic “induced demand problem” (Hansen 1995) given that oversupply increases the appeal of arriving by car, which in turn heightens demand for parking and road capacity.
* Motorists cruising for parking and doubling back for cheaper parking are estimated to be 30percent of inner city traffic (Shoup 2006; Weinberger 2012)
* Estimates suggest private vehicle remain in motion just 5% of the time (Button 2006).
* There is a “dormant vehicle” problem since private vehicles are typically waiting to be used (Spurling 2020) and likewise US estimates suggest there are three parking spaces for each registered vehicle waiting to be used (Shoup 2018; Jakle & Sculle 2004; Cullinane, Smith, & Green 2004) that could potentially be put to more productive use.

## Policy Mindsets:

* Parking policy is a potent tool for influencing whether, when, and where driving is preferred given that driving begins and ends in a parking space (Meyer 1999; Young & Miles 2015; Manville 2017).
* Barter (2015) argues that policy *mindsets* vary according to whether parking is regarded a private luxury or public infrastructure, and by whether it is orientated towards a particular site or an entire district (Table x).
* A conventional policy mindset ensures onsite “parking self-containment” to minimise parking overspill into nearby sites that becomes a source of conflict throughout the residential/commercial/mixed-use district.
* An area management policy mindset regards parking a market failure thus requiring the government to intervene to minimise cruising, avoidance, and commercial parking monopolies.
* A *responsive* policy mindset provides parking to fulfil existing demand given that parking can be profitable leasing of urban space.

Table 1 Parking Policy Mindsets (adapted from Barter 2015)

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | Focus | |
|  |  | **Site** | **District** |
| Framing | **Infrastructure** | Conventional | Area-Management |
| **Luxury** | Unobserved | Responsive |

## The conventional parking policy mindset

* The conventional mindset typically manifests through a “predict and provide” approach to planning whereby parking demand is *predicted* and developers must *provide* accordingly to ensure all parking demand during the peak-demand period can be contained on-site (Goulden, Ryley, & Dingwall, 2014).
* In policy, this will manifest in policy as parking minimums, which is the minimum parking required to contain all anticipated demand (Shoup 1999).
* These parking minimums typically vary according to land use type and dwelling capacity (McCahill & Garrick 2014).
* There can be goods-wise variation in the degree to which parking influences the choice between traders (Timmermans 1982; Shobeirinejad et al. 2013) and so there could be problems when all commercial spaces are regarded equal in policy.
* Parking minimums typically lack a rigorous evidence base (Andersson 2016; Shoup 1999; Millard-Ball 2015) or are little more than the ad nauseam reproduction of the Institute of Transportation Engineers’ 1987 Trip Generation Manual that was calibrated for low density suburban development (Shoup 2005).
* Arguably, it is not possible to predict parking demand where viable alternatives exist (i.e. public, active, and shared transport), it is just an attempt to increase the appeal of a site to those unable or unwilling to arrive by the alternatives.
* Relatively recent research suggests that this manual overestimates trip generation by 55 percent when checked against household survey results (Millard-Ball 2015) thus providing Shoup (2005) with reasonable cause to describe parking minimums as a baseless ‘pseudoscience’.
* There are at least three non-residential parking spaces for every registered vehicle in the United States thus further revealing the enormity this free parking privilege (Shoup 2018)
* There are benefits for the district given that generous parking supply can minimise the time spent cruising for vacant parking which typically slows trailing traffic (Seibert 2008).
* The site-level focus does not take nearby land use into account (Shoup 2010; Inci 2015; Rowe, Bae, & Shen 2010) and misses opportunities for *reciprocal parking* *arrangements* e.g. between a school and church that have distinct peak demand periods (Shoup 2005).
* The one-size-fits-all approach with parking minimums means that even car-free households must purchase parking (Marsden 2006)
* Parking is ‘shadow market’ since parking minimums hide the marginal costs of providing parking (Manville 2017).
* Everyone pays for free parking since developers must embed the marginal costs of fulfilling parking minimums into property sales and rents, and merchants must embed the cost of their bundled parking into the sale of goods and services (Shoup 2005).
* If fulfilling parking minimums is more expensive closer to the inner-city, then this policy is incentivising developers to choose peripheral locations and facilitating further urban sprawl (Shoup 2014).
* Parking minimums inflate parking demand and create price ceilings since parking stretches the urban form so that private automobiles become more of a necessity (Manville 2017).
* Parking minimums inflate the Seattle residential construction by between US$10,000 and US$14,000, and Los Angeles shopping centre construction by 67 percent when parking is constructed above ground and 97 percent when constructed below ground (Shoup 2014).
* Parking minimums also inflate Stockholm residential construction costs by 10 percent and reduce the residential stock by 1.2 percent (Andersson et al. 2016), and the cost of renting in the US by 10 percent on average (Gabbe and Pierce 2017).
* Having spare parking bays triples the likelihood of further vehicle purchases (Christiansen et al. 2017b).
* “Bay-sharing” services are on the rise (e.g. Parkhound and Kerb) which reveals where parking is being oversupplied (Kimpton et al 2021).

