A practical application of modelling remote parking behaviour

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Abstract

Limited parking supply and expensive parking fees within city centre areas prompt car drivers to park at a location that is remote to their final destination, which contrasts the conventional assumption of on-site parking for all car drivers in many strategic transport models. Modelling this behaviour is essential to produce realistic parking costs that can then affect travellers' choice of trip destination and travel mode. This paper describes the modelling of remote parking behaviour in the context of a parking model that has been commissioned by the Queensland Department of Transport and Main Roads and is one of the components in the BNE Model Improvement Program.

A parking choice model has been developed using a logit choice formulation. Two explanatory factors, cost and availability of parking space, have been included to estimate drivers' choice between alternative parking types and locations. The model produces a static picture of parking demand and costs at a given time of day.

A time profile model has been devised to replicate the parking choice throughout the day. It involves a parking discharge process for return or exiting trips that is crucial to update parking availability for latter arrival trips.

The resultant parking model estimates parking demand in line with observed volumes from the Household Travel Survey, and produces reasonable parking costs for the next step of destination and mode choice within the BNE model.

1. Introduction

The parking model described in this paper was commissioned by the Queensland Department of Transport and Main Roads (TMR) and is one of the components in the BNE Model Improvement Program. The BNE program is to enhance the trip generation, distribution and choice models on the TMR Brisbane Strategic Transport Model-Multi Modal (BSTM-MM) V1.2 platform. One of the key inputs for the model enhancement is travel cost in that parking cost is a significant component for car drivers travelling to the parking constrained areas. The model development discussed in this paper was done using BSTM-MM V1.2 platform. The parking model has now been transferred and is operational in the BNE model under development.

In the BSTM-MM v1.2, parking costs are not responsive to either a parking supply constraint or a realistic parking charge. This limits the model's ability to reflect how the cost and supply of parking influence travel destination and mode choice. In the Brisbane Central Traffic Area (CTA), parking is limited and expensive, with both parking fees and the supply of parking varying through the day. In this project our aim has been to develop a method of modelling the supply and demand of parking so that parking capacity constraints and parking related costs can be realistically and practically incorporated into the BNE Model. The BNE model is a strategic transport model using aggregate zonal estimates of travel demand and a static, average time period approach to network assignment, and the estimates of car parking costs are to be developed to fit within this overall modelling approach.

The supply model distinguishes two forms of parking within the CTA: private and public. In the demand model car drivers are segmented to those with a private parking entitlement and those competing for available public spaces. The drivers who are entitled to private parking, for instance staff parking, are assumed to park on-site[1] at the location of their trip destination. Others choose between public parking options, in that parking remotely and then walking to their trip destination is a common behaviour. This paper is primarily concerned with the choice process associated with the remote parking.

Initial formulation of a logit choice model utilises parking costs as the only explanatory factor that influences drivers' choice between alternative public parking types and locations. This leads to excessive use of relatively inexpensive alternatives such as on-street parking. Refinement is undertaken by adding the availability factor measured by the number of vacant parking spaces, reflecting the impact of drivers' knowledge of parking availability on their choice of parking location.

The logit choice model produces the parking demand at a given time of day. This model is applied through a parking profile process, generating varying parking occupancy across time of day. A key component of the profile model is the parking discharge process that ensures that return trips, in aggregation, depart from the chosen parking sites upon arrival, producing reasonable levels of parking availability as inputs for the logit choice process.

The resultant model produces parking demand that is in line with observed numbers from the Household Travel Survey and generates realistic estimates of the parking costs.

2. Remote parking behaviour

The conventional assumption used in the BSTM-MM v1.2 assumes that all the car drivers travelling to the CTA area park at their final destination. As illustrated in Figure 1, the alternative parking sites such as k1 and k2 are not considered by the trips ending at location j. This implies unconstrained parking capacity at the destination location j that allows all the arrival trips to park on-site, making the modelled car driver demand unresponsive to parking supply and tend to over-estimate the number of car driver trips to the CTA area.

Figure 1: Example of on-site parking
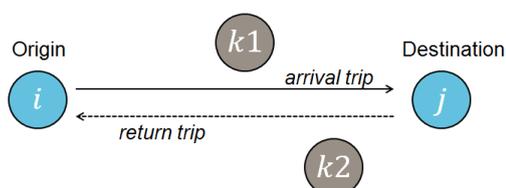
In the real world, car drivers choose between on-site and remote parking sites, as illustrated in Figure 2. Some of the car drivers may choose park at site k1 or k2, and then walk to their final destination j, as limited space and/or an expensive parking charge at j make the parking at remote sites more attractive. The cost of travelling to destination j is therefore associated with the parking supply and cost at j and also the parking supply and cost of the alternative remote parking sites. Modelling remote parking behaviour is therefore essential to incorporate the impact of the parking supply constraint on the travel costs, producing more realistic cost inputs for destination and mode choice.

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[1] In the context of strategic modelling parking within the travel destination zone is considered on site. Parking in an adjacent or nearby zone is considered remote.

Figure 2: Example of remote parking
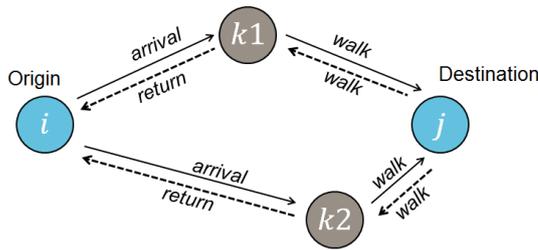
The following two major capabilities are required for modelling remote parking:

- Parking choice model, that estimates car drivers' choice between alternative parking types and locations upon their arrival, based on a number of explanatory factors. The choice model by itself produces a static picture of parking demand and costs at a given time of day.

