Analysis and Modelling of Truck Parking in Downtown Toronto

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Civil Engineering
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Cost, Congestion, and Conflict

- The “last mile” is the most expensive portion of the supply chain.
  - Commercial vehicles (CVs) in Toronto incurred over $27M in parking citations in 2012.

- Commercial vehicle (CV) parking is a major source of congestion in urban areas.
  - CV loading activities lead to over 476,000,000 vehicle-hours of delay every year in the US.
Cost, Congestion, and Conflict (cont.)

✦ Illegally parked CVs can result in safety issues for other road users.

> In NYC, 14% of curbside deliveries result in a conflict with a cyclist.

✦ The problems intensify as cities grow.
Research Questions

✦ Does the built environment have an impact on illegal parking?

✦ Are parking infractions occurring because of inadequate parking supply?

✦ Does increased supply reduce illegal parking?

✦ Can we simulate the process of parking search and evaluate parking policies?
Two Research Approaches

- Phase I - Parking Ticket Analysis
- Phase II - Integrated Traffic / Parking Simulation Model
Phase I - Parking Ticket Analysis Method

• Collect information on parking supply, parking demand, and parking citations
  ◦ Aggregate to postal code
  ◦ 4:00 — 6:00 PM

• Analyze spatial distribution of data to identify patterns

• Estimate regression models to quantify relationships
Study Area for Parking Ticket Analysis
Parking Supply

- Complete parking inventory of Toronto CBD
- Multiple categories
  - On-street
  - Surface lot & parking garage
  - Loading bay & loading zone
- Varies by time of day
  - Policy restrictions
  - Competition
Parking Demand

- Freight trip generation (FTG) model
  - Employment-based
  - Segmented by industry classification

- Parameters estimated for Greater Golden Horseshoe Commercial Vehicle Model

- Business establishment classification, location, and employment from InfoCanada
Parking Tickets

✝ Tickets for all vehicles available from City of Toronto Open Data

☞ FOI needed to identify commercial vehicles

✝ 630,280 CV tickets in Toronto

✝ Over $27M in fines
Freight Trips Generated (FTG)
CV Accessible Parking Spaces
CV Parking Tickets
Regression Model for CV Tickets

- Dependent variable: Parking ticket density
Regression Model for CV Tickets

✦ Independent variables:

- Freight Trips Generated (FTG)
- FTG density (FTG/road meter)
- 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
Phase I - Conclusions

- There is a link between Freight Trip Generation and illegal commercial vehicle parking
- It is unclear whether parking infractions occurring because of inadequate parking supply.
- It is unclear whether increased supply reduce illegal parking
- Aggregation of data may be masking effects
- Missing the effect of car/truck competition
Phase II – Traffic/Parking Simulation

- Looking at the process of ‘parking search’
  - 30% of vehicles cruising
- Parking choice model
- Microsimulation
- Compare alternative policies
- Useful tool for policy makers
Additional Data Collection
Driver Interviews

• 200 drivers interviewed
  • Short, multiple choice, and a few qualitative questions

• Information collected:
  • Parking location, facility type, arrival time, etc.
  • Delivery location, type of goods, total weight, etc.
  • Driver’s difficulties and experiences
Parking Choice Model

- Binary logit model

- Choice is a function of:
  - Availability of a spot
  - Suitability for truck parking
  - Distance from parking spot to destination
  - Facility type (e.g. loading bay vs street parking)

Diagram:
- Truck arrives at parking spot
- Select Spot
- Wait for better spot
# Parking Choice Model

$$P_i = \frac{e^{\beta x_i}}{1 + e^{\beta x_i}}$$

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>t-stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance to destination</td>
<td>-6.23E-03</td>
<td>-3.87</td>
</tr>
<tr>
<td>On street parking facility</td>
<td>-1.61</td>
<td>-4.11</td>
</tr>
<tr>
<td>Loading bay parking facility</td>
<td>2.21</td>
<td>2.09</td>
</tr>
<tr>
<td>Constant</td>
<td>2.12</td>
<td>6.09</td>
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</table>

**TABLE 1 Binary Choice Model for Freight Vehicle Parking Location**

- Log Likelihood: -84.35
- Pseudo $R$-squared: 0.3086
Traffic Simulation

• Software:
  • Paramics
  • car-by-car simulation

• Inputs:
  • Detailed road network
  • Parking facility type, location, and capacity
  • Truck and passenger vehicle demand matrices
Choice-Simulation Model Integration

- Vehicles are tracked when within 250 m of destination
Choice-Simulation Model Integration

- Tracked vehicles evaluate parking facilities using the binary choice model
Choice-Simulation Model Integration

- If no spot selected, vehicles cruise around the block and try again
Choice-Simulation Model Integration

- Once parked, vehicles dwell at the spot for a modelled dwell time and then depart.
Simulated Scenarios

Scenario 1:
Interior streets reserved for trucks
All trucks park on interior streets

Scenario 2
Interior streets reserved for trucks
Trucks may also park on other roads
## Simulation Results

<table>
<thead>
<tr>
<th></th>
<th>Search Time (minutes)</th>
<th>Walking Distance (metres)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Freight</td>
<td>Passenger</td>
</tr>
<tr>
<td>Mean</td>
<td>Mean</td>
<td>Mean</td>
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<tr>
<td>Base Case</td>
<td>1.87</td>
<td>1.50</td>
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<tr>
<td>Scenario 1</td>
<td>1.26</td>
<td>1.61</td>
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<tr>
<td>Scenario 2</td>
<td>1.01*</td>
<td>1.76</td>
</tr>
</tbody>
</table>

*: Values are significantly different from the base case at the 90% confidence level
Potential Solutions

- Space management
- Parking information
- Dynamic pricing
- Parking reservation
- Off-peak deliveries
Thank you

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