

Pilot Off-Peak Delivery Program in the Region of Peel

Final Report

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1. INTRODUCTION

Off-peak delivery (OPD) is the delivery of goods during the evening and overnight hours. This strategy has the potential to alleviate congestion during peak periods and increase utilization of existing transportation infrastructure capacity. It can also offer greater efficiency to delivery firms by potentially reducing costs for the shippers and the receivers.

The purpose of this project is to initiate an OPD pilot in the Region of Peel. Lessons learned during this pilot will encourage the long-term goal of implementing a full time OPD program in Peel in the future. Focus is placed on deliveries to areas in the Region of Peel where OPD is feasible and beneficial for participating firms. In contrast to other previously implemented OPD projects, this pilot focuses on deliveries in suburban areas. Lessons from the pilot are intended to inform how the Region of Peel and, more broadly, municipalities across the Greater Toronto and Hamilton Area can enable OPD. The desired outcomes are:

- 1) To reduce traffic congestion on corridors with high truck traffic volumes,
- 2) To provide firms and municipalities with a strategy to mitigate congestion, and improve goods movement efficiency,
- 3) To take lessons from the pilot to inform the scalability of OPD in Peel Region and in the Greater Toronto and Hamilton Area in the long term.

The project was initiated in January 2017, by the Smart Freight Centre (SFC) and the Region of Peel in collaboration with MRK Innovations and Partners in Project Green. The project received funding from The Atmospheric Fund, Region of Peel, Metrolinx and the University of Toronto. Deloitte Canada acted as an advisor on the project.

2. OBJECTIVES

The objectives of this pilot project are as follows:

- Identify and recruit firms that are interested in participating in the OPD pilot;
- Collaborate with participating firms to identify challenges to pilot OPD, develop strategies to respond to the challenges, and design customized business plans;
- Implement the OPD pilot to the selected stores from each participating business;
- Measure performance of OPD;
- Collect lessons learned for region-wide implementation of OPD.

The first of these objectives was achieved, through the efforts of the Region of Peel, Partners in Project Green and MRK Innovations. The remaining objectives were achieved by the Smart Freight Centre (led by University of Toronto) and the Region of Peel.

3. BACKGROUND REVIEW

3.1 Case Studies

A review of international case studies in OPD was conducted. These case studies were reviewed in order to get a better understanding of: a) the key benefits and challenges to expect in a pilot program, and b) the appropriate strategy for evaluation and benchmarking of results. A

tabulation of these case studies is provided in Appendix A. The case studies include applications in Sao Paulo, New York City, Denmark, Colombia, Stockholm, Barcelona, Orlando, Toronto, and London, UK. Appendix A categorizes the case studies in terms of the geographical location, time frame (year and duration), the scale of operations (number of shippers, carriers and receivers involved), performance measures used, strategies for recruitment, unique technologies employed and current status.

Experiences experienced world-wide indicate that a successful off-peak delivery program requires cooperation and communication between shippers, receivers and carriers, as well as a clear understanding of the benefits and challenges associated with delivering during off-peak hours. Benefits and challenges of off-peak deliveries are discussed in the following section. Performance measures identified in the case studies included travel time/speed, loading/unloading time, fuel consumption, air quality, noise, and participant experience.

3.2 Benefits and Challenges

Potential benefits of off-peak delivery include societal benefits to residents, as well as operational benefits to businesses. Both are important goals for the residents of Peel, since productive goods delivery improves the health of the regional economy, which leads to jobs and less expensive consumer products. A primary goal of off-peak deliveries is to reduce congestion during the day-time hours when traffic congestion is the greatest. Removing truck traffic during congested periods frees up roadway capacity during the day and potentially reduces travel times for commuters, including those using transit modes that operate in mixed traffic. Reduction of truck travel during the daytime also reduces air quality pollutants emitted at that time. Diesel engines in trucks disproportionately produce emissions of NO_x and particulate matter (PM) which have harmful health effects. Cyclists and pedestrians, who are more likely to be at the roadside during the daytime hours, could therefore experience positive health effects from a shift in truck travel to the evening or earlier morning. Reductions in truck idling and slower travel speeds in congestion are also expected to reduce the total emissions for the same number of deliveries. Reduced interactions between trucks, and vulnerable primarily daytime road users such as pedestrians and cyclists also have potential for improvement in safety.