## The area-management parking policy mindset

* An area management mindset manifests as public parking.
* Everyone pays for free public parking since councils must embed the costs into rates, registration, and taxes (Shoup 2005).
* Public parking is often criticised as a Band-Aid solution for winning votes (Weinberger 2012; McCahill & Garrick 2014; Shoup 2005).
* Public parking can be a misallocation of resources when it increases how often motorist take short, low-value trips, and therefore are impeding motorists travelling longer, high-value trips (Manville 2017b).
* Once the public has developed the expectation for public on-street parking, they tend to overlook new off-street parking (Adiv & Wang, 1987).
* Public on street parking can provide the opportunity for misuse such as repurposing residential off-street parking as general storage and overspilling into on-street parking. On one occasion, an Australian resident exhausted eleven on-street parking bays to the frustration of nearby residents left with nowhere for their visitors to park and to the frustration of motorists that had their sightlines blocked by tall vehicles (i.e., six cars, a campervan, a caravan, two boats, and a jet ski). The council was powerless to respond given that each vehicle was legally parked (Lim, 2014).
* Public on-street parking narrows roads and therefore reduces road stream speed and capacity (Box, 2004; Cao, Yang, & Zuo, 2017; Chen, Li, Jiang, Zhu, & Wang, 2017; Chiguma, 2007; Edquist, Rudin-Brown, & Lenné, 2012; Kladeftiras & Antoniou, 2013; Rudjanakanoknad, 2010).
* On-street parking is typically more convenient for motorists yet their cruising for vacant parking and manoeuvring into parking generates congestion (Yousif, 2004).
* On-street parking increases the visual complexity within the road environment which delays reactions and reduces traffic speeds and pedestrian safety (Biswas, Chandra, & Ghosh, 2017; Gitelman, Balasha, Carmel, Hendel, & Pesahov, 2012; Loukaitou-Sideris, Liggett, & Sung, 2007).
* Between 13 and 17 % of British pedestrian causalities are a result of pedestrians stepping out from between parked automobiles (Biswas et al. 2017) although arguably this statistic does account for exposure (e.g. are more pedestrians crossing near cars) nor controls (e.g. does this rate differ from roads without on-street parking).
* Shifting the expense to the user e.g., parking meters and parking permits
* Motorists typically undervalue their time spent cruising and doubling back for free or cheaper parking, and ignore the value of other motorists’ time since their cruising and manoeuvring delays trailing traffic (Marshall et al., 2008; Shoup, 2006; Spiliopoulou & Antoniou, 2012; Weinberger, 2012; Calthrop & Proost 2006; Kobus et al. 2013; Glazer & Niskanen 1992; Inci 2015; Inci & Lindsey 2014).
* Motorists often gamble the likelihood of being fined against the certainties of parking rates yet perfect parking enforcement may be financially infeasible for councils (Inci 2015).
* Expensive public parking provides commercial parking operators with a local power monopoly when setting rates (Froeb, Tschantz, & Crooke 2003; De Nijs 2012; Kobus et al. 2013)
* When parking rates vary spatially, the motorists least able to afford expensive parking must walk further or spend more time cruising for parking within their budget (Glazer & Niskanen 1992).
* The introduction of paid parking is associated with a loss of customers (Baker & Wood 2010; de Wit 2006) and on an occasion, a councillor attacked from behind and a further almost strangled by a trader enraged by the introduction of parking meters at a public forum (ABC News 2015).
* While councils claim parking restrictions are to improve turnover, pricing and permits are controversial with the media frequently framing these approaches as government ‘revenue raising’ (O'Sullivan & Gladstone 2019; Fuller 2018).
* Public parking rates are more publically palatable when the revenue is spent directly on uplifting the district (Shoup 2011).