- Parking profile model, that replicates the parking choice across time of day. This requires a discharge process for return trips, ensuring that each return trip departs from the same parking site that has been chosen upon arrival, and updating the parking occupancy for latter arrival trips.

Underpinned by the above two functionalities, the parking model generates a profile of parking demand and costs across time of day.
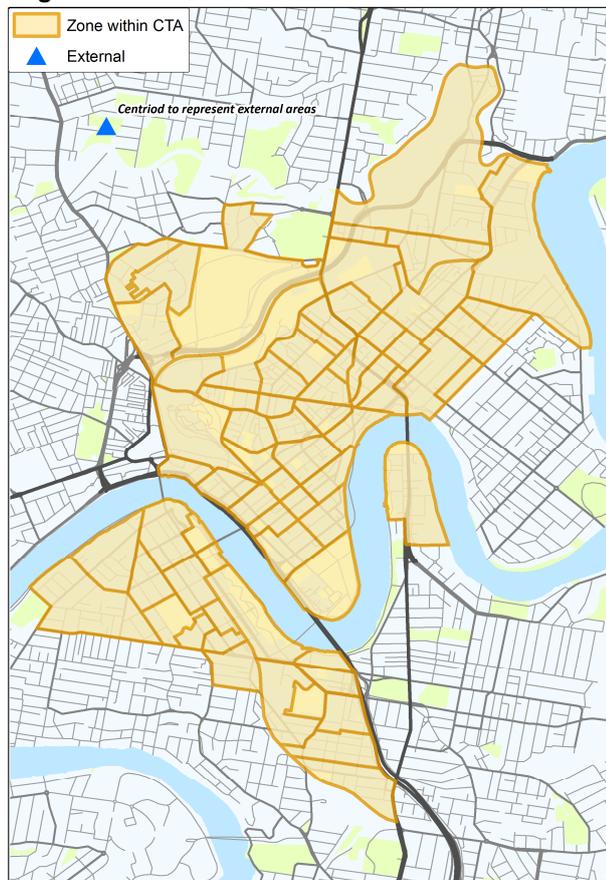
3. Parking choice model

3.1 Choice alternatives

The following terms are used in this paper to define parking alternatives:

- Parking type, denoted by π. Three main types of parking are identified, including (1) off-street parking, (2) on-street metered, and (3) on-street non-metered. Further disaggregation into long term and short term parking is also considered.

- Parking location, denoted by k. Different parking locations are represented by individual traffic zones within the CTA in the BSTM-MM v1.2, as displayed in Figure 3. Each zone represents a distinct parking location.

- Parking site, denoted by πk. A parking site is a combination of parking type and parking location.

The choice set of parking alternatives consists of all the feasible parking sites where the parking supply, measured by

Figure 3: Traffic zone

the number of parking spaces, is greater than zero[2].

3.2 Initial choice model

A multinomial logit model form is used to estimate the probabilities of choosing between alternative parking sites. The formula is:

$$P_c = \frac{\exp(U_c)}{\sum_{c' \in C} \exp(U_{c'})} \qquad \text{Equation (1)}$$

Where: c = a parking site πk which is a combination of parking type π and parking zone k
C = choice set that includes all feasible parking sites
U = utility of choosing a parking site (an alternative)

The utility for a car driver trip parking at site c is:

$$U_c = t \times T_{ik} + w \times W_{kj} + s \times S_{\pi k} + m \times M_{\pi k} + b_{\pi} \qquad \text{Equation (2)}$$

Where: T_{ik} = car leg travel time from origin zone i to parking zone k

W_{kj} = walking time from parking zone k to destination zone j

$S_{\pi k}$ = searching time for parking site πk

$M_{\pi k}$ = parking fee at parking site πk

t, w, s, m = coefficients representing the weight of each cost component

b_{π} = constant representing bias to different parking type π

3.2.1. Explanatory factors

The four explanatory factors in Equation (2) constitute the utility for a trip that involves parking.

Car travel times from trip origins to parking locations are skimmed from highway assignment in BSTM-MM v1.2. This means that delays due to traffic congestion are reflected in the car leg times.

Similarly, walking distances from parking locations to final destination zones are skimmed from highway assignment taking into account walk links[3]. A constant walking speed of 5 kilometres per hour is assumed for converting walking distances to times. The walking time for parking at destination zone is assumed to be 0.8 times of intra-zonal time.

Searching times are estimated as a function of the occupancy to capacity ratio through the function borrowed from the Leeds Transport Model Update (Masood 2014), as displayed in Figure 4. Occupancy to Capacity ratios greater than 1 are considered, and in such circumstances cars must simply circle the car park until another car leaves. The maximum searching time is capped at 15 minutes. It should be noted that the function is not designed to model significantly and consistently over-crowded car-parks.