For businesses, benefits of off-peak delivery can include faster travel time while travelling to and from customers and reduced unloading time during the delivery. Lower traffic levels are generally experienced during the overnight hours, leading to shorter travel time, higher travel speeds, less idle time, and fewer emissions. Holguin-Veras et al. (2014b) organized a pilot off-peak delivery project that moved the delivery schedules of 35 food delivery firms to off-peak hours. During the pilot, the trucks were monitored using GPS technology to track location and speed. A speed increase between the depot and first customer was observed, from 11.8 mph to 20.2 mph, while a smaller increase was found while traveling between subsequent customers. It was estimated that the delivery time during the pilot project was, on average, half of what would normally be experienced during the morning hours, when the majority of the deliveries would have taken place.

Making deliveries in urban areas can also be difficult due to the lack of proper truck parking. It is estimated that upwards of 96,000 additional vehicle kilometers are travelled every year on an average city block due to the search for parking by automobiles (Shoup, 2005). For commercial

vehicles, the additional parking search time is likely to have a significant impact on total tour time. In addition, the delivery of many types of goods requires parking near the delivery location. As a direct result of this, many commercial vehicles are forced to park illegally closer to their delivery location, resulting in parking tickets. Parking is typically easier to find in the off-peak.

Several studies have shown the potential of off-peak delivery in reducing truck emissions. Yannis, Golias, & Constantinos (2007) used a traffic simulation model to show improvements in overall traffic emissions by restricting truck movement during peak hours. Campbell (1995) generated analytical models which showed that emissions reductions were possible, but only under conditions where the average speed increased. For the case of Los Angeles, where there were night-time restrictions on truck movement in some areas, the increase in average speed is negated by the extra distance needed to travel to avoid the restricted areas. The Barcelona night-time delivery project showed the potential for reducing the number of trucks required to make deliveries. The project showed that seven smaller trucks which would normally make the daily deliveries could be replaced by two larger trucks, which would normally not be able to manoeuvre through downtown peak hour traffic (Chiffi, 2014).

The implementation of an off-peak delivery program requires addressing a number of challenges, including: receiver participation in the off-peak delivery program, noise restrictions when delivering near residential areas, and security issues associated with making deliveries at night.

Considerable research (Holguin-Veras et al. 2007a, 2007b, 2007c, 2014b) suggests that an important barrier to consider is receiver willingness or ability to accept off-peak delivery. Selection of participants for an off-peak delivery program should consider the ability of their receivers to accept off-peak deliveries.

Noise regulations and bylaws may restrict what activities may be done at night. Nighttime noise can generate opposition to off-peak delivery projects from members of the community (Holguin-Veras et al. 2014). Noise can come from moving products within the vehicle, loading and unloading the ramp, backup beepers as well as closing doors (Holguin-Veras et al. 2014). Wang et al. (2014) and Holguin-Veras et al. (2014a) suggest some possible solutions to reduce noise, including electric trucks, isolated and insulated refrigeration units, low noise lifts, 'quiet' truck beds or liners and driver training. In Barcelona delivery trucks were refurbished to include many of the low noise technologies. After this retrofit, noise caused by the delivery was shown to differ very little from ambient background noise (Chiffi, 2014). A pilot off-peak delivery project organized by Ontario's Ministry of Transportation (2014) monitored the noise levels of deliveries in downtown Toronto. The conclusions of the pilot project were that "background hum" of the urban environment was able to mask the sounds of the off-peak delivery, and that the noise produced in the residential areas was sufficiently low as to not bother the residents. No complaints were received during the pilot project from residents.

3.3 Off-Peak Delivery Methods

Assisted delivery is the most common delivery method for daytime deliveries. It involves having a person present in the receiving store to accept deliveries. Assisted delivery poses a barrier to OPD if the receiver does not otherwise maintain staff in the off-peak hours.

