ILLEGAL COMMERCIAL VEHICLE PARKING, PARKING DEMAND, AND THE BUILT ENVIRONMENT

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Introduction

In 2012, Commercial vehicles (CVs) incurred over $27 million in parking fines in the City of Toronto. These fines are a major contributor to the high costs associated with the last mile of the supply chain, and are passed on to consumers in the form of higher prices for final goods and services. Recent changes to City of Toronto bylaws, increasing the fine for illegal on-street parking during rush hour from $60 to $150, may drastically increase the cost of parking violations for CVs. Policy makers hope this increase will lead to a behavioural shift among CV operators, and reduce the incidence of illegal parking overall (City of Toronto, 2014). However, many CV operators accept parking fines as a cost of doing business and may be resistant to behavioural change (Haider, 2009). Illegal CV parking is also a major source of congestion. Han et al. estimated that illegal CV parking in urban areas results in 476 million vehicle-hours of delay each year in the United States, ranking third behind only construction and crashes (Han et al., 2005). Illegal CV parking can also cause unsafe road conditions for cyclists and other road users. When CVs park illegally on a roadway with a bike lane, the cyclist is forced to merge into the travel lane, a manoeuvre that can easily become dangerous for the cyclist. Toronto is now the fourth most populous city in North America, and one of the fastest growing. As of October 2013, over 147 skyscrapers were in development in Toronto. If illegal CV parking is left unaddressed, the fines, congestion, and safety issues caused by it will continue to grow.

A recent study by Kawamura et al. analysed illegal CV parking in Chicago, and identified several socioeconomic and land use factors that contributed to high densities of CV parking citations. Though the study did not include information on the supply of parking, it found that alleyways may reduce the incidence of illegal CV parking (Kawamura et al., 2014). A study in New York estimated the demand for and supply of parking in Manhattan, and found that many areas have CV occupancy rates well over 100%. This indicates a significant deficiency in the supply of CV parking facilities (Jaller, Holguín-Veras, & Hodge, 2013). Other studies have addressed the impacts of illegal CV parking on congestion and safety. Han et al. found that the congestion related costs of urban CV activity were about $10 billion annually across the United States (Han et al., 2005). Conway et al. found that in New York, 14% of CV curbside pick-up and delivery events resulted in potentially dangerous conflicts with cyclists (Conway et al., 2013). Potential solutions to urban CV parking problems have been proposed by several studies (Muñuzuri et al., 2005, Pivo et al., 2002, NYCDOT, 2004, FHWA, 2009, & Nourinejad et al., 2013). However, these solutions have yet to be widely applied in practice.

The main objective of this study is to investigate illegal CV parking in the Toronto CBD, with an attempt to identify the relationship between illegal CV parking and demand for parking within the context of the existing built environment. CV parking citation data for the City of Toronto is used to identify illegal CV parking in the downtown area. In addition, a freight trip generation (FTG) model is used to estimate the demand for CV parking in the CBD. The built environment is represented by a previously collected inventory of the downtown parking supply. A regression model is developed to identify the effects of these factors on illegal CV parking in downtown Toronto.

The paper is organized as follows: the next section describes the data used in this study, followed by a presentation and analysis of the model results. The paper concludes by summarizing key findings and identifying directions for future work.

Data

Parking Supply

Data on the supply of parking was initially collected in August 2010. A complete inventory was established for the Toronto Central Business District (CBD), an area located between Queen Street, John Street, Front Street, and Victoria Street (Figure 1). This inventory includes all on-street spaces, off-street surface lots, alleyway loading zones, loading bays, parking garages, and private garages. A more detailed description of the data collection can be found in (Kwok, 2010). The on-street portion of this inventory was updated in August 2013 to include detailed information on the timing of parking restrictions for on-street parking spaces. This work focuses on the time period between 4:00 and 6:00 PM. This period is selected over other times during the day for four reasons: parking regulations which limit the on-street parking supply are consistent within this period, many spaces are still being occupied by vehicles parked for the day, there is a high level of congestion on the network, and there is competition for the small number of available spaces between CVs and passenger vehicles during this period. Although fewer CVs are active during this period than during mid morning, the CVs that are active have few choices but to park illegally. Figure 1 shows the spatial distribution of CV accessible (i.e. on-street, loading bays, loading zones) spaces in the Toronto CBD.