The parking fee varies for different car drivers in the real world, based on a number of factors including parking type, parking location, parking duration, time of day etc. Replicating these factors at the most disaggregated level, for example different parking fees for individual car parks, is not feasible given the spatially aggregate nature of a strategic transport model. Moreover, the parking model is not devised for the simulation of parking prices at individual

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[2] A parking supply model has been developed as part of the overall parking model for estimating the number of parking spaces at each parking site.
[3] In the on-going BNE model development that incorporates the parking model, a specific walk assignment is used to produce walk distances.

car parks or for individual car drivers. Therefore we have applied parking charges at a more aggregated level, as presented in Table 1, representing key differentiation factors including parking area (not individual car parks), parking type, and broad duration (long term and short term parking)[4].
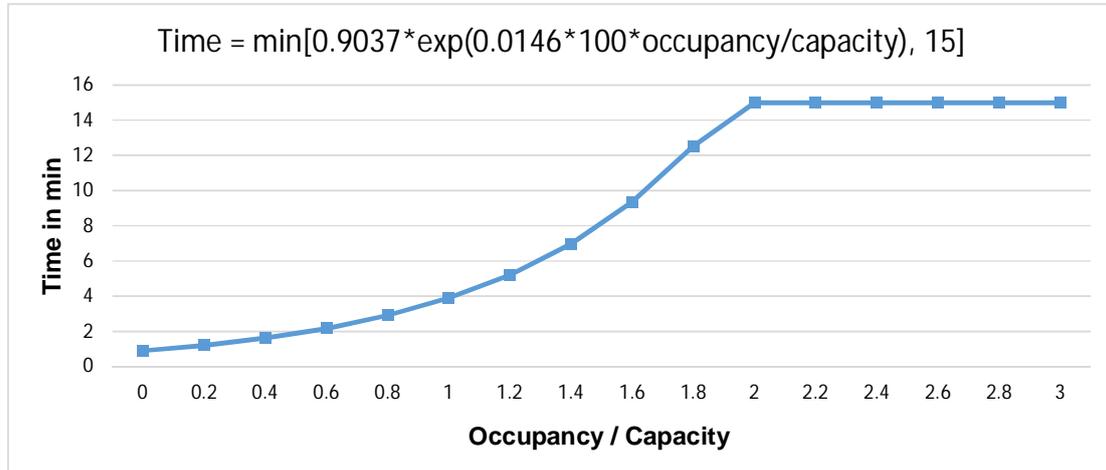
Figure 4: Search time function

$$\text{Time} = \min[0.9037 \cdot \exp(0.0146 \cdot 100 \cdot \text{occupancy/capacity}), 15]$$

Table 1: Applied parking fees

Sub-area within CTA	Off-street		On-street meter	
	Daily rate for long term parking ($)	Hourly rate for short term parking ($)	Daily rate for long term parking ($)	Hourly rate for short term parking ($)
CBD North	22.0	20.6	10.0	4.3
CBD South	23.1	22.2	10.0	4.3
Spring Hill	18.8	19.5	8.4	2.5
Fortitude Valley	9.3	15.0	8.4	2.2
South Brisbane	15.4	9.7	8.4	2.4
Outer area	8.0	4.0	8.4	1.7

3.2.2. Parameters

Due to the absence of any local state preference surveys, the values of the parameters in Equation (2) are borrowed from a study in the UK (Stephane 2004) that estimated similar model form and parameters from data collected in three cities. The parameter values are presented in Table 2. Statistical testing of the transferability of these parameters should be based on the ability of the transferred model to describe observed choices in the new Brisbane context (Ortuzar 1994), which requires local surveys that are not available for this study. Therefore the sensibility of the parameters is verified through sensitivity test of model responsiveness as described in section 5.2.

The values of time (VOT) implied by these parameters need to be consistent with the VOT used in other components of the travel demand model in BSTM-MM v1.2. We have compared the implied VOT from the borrowed parameters with the VOT values used by the

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[4] Short and long term parking is separated as two sub-types in the parking model due to their significant differentiation in parking spaces and charges. The same parking choice model presented in this paper is applied for both of two sub-types.

BSTM-MM v1.2 and guideline of Australia Transport Council (National Guideline for Transport System Management in Australia, 2006). It shows that the implied VOT values are about half of the values in the BSTM-MM and guideline. As such, the parameters for parking fee are adjusted from -0.973 and -0.570 to -0.487 and -0.285 for long term and short term parking[5] respectively, as shown in Table 2, increasing the implied VOT to the range consistent with the BSTM-MM v1.2 and guidelines.

The constant values for off-street and on-street parking suggest that car drivers prefer off-street to on-street parking with other things being equal. Adjustments of these constant values have been tested during the analysis of the initial model outcomes.

Table 2: Borrowed parameters for parking choice model

	UK study (Stephane 2004)		Adopted parameters	
	Commuting trips	Shopping trips	Long term parking	Short term parking
car leg travel costs (in minutes)	-0.051	-0.028	-0.051	-0.028
Searching time (in minutes)	-0.063	-0.059	-0.063	-0.059
Walking time (in minutes)	-0.093	-0.092	-0.093	-0.092
Parking fee ($/hour)[6]	-0.973	-0.570	-0.487	-0.285
constant – off-street	0.283	-0.091	0.283	-0.091
constant – on-street[7]	-2.763	-0.813	-2.763	-0.813

3.2.3. Limitation of initial model form

Initial model results show that the modelled on-street parking demand is significantly above the capacity, as illustrated in Figure 5 for the modelled parking occupancy to capacity ratio (occupancy ratio) in the CBD and CBD fringe within the CTA. The occupancy ratio reaches 2.50 within the CBD area, which is unlikely in the real world. When the demand approaches or exceeds the capacity, car drivers would choose other parking sites.