Different methods for unassisted delivery exist, depending on the type of product being delivered and the business setup. Delivery lockers or staging areas do not require direct access to the store (Holguin-Veras et al. 2013). Both methods require a space separate from the interior of the business premises where the delivery can be placed. The downside is that some products, like perishable goods, frozen items or high value goods require extra infrastructure that can be expensive. Virtual cages use a series of small sensors to monitor a small area of floor space in the store proper (Holguin-Veras, 2014d). Drivers are allowed access to this small area inside the store proper where they can leave the goods. The sensors are able to detect if the driver leaves the virtual cage and enters into restricted areas of the store. A driver may be given access to the store, either through the use of a key or electronic code (Holguin-Veras et al. 2013). This is less expensive than delivery lockers because no additional space or infrastructure is needed. However, trust between carrier/driver and receiver is required and security measures would have to be altered when drivers changed jobs.

4. OVERVIEW OF THE OPD PILOT IN THE REGION OF PEEL

Three firms participated in the off-peak delivery program over a six-month period from February 25 to August 31, 2019. These firms include LCBO, Loblaw Incorporated and Walmart Canada. These firms were recruited by MRK Innovations and Partners in Project Green. The three firms shifted delivery times at a total of 14 participating retail stores. The retail stores were selected, in collaboration with each firm and the Region of Peel, on the basis of their proximity to residential areas (selecting locations with lower potential neighbourhood impacts) and the expected operational benefits. The selected retail stores are shown in Figure 1. For the three firms, two distribution centres are located in the Region of Peel, one is located in London, Ontario and one in Cambridge, Ontario.

The local municipalities in Peel, which include the Cities of Brampton, Mississauga and the Town of Caledon, provided a blanket exemption from the noise by-laws to allow deliveries to be made in the evening for the duration of the pilot program.

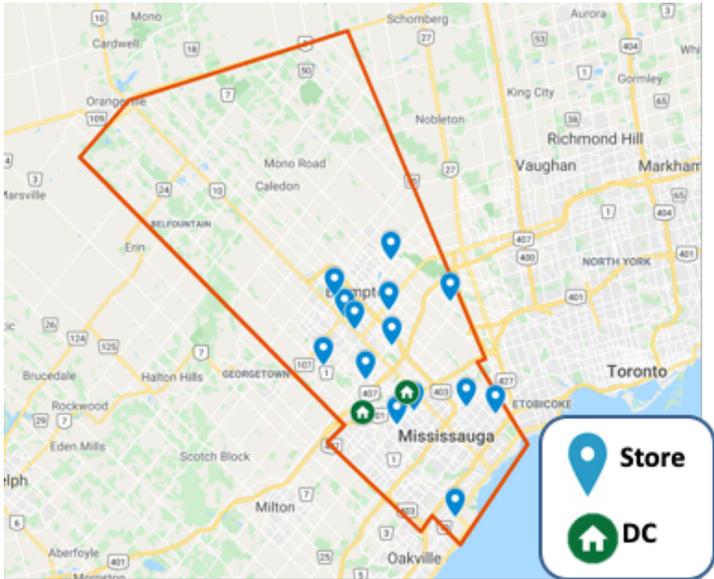


Figure 1 – OPD Retail Locations in the Region of Peel

5. DATA

The Smart Freight Centre (SFC) received truck tracking and other databases from each of the three participating firms for the duration of the six-month pilot period. The SFC:

- a) Developed a procedure to clean the data that were received, and to impute missing information;
- b) Processed the data to extract estimates of performance measures including travel speed, delivery service time, and vehicle emissions for each trip that has accessed the 14 participating retail centres;
- c) Summarized the differences between day-time (7:00am to 7:00pm) and off-peak (7:00pm to 7:00am) performance for each of these performance measures.

This section summarizes the methodology used to clean and process the data.

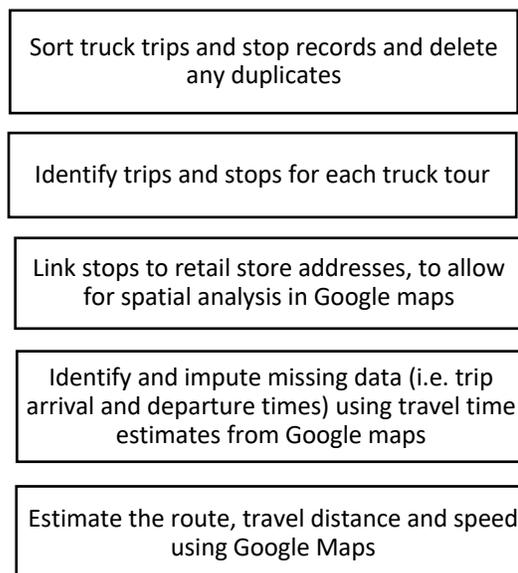
Data were received from each firm starting from end of February or early March, 2019 (depending on the firm) to August 31, 2019.