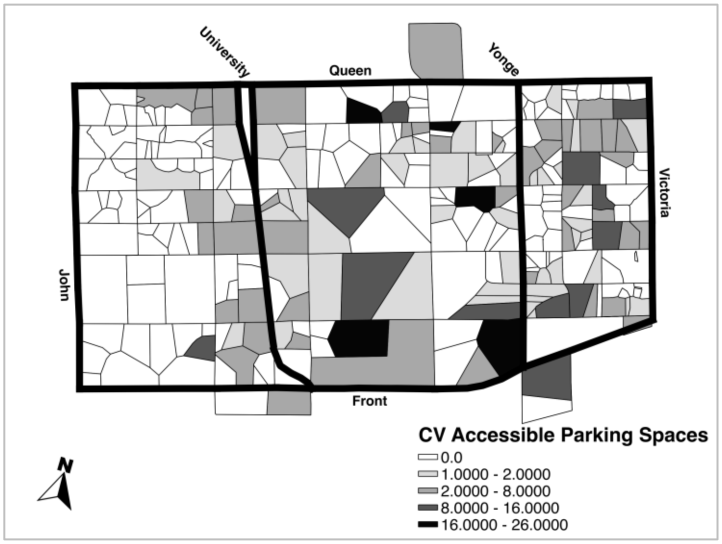

Figure 1: CV accessible parking supply between 4:00 and 6:00 PM

Parking Demand

Demand for parking is represented by freight trip generation models. FTG rates are calculated for each industry class, using the Standard Industrial Classification (SIC) system for segmentation. The models use parameters estimated in the Freight Trip Generation and Land Use Draft Handbook (NCFRP, 2014), produced as a part of National Cooperative Freight Research Program 25: Freight Trip Generation and Land Use Project. Parameters from the Quick Response Freight Manual (QRFM) are used for the industry classes that were not considered by NCFRP 25 (Cambridge Systematics, Inc, 1992). The establishment data needed for these models, employment, SIC code, and location, was obtained from an InfoCanada database of commercial establishments. Once the total daily number of freight trips was estimated for each establishment, the proportion of trips generated during the study time period was determined using cordon count data. It was found that 18% of daily CV trips occurred during the 4 – 6 PM time period. The trips generated by each establishment were then aggregated to the postal code level. Figure 2 shows the spatial distribution of FTG in the Toronto CBD.

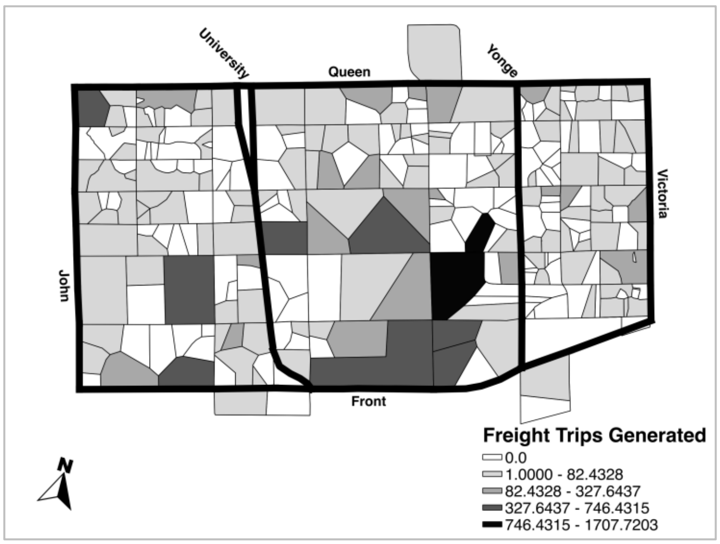

Figure 2: Freight trips generated between 4:00 and 6:00 PM

Parking Citations

The parking citation data used in this work is from the City of Toronto for 2012. Table 1 shows the distribution of infractions for 2012 CV parking citations. Three of the five most common infractions are parking, stopping, and standing during a prohibited time of day. Figure 3 shows CV parking citations by time of day. The distribution of CV activity generally matches the distribution of parking citations with somewhat less pronounced peaks in the mid-morning, noon, and afternoon peak periods. This indicates that CVs operating during peak periods are incurring a greater share of citations than CVs operating at off-peak times. Figure 4 shows the spatial distribution of CV parking citations in the Toronto CBD.