## The responsive parking policy mindset

* The responsive parking policy mindset typically manifests through the *unbundling* of parking from land sales and through a demand management approach to planning policy that regards demand for the luxury of parking to be potentially limitless and therefore requires management to ensure that active and public transport remain appealing options (Brennan, Ter Schure, & Napolitan, 2013).
* Specifically, parking maximum policies are introduced that cap parking supply and therefore the convenience of driving relative to the alternatives (Brennan, Ter Schure, & Napolitan 2013; Shoup 2005, 2011; McCahill & Garrick 2014).
* While not always termed “unbundled parking”, parking maximums that cap parking supply below dwelling supply can suggest “unbundled parking” since parking could not be bundled with every dwelling purchase (Martens 2005, Guo & Ren 2013).
* Dwellings without bundled parking are more likely to remain auto-free (Manville 2017a)
* Unbundled parking reduces the wealth transfer from households that are unable to afford automobiles to those that can and choose to drive (Manville 2017a).
* Parking maximums are associated reducing driving (McCahill & Garrick 2014), increasing public transit ridership (Chatman 2008) and the knock-on effect is reductions in traffic congestion, road capacity requirements, and the associated municipal overheads of accommodating private automobiles (Young & Miles 2015; Marsden 2006).
* Parking maximums are typically zoned within the inner city or near rapid transit nodes (i.e. Transit Orientated Development) where public transport can be a viable alternative to driving (Marsden 2006; Christiansen et al. 2017a).
* Cities with urban consolidation policies are typically the earliest to introduce parking maximums (Bajracharya et al. 2005; Griffiths & Curtis 2017; Chatman 2008).
* Parking maximums and unbundled parking are gaining popularity throughout North America, Europe, Asia, Australia, and the Middle East, and becoming binding for residential markets throughout London, New York, and most of Los Angeles (Inci 2015; Guo & Ren 2013; Gabbe & Pierce 2017).
* Zurich authorities cap the current parking supply to the city’s 1990 supply to discourage further car purchases and have so far observed a per capita decline in driving (McCahill & Garrick 2014).
* San Francisco unbundles private parking and has minimums for auto-sharing parking bays within new residential buildings (Ter Schure, Napolitan, & Hutchinson 2012).
* Los Angeles introduced employee cash out policy where employees can request the value of parking added to their salary in lieu of receiving workplace parking, which is increasing car-pooling and public transit ridership (Shoup 2005; Christiansen et al. 2017a).
* A self-selection bias rather than influence may explain change since auto-free households have greater incentive to relocate near rapid transit nodes (Zahabi et al 2012, Christiansen et al. 2017b).
* Homeowners may threaten to leave when parking restrictions are introduced (Jacks 2019)
* Folk legality can emerge whereby residents make false claims for adjacent on-street parking thus exhausting the local parking supply for guest and customers (Christiansen et al. 2017b; Taylor 2016).
* Unbundled parking can also inflate the market value of parking given that weekly expense of inner-Brisbane, Sydney, and Melbourne parking in 2016 ranged from 50 to 58 percent of the median Australian income (e.g., AU$65.59\*5/ AU$662; AU$76.83\*5/AU$662; Royal Automobile Club of Queensland 2016; Australian Bureau of Statistics 2016 [see if I can update]), and one inner-Sydney residential parking space auctioned for around US$80k in 2015 (Bianchi 2015).

## Our research contribution to the planning literature

* We explore change to parking policy within the City of Melbourne Local Government Area (LGA) using template analysis
* Given that parking maximums apply throughout the study period, we examine and explain how much parking developers are choosing to provide by the pre-existing parking supplies (residential, public, commercial) that is nearby and a theoretically-relevant land use that is also nearby.
* What we are attempting to reveal is the developers’ risk aversion given that: (a) too few parking bays could leave developers with dwellings that are difficult to sell without parking available for unbundled purchase and (b) too much parking could leave developers with unsold parking
* It is generally a ‘blanket policy’ for the LGA or except for the Dockland area so there should not be spatial variation however if spatial or temporal autocorrelation is apparent, then a spatial and/or panel model will be used as appropriate

# Material and methods

## The City of Melbourne

* The City of Melbourne local government area is the inner city of Melbourne, Victoria, Australia, which has remained one of the world’s wealthiest cities since its 1850s gold rush made famous by historical figures including Ned Kelly.
* This city was ranked the world’s most liveable city from 2007 to 2017 until dethroned by Vienna in 2018 (Economist Intelligence Unit 2018).
* The city is also iconic for 250 kilometres tram network which makes it the longest tram network in the world (Yarra Trams 2017).
* Inner-Melbourne is also notorious among Australian and visitors for frequent ‘hook turns’ that require turning across traffic to navigate around tram lanes.
* The city’s Metrotunnel project has also gained considerable press coverage due to continual delays and financial blowouts but will enable cross-city train riders to bypass most inner-city stations (Metrotunnel 2018).