The data received from each participating firm included the following:

- Truck trip information (either provided as tracking information or trip summaries)
- Retail outlet (receiver) addresses
- Truck fleet attributes (including age and truck type)

5.1 Data Cleaning

Data received from each firm includes information about each stop within each tour (where a tour is defined as a sequence of consecutive trips starting at a depot, to other locations and back to the depot). The cleaned dataset included only those tours that originated from the firms' depot(s) and that accessed one of the pilot retail stores participating in the off-peak delivery program. Data management, data cleaning and processing were conducted using the Python Pandas Data Frame. The following steps were taken as part of data cleaning:



5.2 Data Processing

The following attributes are calculated for each stop and tour.

Based on GPS-based truck tracking information received from each participating firm,

1. Stop GPS service time: the difference between departure and arrival times for each stop;
2. Trip GPS travel time: the difference between the arrival time of the end stop and departure time of start stop;
3. Tour time: the difference between end time and start time of a tour (where available, in some cases the return to depot was not recorded);
4. Tour GPS service time: the sum of service time for all stops in a tour;
5. Tour GPS travel time: the sum of GPS travel times for all trips on a tour;

Google maps was used to supplement the GPS data where concern arose due to GPS inaccuracies, as follows:

6. Trip Google Map travel time: travel time between two stops estimated using Google Map;
7. Trip Google Map distance: the trip distance between two stops estimated using Google Map;
8. Tour Google Map travel time: the sum of Google Map travel times for all trips on a tour;
9. Tour Google Map service time: calculated by subtracting tour Google Map travel time from GPS tour time;
10. Stop Adjusted Service Time: This is an adjusted stop GPS service time, where the GPS service time is adjusted by a factor that is equal to the division of tour Google Map service time by tour GPS service time.

Emissions: Five emission measurements, including GHG, CO, NO_x, PM₁₀, and PM_{2.5} are calculated from MOVES based on trip speed, distance, vehicle type, and vehicle age. MOVES (Motor Vehicle Emission Simulator) is the US Environmental Protection Agency's emissions modelling system for mobile sources (<https://www.epa.gov/moves>).

6. RESULTS

Table 1 shows the percentage of off-peak stops for the pilot retail stores. Overall, during the pilot, 1599 stops at participating retail stores were made in the off-peak hours, which represented 30.1% of total stops to those stores.

Table 1 - Percentage of off-peak stops for pilot retail stores

Month	Number of day-time (7:00am to 7:00pm) stops at pilot stores	Number of off-peak (7:00pm to 7:00am) stops at pilot stores	Percentage of stops in the off-peak (7:00pm to 7:00am)
March 2019	591	234	28.4%
April 2019	601	259	30.1%
May 2019	602	283	32.0%
June 2019	638	292	31.4%
July 2019	660	253	27.7%
August 2019	622	278	30.9%
March to August 2019	3714	1599	30.1%

Performance measures include average speed, emission factors, average service time, and noise. These performance measures are summarized separately for trips that are performed in the day-time period (7:00am to 7:00pm) and in the off-peak period (7:00pm to 7:00am). In summary, in the off-peak period, average speed improved by 18.1%, emissions reduced by 10.6% to 15.0%, average service time increased by 11 minutes, and no noise complaints were submitted.

6.1 Average Speed

Average speed is calculated as an indicator of travel times. Average speed is a preferred indicator over travel times because truck routes and travel times selected from day-to-day vary as a result of dynamic routing of the participating firms, which would pose difficulties in the comparison. The average speed is based on the trips from participating firms' depots to the pilot retail stores, which is a reasonable indicator of the average speeds experienced in the Region of Peel. These trips are extracted after data cleaning from the provided data.