Table 1 – Most frequently incurred CV parking citations

Infraction	Citations	Percentage	Total Fines
PARK HWY PROHIBITED TIME/DAY	179,092	28.4%	$7,163,680
STOP HWY PROHIBITED TIME/DAY	83,256	13.2%	$4,995,360
PARK PROHIBITED TIME NO PERMIT	70,449	11.2%	$2,113,470
PARK FAIL TO DISPLAY RECEIPT	62,040	9.8%	$1,861,200
STD VEH HWY PROHIB TIME/DAY	46,078	7.3%	$2,764,680
PARK/LEAVE ON PRIVATE PROPERTY	41,554	6.6%	$1,246,620
PARK FAIL TO DEP. FEE MACHINE	35,979	5.7%	$1,079,370
PARK HWY OVER PERMITTED TIME	12,942	2.1%	$388,260
PARK OVER 3 HOURS	12,565	2.0%	$188,475
ALL OTHERS	86,325	13.7%	$5,814,260
Total	630,280	100.0%	$27,615,375

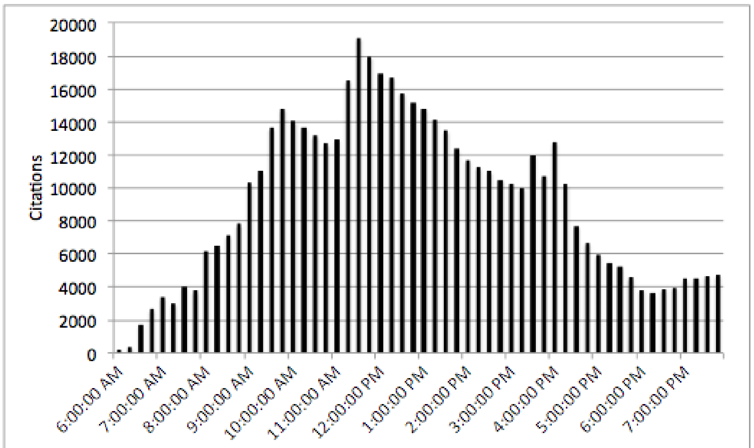

Figure 3: CV citations by time of day

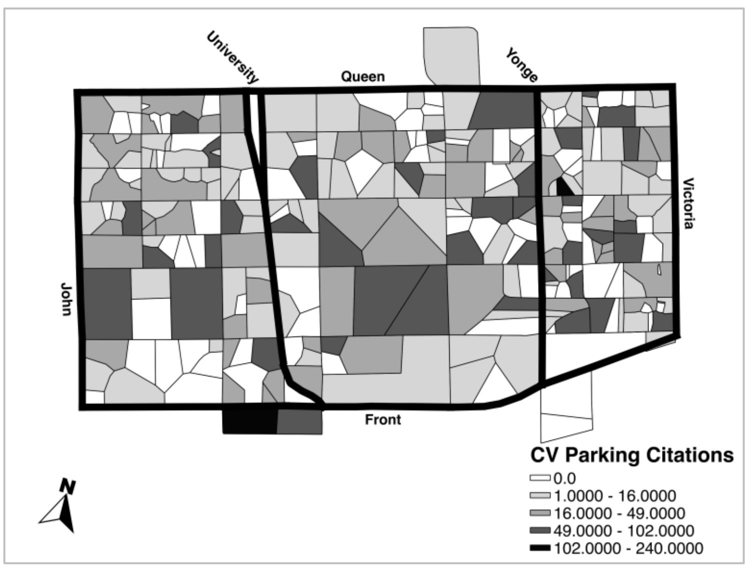

Figure 4: CV parking citations incurred between 4:00 and 6:00 PM

Results and Discussion

The analysis in this section examines the relationship between the number of CV tickets incurred in each area, the FTG by establishments in that area, and built environment factors represented by the parking supply using ordinary least squares regression. The dependent variable used in model was parking citation density, calculated as the number of citations in a zone divided by the length of roadway in a zone. Using a density value instead of the number of citations helps to control for variations in the size of the zones used in this analysis. Independent variables that were tested include:

- FTG
- FTG density
- Number of loading zone spaces
- Number of loading bay doors
- Number of on-street parking spaces
- Density of on-street parking spaces
- Number of on-street standing spaces
- Density of on-street standing spaces
- Number of surface lot spaces

The model is summarized in Table 2. The final model includes only parameters that are significant at the 95% confidence level, and achieved an adjusted *R*-squared value of 0.68. Variables relating to the supply of parking did not enter the model, as their coefficients were not found to be statistically significant. The positive coefficient of the FTG density term shows that CV parking citations increase as CV activity in the zone increases.

Table 2 - Linear regression model for CV parking citations

Observations		274
Adjusted *R*-squared		0.68
Dependent variable		Ticket Density
Independent Variables	Coefficient	*t*-Stat
FTG Density	1.73	24.71

A possible explanation as to why parking supply variables were found to have no impact on CV parking citations is that their impact is being masked by the zonal aggregation. As shown in Figure 5, CV operators commonly park very close to their delivery destination. When they are searching for parking, operators may only consider spots within a small area surrounding their destination. By aggregating the parking supply to zones, establishments generating freight trips may be grouped with parking spaces that CV operators never consider when making deliveries to that location. This problem is especially relevant when considering loading bays and loading zones. These facilities are privately owned, and serve only a single establishment. A large loading facility at one establishment should have very little impact on the incidence of illegal parking done by CV operators destined for an establishment next door with no such facilities. A second limitation of this model is that it does not consider passenger vehicles, which CVs must compete with for the limited supply of on-street space available.

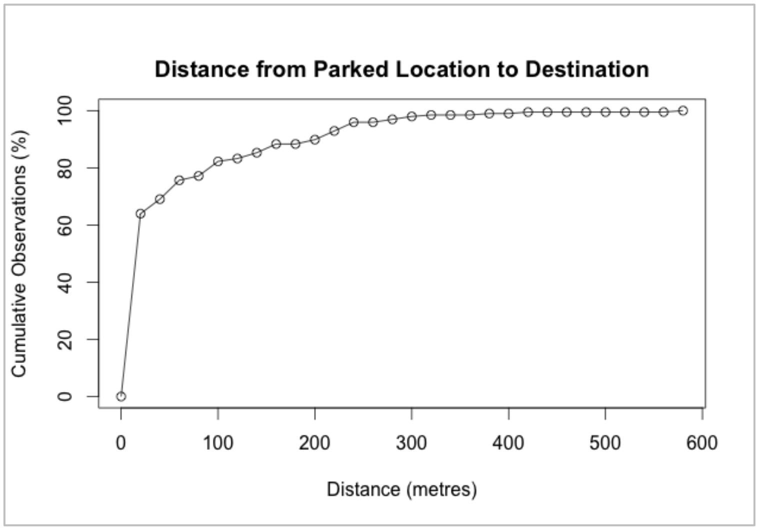

Figure 5: Cumulative plot of distance between parked location and delivery destination

Conclusion

The analyses performed in this paper have focused on the relationship between parking supply, parking demand, and illegal CV parking citations. Analysis of these factors using geographic information system tools did not reveal clear differences in their spatial distribution within the Toronto CBD. The regression model was able to find a statistically significant relationship between CV parking citations and FTG. The limited ability of these analyses to reveal the underlying relationships is thought to stem from the aggregation of these factors to the postal code level. Several improvements can be made to address the limitations of the presented model. First, these analyses should be performed at a more disaggregate level. It has been shown that CV operators are sensitive to distance between their parked location and their delivery destination. By disaggregating this analysis to the address level, this sensitivity to distance can be captured using distance-based accessibility measures. Second, as passenger vehicles occupy a significant portion of the parking supply at any given time, passenger vehicle parking demand should be added to account for the competition for spaces. Third, other facets of the built environment should be considered. For example, the number of lanes or the existence of a streetcar line on a road may have an influence the operation of that road that results in more or fewer parking citations. These improvements will be made in future work.

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