travel modelling group

PARKING REPORT #1: Data

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Background

Parking supply (availability and cost) and demand (where drivers choose to park) are critical components of the travel demand modelling process; however, they are primitively modelled (if at all) in current regional travel demand models. In GTAModel, parking cost is included in the auto-drive mode utility function based on the average hourly weighted parking cost of the destination traffic zone for non-home-destined trips. The supply constraints are entirely ignored, as the model assumes that every driver can always find a parking spot at his/her destination and the walk time to/from the parking spot is neglected.¹ In GTAModel V4, a "soft supply constraint" is applied to the drive-access-transit mode where the disutility of the mode increases with the number of vehicles assigned to a given station parking lot. Nevertheless, the drivers are still allowed to park at the given lot even if the lot's capacity is full or exceeded.

Parking availability and cost, as well as the associated walking time, have significant impacts on travel decision-making,² and such influence is expected to become more critical in the coming years as new technologies (e.g., autonomous vehicles) and services (e.g., ride-hailing and ride-sharing) will provide different travel opportunities that may potentially change the role of parking. Therefore, a comprehensive and consistent database of parking supply is required to provide the foundation for parking modelling.

With the goal of improving the representation of parking in GTAModel, TMG has collaborated with its partner agencies to collect parking supply information and has assembled a comprehensive and accurate parking database for subsequent modelling. This report presents the final database of fall 2016 parking supply, which has been used in GTAModel V4.1.1 and will continue to be used for modelling parking in greater detail for GTAModel V4.2.

Challenges

One of the key reasons why parking modelling has been largely neglected in the regional models is the difficulty of collecting consistent and comprehensive parking data, as it needs to contain at least the locations, capacity and cost to be useful, and there is a wide range of parking supply options in the region (e.g., public vs. private, on-street vs. off-street, and various residential parking options at the home end). In GTAModel V4.1.0 and before, only the parking data from the City of Toronto and downtown Hamilton where included, as shown in Figure 1.

To achieve a region-wide parking database, TMG has contacted all its partners in regard to the available parking supply data. In the case of missing data, such as coordinates and capacities of the parking lots, Google Maps and Google Earth satellite images have been used to identify or verify the information. Alternatively, third-party websites have been used to determine the parking lot capacities, types, and rates (e.g., Parkopedia, Parkme).

¹ More technically, the average effect of walking to/from parking is incorporated in the model's mode-specific constants.

² Miller, E.J. "Central Area Mode Choice and Parking Demand", *Transportation Research Record* 1413, 1993, pp. 60-69.



Figure 1 Parking Supply Data Coverage for GTAModel V4.1

Database Coverage

The parking data collected to date are summarized in Table 1. By definition, the municipal parking lots are managed by local or regional municipalities while the private lots are operated by the licensed parking management companies. With regard to the types of parking, there are two categories: on-street and off-street (surface or garage). On-street parking is basically managed by municipalities, and off-street lots can be either municipal or private parking. In addition, the parking data of Toronto public parks and TTC subway commuter lots are also collected, although they are not included in the zonal average cost calculation, which is discussed later.

With respect to data availability, municipal off-street parking data are generally available across the region, while on-street parking data is only available for the cities of Toronto, Mississauga, and Brampton. In regard to availability of private parking lot data, it has to include at least the location, cost, type and licence holder information. The private lots that are designated to be used by particular visitors only (e.g., hospitals) are excluded from the zonal hourly cost calculation, though they are still included in the database.

Table 1 Parking Supply Database

Region	Local Municipality	Parking Agency				
Toronto		Municipal (On street)				
	Toronto	Municipal (Off street)				
	τοτοπιο	Public Parks				
		TTC Commuter Lots				
Hamilton	Hamilton	Municipal (Off street)				
	Hamilton	Private				
Durham	Oshawa	Municipal (Off street)				
	Clarington	Municipal (Off street)				
	Whitby	Municipal (Off street)				
	Pickering	Municipal (Off street)				
	Burlington	Municipal (Off street)				
Lieltere	Oakville	Municipal (Off street)				
пацон	Milton	Municipal (Off street)				
	Halton Hills	Municipal (Off street)				
	Mississauga	Municipal (On street)				
Peel	IVIISSISSauga	Municipal (Off street)				
		Municipal (On street)				
	Brampton	Private				
		Municipal (Off street)				
	Caledon	Municipal (Off street)				
York	York	Municipal (Off street)				

To visualize the spatial coverage of the database, a map of the zones with at least one entry of parking data available is illustrated in Figure 2. Further, the zoomed-in maps for each municipality are shown in Figure 3. As indicated by the maps, the parking database has covered most of the urban areas, yet many suburban and rural areas are still lacking parking information. It should be noted that the parking lots which are free to use are also included in the database and coverage maps; thus, the zones marked as no data available are actually the areas with no parking information. One of the reasons why many areas are lack parking information is because there is no residential parking data collected/available up to now, and this issue is expected to be solved in the next steps.



Figure 2 Coverage of the Collected Parking Data



a) Toronto



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Figure 3 Coverage of the Collected Parking Data (Zoom In)

Data Attributes

For each parking lot recorded in the database, there are several basic attributes, including XY coordinates, municipality, address, traffic zone ID, planning district ID, capacity, type, year, parking agency, and cost. The traffic zone ID is matched with the coordinates based on the 2006 zone system, and all the parking data are based on the year of 2016, except for Toronto on-street parking which is 2015.