Table 2 presents a summary of the average speed for day-time and off-peak hours. The average speed is weighted based on the trip length. Table 2 shows a higher average speed in off-peak hours compared to day-time hours. For instance, in July 2019, the average speed of the trips in the off-peak hours is 19.8% faster than those that happened in peak hours. Overall, the average speed is 18.1% higher in the off-peak hours than in the day-time hours.

Table 2 - Average speed for day-time and off-peak deliveries

Month	Day-time (7:00am to 7:00pm)		Off-peak (7:00pm to 7:00am)		Percentage increase in average speed in off-peak hours
	Number of trips	Average Speed (weighted by trip km) (km/h)	Number of trips	Average Speed (weighted by trip km) (km/h)	
March 2019	529	45.2	131	53.7	18.8%
April 2019	548	46.6	154	54.9	17.6%
May 2019	539	45.6	173	54.3	19.1%
June 2019	616	46.2	176	55.2	19.5%
July 2019	609	46.0	137	55.1	19.8%
August 2019	564	46.3	180	52.6	13.5%
March to August 2019	3405	46.0	951	54.3	18.1%

6.2 Emissions

Five emission estimates, including GHG, CO, NO_x, PM₁₀, and PM_{2.5} were determined from MOVES based on trip speed, distance, vehicle type, and vehicle age. The average age of the truck fleet is considered for all trips instead of vehicle age specific to each trip due to lack of data on specific vehicles used for each trip. This average age is one to two years based on the data provided by each participating firm. Table 3 provides average emission factors (weighted by trip kilometres) for the five emissions for day-time and off-peak. Improvements in GHG emissions averaged at 10.6% for trips made in the off-peak. Reductions in air quality pollutants, including CO, NO_x, PM₁₀ and PM_{2.5} ranged from 10.8% to 15.0%

Table 3 - Emission factors for GHG and air quality pollutants in day-time and off-peak

Month	Day-time Emission Factors (grams/km) (7:00am to 7:00pm)					Off-Peak Emission Factors (grams/km) (7:00am to 7:00pm)				
	GHG	CO	NO _x	PM10	PM2.5	GHG	CO	NO _x	PM10	PM2.5
March 2019	1253	0.250	0.842	0.019	0.018	1125	0.223	0.749	0.017	0.016
April 2019	1245	0.249	0.837	0.020	0.018	1111	0.222	0.743	0.017	0.015
May 2019	1252	0.251	0.844	0.020	0.018	1121	0.222	0.748	0.017	0.015
June 2019	1255	0.250	0.842	0.020	0.018	1106	0.221	0.739	0.017	0.015
July 2019	1255	0.250	0.843	0.020	0.018	1113	0.221	0.744	0.017	0.016
August 2019	1252	0.251	0.844	0.020	0.018	1137	0.227	0.761	0.018	0.016
March to August 2019	1252	0.250	0.842	0.020	0.018	1119	0.223	0.747	0.017	0.016
% lower than day-time						-10.6%	-10.8%	-11.3%	-15.0%	-11.1%

6.3 Service Time

Average service time is assessed at each pilot retail store as the first element of performance measurement. For two firms the Stop GPS service time is selected and for the third firm, the stop adjusted service time is chosen. Stop adjusted service time is chosen for this firm because the accuracy of service times based on GPS data alone was considered to be insufficiently precise, therefore requiring adjustment.

Table 4 provides the summary of average service times for the 14 pilot retail stores in the day-time (7:00am to 7:00pm) and off-peak hours (7:00pm to 7:00am), after data cleaning. For instance, in March 2019, average service time in day-time hours is equal to 74 minutes based on 591 observations. Table 4 shows average service time in off-peak hours compared to the day-time. Significant variance was found in service times. For some firms the service times increased in the off-peak hours, while for others the service time decreased, though on average, stop time increased. Discussions with logistics staff indicated that there were a variety of logistical reasons for delays in the off-peak.