Figure 5: Modelled parking occupancy ratio for on-street parking
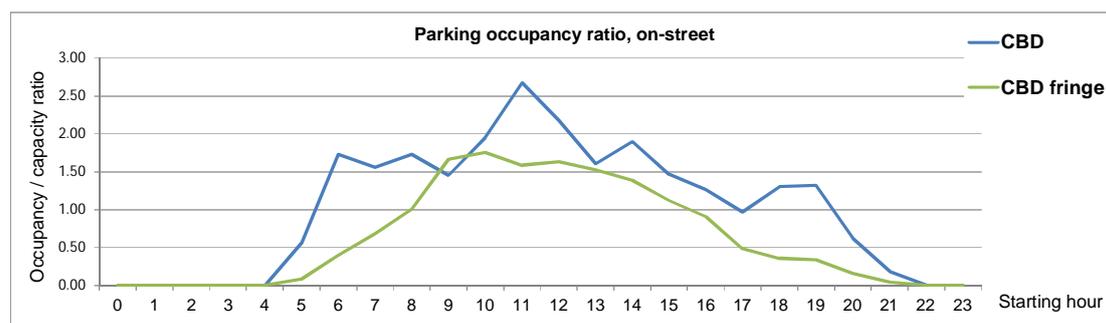
Adjustment of the constants for off-street parking has been tested to discourage on-street parking and mitigate the demand overflow. The original constant values for off-street parking

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[5] Parameters for commuting trips are applied for long term parking choice, and parameters for shopping trips are used for short term parking choice.
[6] The price unit in the UK model was pounds per hour. The parameter for the price factor is adjusted to be consistent with the value of time in Australia as explained in section 3.2.2.
[7] The same constant value is applied to the two types of on-street parking: on-street metered and on-street non-metered.

are -2.763 and -0.813 for long term and short term parking respectively. These have been increased (in absolute value) gradually to -4 and -2 and then to -5 and -3. However, the resultant decrease of off-street parking demand is minor, as illustrates in Figure 6, producing occupancy ratios that are still significantly and persistently above 1.0 within the CBD area. Although further increase of the constant values (in absolute value) may produce more realistic outcomes in term of parking occupancy ratios, this would undermine the model's responsiveness to the parking costs due to reduced sensitivity to explanatory factors. Therefore adjusting the constant parameters is not considered as an effective solution and the original constant parameters in Table 2 are retained.

Figure 6: Impact of adjusting on-street parking constants
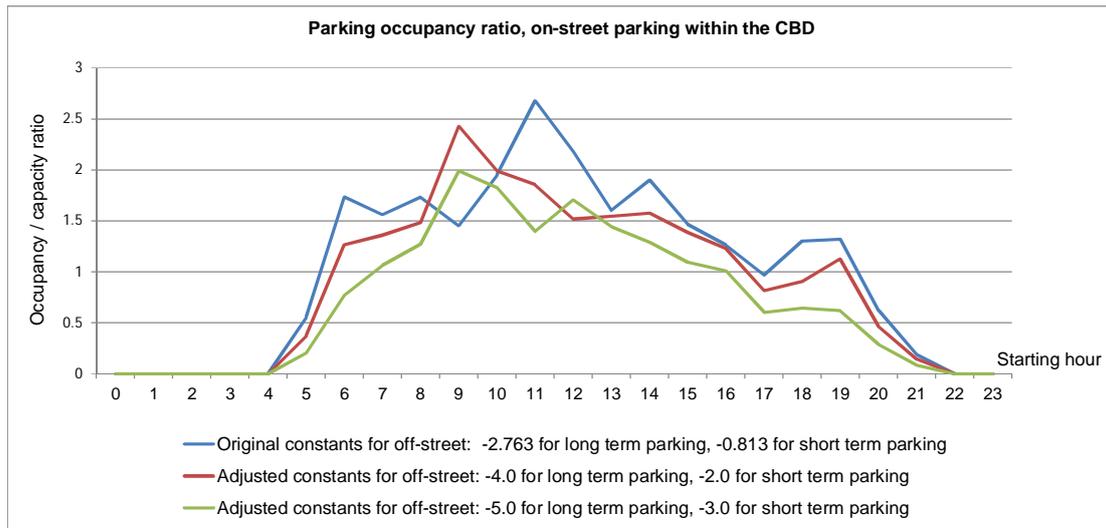
Another option for solving the excessive demand at off-street parking is to apply a more sensitive search time function, for example removing the cap of 15 minutes. However, in reality the extremely high searching times (say >15 minutes) may not occur, because drivers would have chosen other options in expectation of the low availability and high searching time. The impact of availability to drivers' choice leads to the introducing of a size variable to the logit choice formulation, described in the refined choice model form.

3.3 Refined choice model form

3.3.1 Use of size variable

We note that the information about parking availability (from everyday experience or use of technologies) is not reflected by the parking cost explicitly and sufficiently. For a given parking site, the car leg time, walk time and parking charge are fixed model inputs that are independent of the demand levels. Only the searching time can reflect availability, requiring very rapid increase in searching time when demand is near or above the capacity. However, extremely high searching times may not occur in the real world, as drivers exploit their prior knowledge of the location of available spaces.

Therefore a 'size variable'[8] is introduced. This variable includes the number of available spaces at each parking site, making under-utilised sites relatively more attractive than sites near capacity. The revised logit formulation is as below:

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[8] The term of 'size variable' is borrowed from the UK guideline (TAG Unit M5.1, 2014): "In order to reflect available parking spaces for each πa combination (i.e. combination of parking category π and location a), the relevant terms in the parking choice logit formulation may need to be multiplied by a 'size variable'."

$$P_c = \frac{SS_c \exp(U_c)}{\sum_{c' \in C}[SS_{c'} \times \exp(U_{c'})]}$$
<div align="right">Equation (3)</div>

Where: c = a parking site πk which is a combination of parking type π and parking zone k

C = choice set that includes all feasible parking sites, as discussed above

U = utility of choosing a parking site (an alternative)

SS_c = Number of available spaces at alternative c

This reduces occupancy ratios significantly at on-street parking sites, as illustrated in Figure 7. However, the occupancies in the CBD are well below capacity even during peak periods. This appears inconsistent with anecdote experience about high utilisation of on-street parking within the CBD area. We have solved this issue by undertaking parking choice at more aggregated sector level rather than at traffic zone level.