For cost data, there are various types of parking rates across the region, as summarized in Table 2. Most parking lots allow for the hourly payment with the consideration of minimum and maximum thresholds. In addition to the hourly cost, there are also daily and nightly rates available. For example, the parking cost in the Toronto off-street lots has a daily maximum between 7am and 6pm and a nightly maximum from 6pm to 7am. Additionally, short-term parking rates (e.g., weekly and monthly permits) are available for specific locations.

Table 2 Types of Cost Attribute

Region	Local Municipality	Parking Agency	Min Rate	Max Rate	Hourly Rate	Daily Rate	Nightly Rate	Weekly Rate	Monthly Rate	Weekend Rate	
Toronto	Toronto	Municipal (On street)	Y		Y						
		Municipal (Off street)		Y	Y	Y	Y			Y	
		Parks				F	ree				
		TTC Lots				Y	Y				
Hamilton	Hamilton	Municipal (Off street)	Y		Y	Y			Y		
		Private	Y		Y	Y			Y		
Durham	Oshawa	Municipal (Off street)			Y	Y			Y		
	Clarington	Municipal (Off street)			3hr Free			Y	Y		
	Whitby	Municipal (Off street)			Y						
	Pickering	Municipal (Off street)	Free parking except for 1322 Bayly St								
Halton	Burlington	Municipal (Off street)							Y		
	Oakville	Municipal (Off street)	Y		Y						
	Milton	Municipal (Off street)	Free								
	Halton Hills	Municipal (Off street)	Free								
Peel	Mississauga	Municipal (On street)			Y	Y					
		Municipal (Off street)			Y	Y					
	Brampton	Municipal (On street)	Y		Y						
		Private	Y		Y	Y		Y	Y		
		Municipal (Off street)			Y (1 st hr Free)	Y					
	Caledon	Municipal (Off street)				F	ree				
York	York	Municipal (Off street)	Y		Y	Y					

Zonal Average Hourly Cost

As mentioned above, there are various types of parking rates in the GTHA. When calculating the average hourly cost for a zone, a posted hourly rate is used if it exists, or an estimated hourly rate is adopted if only daily or short-term parking permit is available.

A capacity-weighted average is used rather than the simple average in order to assign more importance to the large parking lots with more spaces.³ Special parking facilities, such as public parks, theme parks, TTC commuter lots, and hospitals, are excluded from the zonal average cost calculation because their parking lots are designated to be used by visitors/customers exclusively.

The capacity-weighted zonal average hourly cost is shown in Figure 4. As expected, the average parking cost in the downtown Toronto area is significantly higher than the suburban areas. The downtown Hamilton area also shows a relatively higher parking rate. Nonetheless, there are still many zones lacking information.



Figure 4 Average Hourly Cost Map

³ This also means that the average is the average cost per parking space rather than per parking lot.

To more accurately represent the destination parking cost and to accommodate the potential biases in the coordinates of parking lots, a buffer method is used as shown in Figure 5.



Figure 5 Buffer Calculation for Zonal Average Parking Cost

It is assumed that drivers may park at the parking lots in zones adjacent to the destination zone as long as the parking lot is within a reasonable walking distance. Thus, a buffer with a given distance is drafted around each zone, and the capacity-weighted average hourly parking rate is calculated based on the parking lots captured by the buffer zone. Three different buffers have been tested, including 500m (Figure 6), 800m (Figure 7), and 1km (Figure 8). It is recommended to use the 500m buffer, which is a common walking distance. As shown in the maps, the buffering procedure results in an increase of the database coverage and a decrease of the zonal average parking rate.



Figure 6 Zonal Average Parking Cost (500m Buffer)



Figure 7 Zonal Average Parking Cost (800m Buffer)



Figure 8 Zonal Average Parking Cost (1km Buffer)

Next Steps

The current database is lacking most private and all residential parking data. Therefore, a major next step is to collect the missing information and make the database as complete as possible. The private parking data is important for parking modelling due to the large number of private parking lots and their competition with public parking. If it proves impossible to collect efficiently private data for other regions, the correlation between private and public parking lots can be potentially examined based on the Hamilton parking data available.

Similarly, residential parking information is also important for parking modelling since it affects not only the home-end parking decisions but also household vehicle ownership. Residents can park on either part of their property (e.g., garage or front yard) or the street (with the latter usually requiring a parking permit). Although the residential parking permit has a relatively low price, the associated locations and permit holders are important information for modelling residential parking. Accordingly, the residential parking permits may be used to collect the residential parking data that is currently missing in the database.

In addition to the database improvement, TMG will propose recommended approaches to enhance the modelling of parking supply and demand within GTAModel (and other regional model systems), given the identified data availability and policy needs. As a start, TMG will look into the development of a new parking model to be integrated with GTAModel V4.2. This model will take into consideration information related to the parking behaviour such as per zone max rates and time of day. Furthermore, the access to free parking at workplaces in the GTAModel is currently based on the TTS database and modelled with population synthesis, which is expected to be improved by increasing the number of free parking data and enhancing the modelling algorithm.