## Parking Policies

* Xx policies were collected spanning from xxxx to xxxx (the former should extend to the last policy in place for the earliest development application used and the latter only needs to extend to the most recent development application used)
* Xx, xx, and xx are where these policies are publically available for download (we only need City of Melbourne policies and Victorian policies that apply to City of Melbourne).

## Development Applications

* Xx residential and xx commercial approved Development Applications (DAs) have been collected from within the City of Melbourne study frame.
* The coverage is from xxxx to xxxx
* The data is a bulk dump of the City of Melbourne’s Development Activity Model (City of Melbourne 2021).
* This data distinguishes commercial and residential development and provides information including project status, location, size, and most importantly for this study, parking provision.

## Census of Land Use and Employment

* Xx CLUE blocks covering the period from xxxx to xxxx
* Reveals x, y, and z about the pre-existing parking supply and associated land use

## Template Analysis

* A template analysis approach is used to systematically examine and contrast parking policies (Brooks et al. 2014; King 2012).
* It features a row for each policy and columns for examples of parking minimums, public parking, or parking maximums policies contained within the policy.

## Statistical Modelling

* The global Moran’s I for annual parking provision rate is calculated for each time period to determine whether spatial autocorrelation will likely influence statistical modelling within the City of Melbourne study frame.

(1)

* + Where: is the number of spatial units indexed by and ; is the variable of interest or model residuals with as its mean; is a spatial weights matrix with zeros on the diagonal; and is the sum of all weights.
  + A Moran’s I index of 1 indicates perfect spatial clustering, a 0 that values are spatially random, and -1 indicates an antagonistic relationship between spatial units resembling a chess board.
* If there is global spatial autocorrelation, there is justification for a spatial model and then calculate the local Moran’s I for annual parking provision rate and plot the results using choropleth maps to reveal spatial patterning between each CLUE block and its nearest neighbours (I’ve used Queen Contiguity previously, which will be suitable).
  + If there are discernible local Moran’s I patterns and theoretical justification for local models, then Geographic Weighted Regression is justified
  + GWR coefficients can vary spatially using a ‘moving window’ to create a continuous surface for each city. As such, the model results are presented using maps rather than tables. The utility of this approach was that it can reveal *where* nearby landuse best explains the parking provision proposed on DA.

(2)

* + where rather than being constant in the whole model and throughout the study area, it is instead function with denoting the centre of the spatial unit and is a spatially weighting matrix where the spatial association tapers to zero at the perimeter of the moving window (Fotheringham, Brunsdon, & Charlton 2002). The width of this moving window is also referred to as ‘kernel bandwidth’ and while this can be determined through trial and error, a cross validation of bandwidth method to empirically select the kernel bandwidth with the smallest model errors was used within this examination (Paez, Farber, & Wheeler 2011). Finally, the Moran’s *I* of each GWR model’s residuals was calculated using Leung and colleagues’ (2000) three moment approximation method to determine the degree to which spatial autocorrelation explains any remaining model error or ‘disturbances’ denoted by .
* Otherwise, there must be a theoretical justification when choosing between Spatial Error, Spatial Lag, and Spatial Autoregressive Combined models
  + Also, if OLS model errors prove to be spatially autocorrelated, then a *Spatial Autoregressive Combined* (SAC) model will be used since this model includes a spatial lag of nearest neighbours for both the dependent variable and the model errors thus addressing spatial autocorrelation rather than assume the neighbourhood units are randomly located within each city (Kelejian & Prucha 1998).

(3)

* + Where: is observations vector on dependent variable ; is matrix on exogenous variables; is vector of regression parameters; and are scalar autoregressive parameters; and are spatial weighting matrices on known constants; is vector on model disturbances; and is vector on model innovations.
* A similar metric is used to determine whether temporal autocorrelation exists within CLUE blocks.
* If there is temporal autocorrelation, then either:
  + Geographic and Temporal Weighted Regression; or
  + A panel/mixed-effects version of the spatial model is appropriate

# Results

# Discussion

# Conclusions

# Glossary

# Appendices

1. The School of Earth and Environmental Science, University of Queensland, St Lucia, Queensland, Australia [↑](#footnote-ref-1)