Figure 7: Modelled parking occupancy ratio for on-street parking, after including size variable
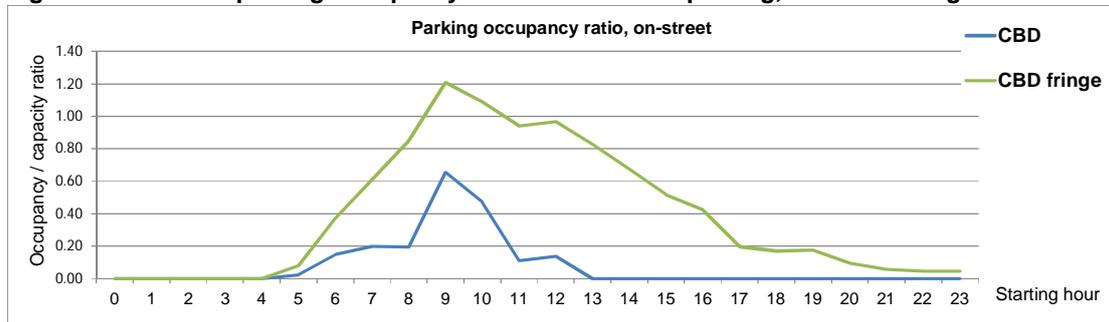

3.3.2 Choice at sector level

We note that the number of on-street parking spaces is significantly smaller than the number of off-street parking spaces. Within the CBD, many of the zones have less than 50 on-street parking spaces, whilst the number of off-street parking spaces is more than 1,000 in most of the zones. Moreover, within the same parking type, some zones have significantly smaller number of parking spaces than others due to their specific locations and/or smaller zone size. When the size information is included in the parking choice through Equation (3), the probability of choosing the parking sites of small size is reduced disproportionally.

Therefore we have adjusted the parking choice process so it is undertaken at a sector level. The parking spaces at the 68 traffic zones within the CTA are aggregated into 12 sectors[9], as illustrated in Figure 8, plus a sector representing parking outside the CTA[10]. The car drivers choose their parking location between these 13 sectors, rather than choosing between individual zones. The resultant parking demand for each sector is then

Figure 8: Parking sectors

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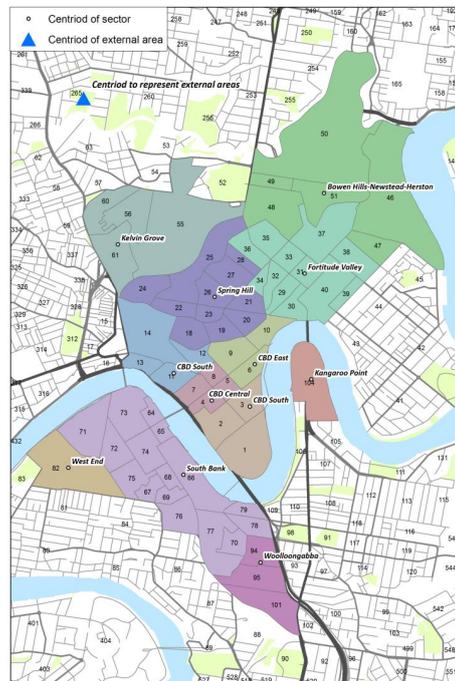
[9] The sector boundaries are generally aligned with suburb boundaries.
[10] The external parking site is unconstrained, serving as a last resort for parking when the parking sites within the CTA have been fully occupied.

distributed to individual traffic zones within the sector based on zonal parking spaces. This produces more reasonable on-street parking occupancy in particular within the CBD area, as shown in Figure 9.

Figure 9: Modelled parking occupancy ratio for on-street parking, after including size variable at sector level


4. Parking profile model

The choice model alone produces a static picture of parking demand at a given time of day. Replicating this picture across time of day is undertaken by the parking profile model. It requires modelling parking discharge that is essential for updating the number of available spaces, a key input for the choice by latter arrival trips.

4.1 Modelling of parking discharge

In the real world car drivers in their return journey walk back to the parking site that has been chosen upon arrival, and then drive from the parking site back to their trip origin. An ideal approach for modelling this behaviour is to trace each individual trip. As illustrated in Figure 10, this would ensure that the red trip returns to the site k1 when it is on its return journey, and the blue trip returns to k2, vacating parking spaces at right parking sites and at right times with appropriate increase in available parking space at each location k1 and k2.

Figure 10: Returning trips for parking discharge
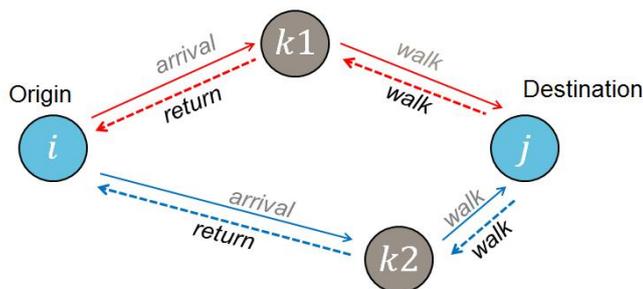
However, this approach is not feasible in the conventional strategic transport model like BSTM-MM v1.2, as trips are modelled aggregately and not individually. This means that, using the same example in Figure 10,

- the model treats the red and blue trip as two identical trips travelling from i to j. A proportion of the two trips choose to park at site k1, and others at site k2 according to the parking choice model.

- the model estimates, according to its time period component, that a proportion of the trips between i and j return during for instance the Inter-peak period, whilst others
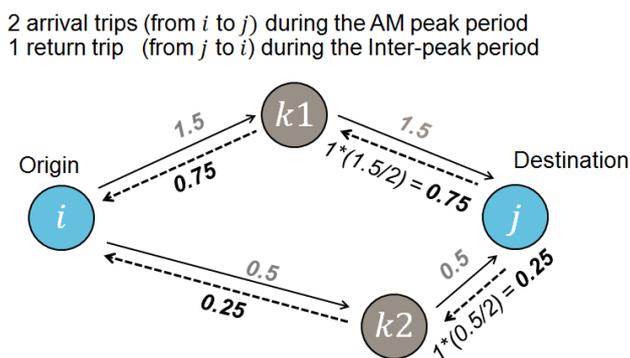
returning during the PM peak period. However, there is no information about the exact parking duration for individual trips.

Therefore an approximation approach has been developed, as illustrated through the example in Figure 11.

- Assume two trips arrive during the AM peak period, and according to the parking choice model 1.5 trips choose to park at site k1 and the remaining 0.5 at site k2. This produces 1.5 walk trips from k1 to j, and 0.5 walk trips from k2 to j.

- For the return trips during the Inter-peak period, estimate the proportion of returning to k1 and k2 based on the proportions in the mirrored walk trips. In this example the mirrored walk trips are 1.5 from j to k1, and 0.5 from j to k2, meaning that 75% of the return trips (i.e. 0.75 trips) are discharged from site k1, and the remaining 25% (0.25 trips) are discharged from site k2.

This process effectively utilises the time period information in the BSTM-MM v1.2 as an approximation of average parking duration. During the implementation of the parking profile model, this approximation is refined by disaggregating the four time periods[11] in the BSTM-MM v1.2 to each hour and every 15 minutes within each of peak hours.

Figure 11: An example for estimating parking discharge

2 arrival trips (from i to j) during the AM peak period
1 return trip (from j to i) during the Inter-peak period

4.2 Modelling of parking profile

The following process is applied to model the parking demand profile across time of day, replicating parking arrival and discharge in time sequence.

1) Consider first car driver trips that arrive between 5am and 6am. It is assumed that parking is closed between 11pm and 5am.

2) Prepare the size variable of each parking site at the beginning of the current period ($SS_{\pi k}^{p}$). For the first hour between 5am and 6am, set $SS_{\pi k}^{p}$ to parking capacity $C_{\pi k}$.

3) Prepare parking costs. For each parking site πk, calculate parking costs at parking type π and parking zone k, including car leg cost from origin i to parking zone k (T_{ik}), parking fee ($M_{\pi k}$), searching time ($S_{\pi k}$), and Walk time from parking zone k to trip destination j (W_{kj}).

4) Implement the parking choice model in Equation 3. Calculate utilities of parking at each parking site ($U_{\pi k}$) from the size variable and cost elements and calculate the probability ($P_{\pi k}^{ij}$) for arrival trips A_{ij} to choose each alternative πk.

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[11] These are AM peak period (7am to 9am), Inter peak period (9am to 4pm), PM peak period (4pm to 6pm) and Evening off-peak period (6pm to 7am).

5) Apply the probabilities to arrival trips A_{ij}, producing number of arrival car trips at each parking site ($A_{\pi k}^{p}$), number of car leg trips (A_{ik}^{p}), and number of walking trips (W_{kj}^{p}) from parking zone k to the final destination zone j during the current period.

6) Accumulate the 'stock' of the mirrored walk trips (W_{jk}^{p}) by the end of current period. For the first hour, W_{jk}^{p} equals the transpose of W_{kj}^{p}.

7) Implement the parking discharge approach. Allocate return trips during the current period from zone j (R_{ji}^{p}) to parking site ($R_{\pi k}^{p}$), based on the mirrored walk trips by the end of the current period (W_{jk}^{p}), producing the number of return walking trips R_{jk}^{p} and return car leg trips R_{ki}^{p}. Meanwhile, update the stock of mirrored walk trips W_{jk}^{p+1} for the next time period:

$$W_{jk}^{p+1} = W_{jk}^{p} - R_{jk}^{p}$$

8) Calculate occupancy to capacity ratio at each parking site:

$$O_{\pi k}^{p} = \frac{\sum_{p'=1}^{p} A_{\pi k}^{p'} - \sum_{p'=1}^{p} R_{\pi k}^{p'}}{C_{\pi k}}$$

Where $O_{\pi k}^{p}$ = parking occupancy ratio at the end of the current period p

$C_{\pi k}$ = parking capacity

$A_{\pi k}^{p'}$ = number of arrival car trips for each of current and previous periods

$R_{\pi k}^{p'}$ = number of return car trips for each of current and previous periods

9) Update the size variable for the next period:

$$SS_{\pi k}^{p+1} = C_{\pi k} \times (1 - O_{\pi k}^{p})$$

10) Continue to the next hour (6-7am, 7-8am, etc.), through step (2) to (9) until all the hours are processed. The last hour is 10pm to 11pm.

The hourly profile of arrival and return trips is derived from the time period component in the BSTM-MM v1.2 and the time information in the Household Travel Survey data. The daily car driver trips are first divided into the four broad time periods, based on the time period factors in BSTM-MM v1.2. Within each time period, the disaggregation to individual hours is based on factors calculated from the HTS data.

In the above process there is an explicit assumption that arrival trips occur at the beginning of each period and return trips at the end. This assumption tends to under-estimate available spaces, because in the real world arrival and departure trips occur throughout the period. To mitigate the impact of this approximation on the estimated parking availability, we have further disaggregated the peak hours within the AM and PM peak periods into 15-minute segments.

5. Model Outcomes

5.1 Parking demand

Figure 12 and Figure 13 illustrate the comparison between observed and modelled parking occupancy in the CBD and CBD fringe. The observed occupancy data are derived from HTS for off-street parking[12] and on-street non-metered parking, and from the parking meter datasets provided by Brisbane City Council for on-street metered parking. The model's performance illustrated by this comparison is indicative, given the limited sample size in the HTS data. More comprehensive quantitative measurement for the model performance requires additional data collection in future.

The comparison shows the observed volumes are generally well replicated. The on-street parking demand is considerably over-estimated, likely due to their lower parking charges given the monetary cost is a key element of the utility. Moreover, the scale of peak on-street parking demand is about 500 and 5,000 vehicles in CBD and CBD fringe respectively, significantly lower than the 20,000 and 35,000 vehicles for the off-street parking. This makes it more difficult to match the smaller demand for on-street parking.

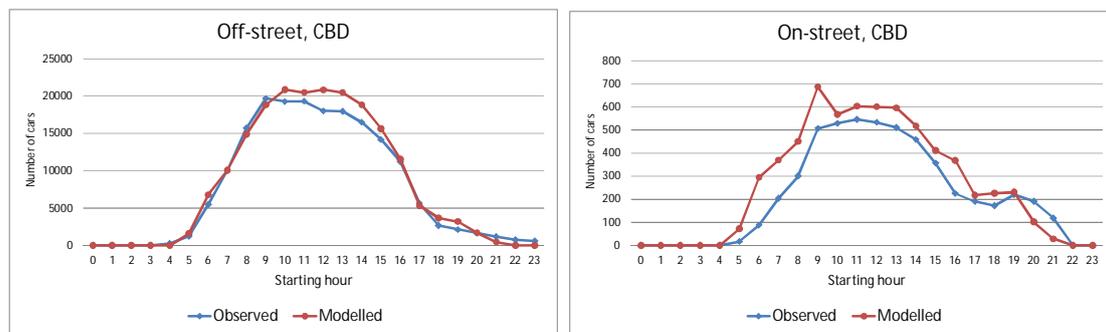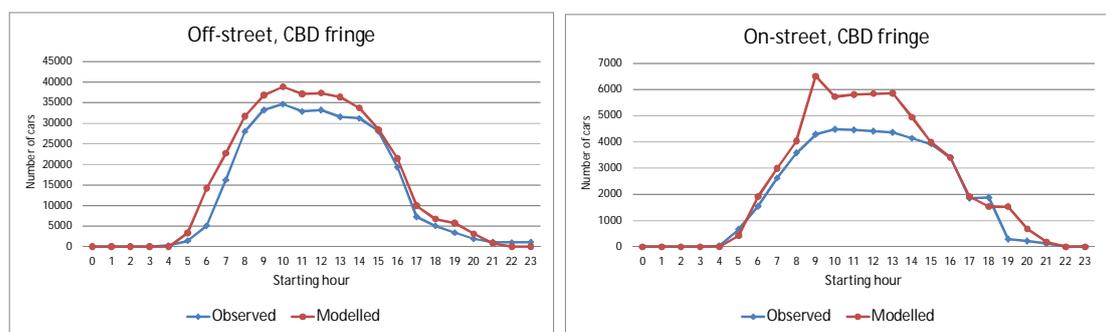**Figure 12: Comparison of observed and modelled occupancy, CBD**

Figure 13: Comparison of observed and modelled occupancy, CBD fringe

5.2 Model Responsiveness

Amongst the factors that affecting parking choice, the number of parking spaces (capacity) and parking charges need to be explicitly specified by model users. Other factors including car leg time, search time and car leg time are calculated by the model. Therefore we have

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[12] The off-street parking demand compared here includes private parking, because the use of private and public parking is not distinguished in the HTS data. Use of public off-street parking contributes to about 67% of parking demand at off-street parking sites within the CBD area according to the car parking model. The modelling of private parking demand does not involve remote parking behaviour and is discussed in a separate paper.

undertaken sensitivity tests focusing on the impact of varying parking capacity and charge on parking demand.

Table 3 presents the changes to off-street public parking demand in the CBD south sector, in response to the changes to parking capacity and charge at the same parking sites.

The parking demand changes are highly sensitive to the capacity changes, with elasticity being 0.78 and 0.91 for AM and daily long term parking respectively. Similar levels of elasticity are also produced by the model for the short term parking. This is due to the inclusion of the 'size variable' in the parking choice.

The parking demand changes are sensitive to the changes to parking charge during the AM peak, being around -0.4 and -1.3 for long and short term parking respectively. The short term parking is more sensitive because it is more abundant than long term parking, which makes the switch to other locations easier when faced with a parking charge increase in one area.

However, at daily level, the parking demand in the long term parking is insensitive to the increase of parking charge with an elasticity of -0.08. In the periods after the AM peak when most of the long term parking sites have been occupied, the arrival car drivers have little choice when faced with higher price but to park at the locations with available (vacant) spaces. Moreover, this is based on the fixed car driver demand in BSTM-MM v 1.2, as its destination and mode choice are not responsive to the increasing parking costs. It is expected that when the parking costs from the car parking model are incorporated in destination and mode choice for the BNE model, the sensitivity of daily parking demand will increase.

Table 3: Sensitivity test of parking demand, off-street public parking in the CBD south

Change to input	Period	Long term parking		Short term parking	
		demand change	Elasticity	demand change	Elasticity
Capacity + 20%	AM (before 9am)	16%	0.78	18%	0.89
	Daily (24 hours)	18%	0.91	17%	0.85
Price + 50%	AM (before 9am)	-22%	-0.43	-66%	-1.33
	Daily (24 hours)	-4%	-0.08	-43%	-0.87

5.3 Parking costs

Parking cost are key outputs from the car parking model. They are intended to be incorporated into destination and mode choice for the BNE model.

Figure 14 and Figure 15 present the average car leg time, searching time, walking time and parking charge for all the car drivers travelling from Logan Central to the CBD south across a weekday for commuting and other trip purposes respectively.

The average parking fee for the commuting trips is between 8 and 18 dollars, increasing from early morning toward 8am and dropping significantly after 6pm. Average parking fee for the non-commuting trips is between 5 and 13 dollars, with less significant variation across different periods.

Average walk time is generally between 5 and 15 mins for commuting trips, and between 10 and 20 mins for non-commuting trips. The largest walk time occurs between 8am and 4pm due to high parking occupancy in this period, and starts to decline after 4pm when car parks are gradually emptied.

The search time is between 1 and 4 mins for commuting trips, and between 1 and 3 mins for non-commuting trips, with small variation across different periods. This is due to limited demand overflow with the application of the size variable.

The car leg cost is close between the commuting and non-commuting trips, as they are skimmed from the same highway assignment. It is highest during the AM peak period between 7am and 9am, reflecting the traffic congestion in the peak direction toward the CBD.

Figure 14: Average parking costs for commuting trips from Logan Central to CBD south
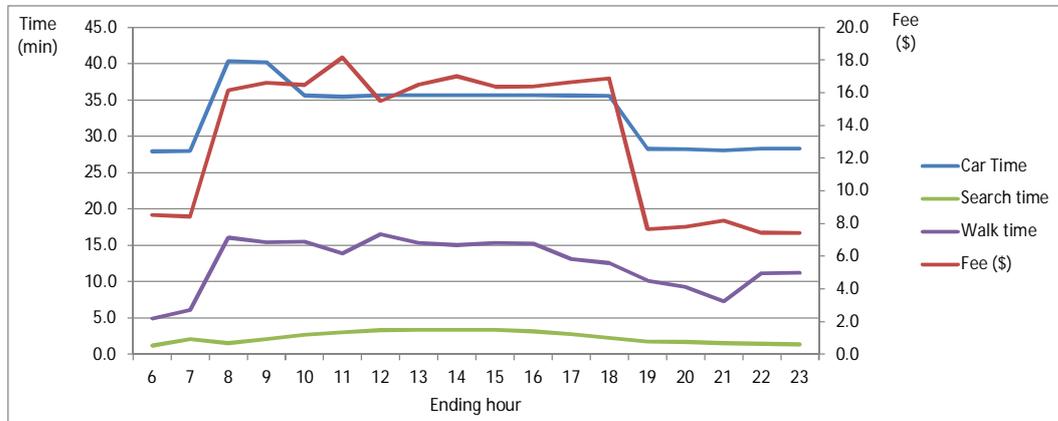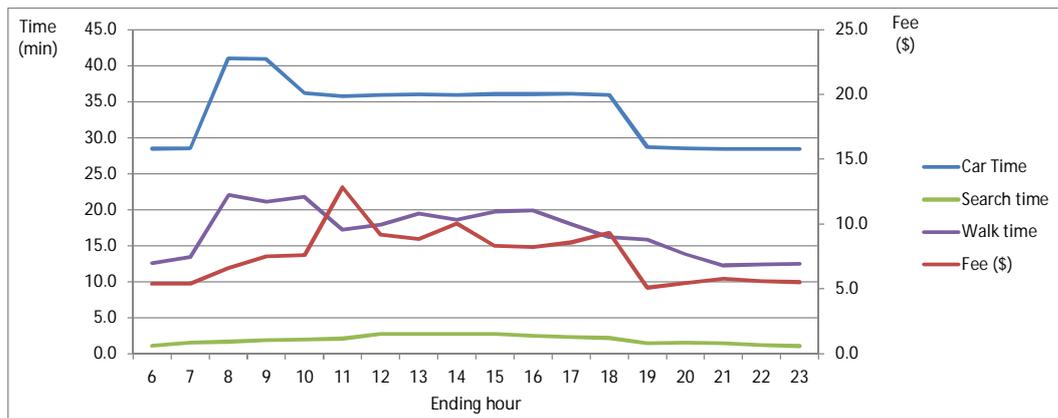

Figure 15: Average parking costs for non-commuting trips from Logan Central to CBD south

6. Conclusions and Further Development

The remote parking model described in this paper utilises trip based car driver demand that is readily available in many existing strategic transport models, without requiring a more complex, tour based specification. Moreover, the development of the parking choice model focuses on the adequacy of explanatory factors by introducing the size variable, which has a more fundamental impact on model performance than adjusting other parameters. The paper demonstrates a practical modelling approach to car-parking that can be fitted within the BSTM-MM v1.2, to produce parking occupancies in line with observed data, plausible responses to changes to key model inputs, and reasonable parking costs for car drivers travelling to Brisbane's city centre.

The parking model outcomes will inform the generation, distribution and mode choice of the new BNE model. This involves updating zoning system, reviewing and specifying supply module inputs, and more detailed examination of model outcomes. This work is currently undertaken by TMR.

Acknowledgements

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