Table 4 - Average stop time for day-time and off-peak hours for the pilot stores

Month	Day-time (7:00am to 7:00pm)		Off-peak (7:00pm to 7:00am)	
	Number of truck stops at the pilot stores	Average stop time (minutes)	Number of truck stops at the pilot stores	Average stop time (minutes)
March 2019	591	74	234	93
April 2019	601	75	259	85
May 2019	602	74	283	73
June 2019	638	67	292	91
July 2019	660	69	253	76
August 2019	622	71	278	81
March to August 2019	3714	72	1599	83

6.4 Noise

Residents were informed of the off-peak delivery pilot via the Region of Peel website and social media at the outset of the pilot. No noise complaints were submitted over the course of the off-peak delivery pilot.

7. LESSONS LEARNED

Post-pilot interviews were conducted with the logistics managers from LCBO, Loblaw Incorporated and Walmart Canada that were most familiar with the OPD pilot. The purpose of the interviews was to learn about challenges, successes, and ways that the pilot program could be improved. The post-pilot interview questions are shown in Appendix B.

7.1 Overall Experience

First, the companies were asked about the challenges/barriers to OPD. Few challenges were expressed, rather, all three firms identified that the OPD pilot was beneficial, and in one case, complaints were received from the retail stores about returning to the original schedule when the pilot ended. Since the companies involved in the pilot program were large, major changes in routing procedures were not needed to accommodate the adjustment to the off-peak for the limited number of participating retail stores.

Part of the success of the program was related to the careful selection of retail stores. First, retail stores were selected in locations that were not remote, therefore routing to multiple retail stores was facilitated, which was considered by one firm to be more cost effective than engaging in OPD for a single remote retail store. Second, retail stores were successfully chosen to avoid complaints from neighbouring residents. While all firms were concerned with the potential for noise complaints, none were received. Third, some advantages were attributed to OPD in terms of staffing, store preparation and shelf stocking. One firm pointed out that deliveries could be made at a time that facilitated store preparation prior to opening time. Finally, it was noted by one firm that the truck / trailer assets could be better utilized, because the same vehicle could make a trip during the day and then another trip in the evening.

7.2 Logistics Costs

No additional logistics costs were identified by the participating firms as a result of the OPD pilot. The project team was concerned in particular about any additional staffing costs for the retail stores or distribution centres for increased off-peak activity. None of the three participating firms identified any additional staffing costs. One firm pointed out that the distribution centres ran overnight shifts even before the pilot started so there were no incremental changes. Another pointed out that some of the cost savings associated with faster travel speeds were mostly experienced by the carrier, who was under a fixed contract, though in the longer-term this could lead to lower costs to the stores. The only additional costs that were anticipated would be with the retail stores, which could incur additional staffing costs for an overnight crew, however, the pilot retail stores did not incur these costs because their current staffing systems could accommodate the OPD. Expansion of the program to include retail stores without after hours staffing could lead to additional costs. One firm pointed out that the existing staff could be used more productively due to the off-peak timing of the shipments.

7.3 Driver Experience

One concern of the project team was about the driver/carrier experience. Two of the firms engaged their outsourced carriers in the OPD program and one firm used their own fleet of drivers. Those that outsourced their transportation identified that the carriers would likely prefer to make deliveries during off-peak hours because they are payed by the kilometer, or by the shipment, and therefore would financially benefit from faster travel speeds. For own-account transportation, no specific preference was identified, rather it was pointed out that individual drivers have mixed preferences of the time of day they prefer to work.

7.4 Distribution Centre Experience

It was noted by one firm that some benefits were experienced at a distribution centre because it was possible to spread out the work-load to avoid bottlenecks. Another firm pointed out that, since the pilot program was relatively small, there may have been efficiency gains that were not noticeable given the scale of operations of the firm.

7.5 Retail Store Experience

The experience at the retail stores was generally positive. One firm pointed out that the store presentation could be better in the morning because more time was available for retail staff to set up the store before opening. Other firms noted the importance of preparation time. If an OPD schedule can be organized with enough advance notice, then staffing and space in the backroom could be arranged to handle the deliveries. The only additional concern that was raised was that for some retail outlets the parking lots were busier in the evening with customers, which could be more difficult for the drivers to navigate. Therefore, evening deliveries would be better suited for retail stores with loading bays. The biggest advantage noted from the retail store perspective was the predictability of shipments. One firm noted that the deliveries arrived within minutes of the expected arrival time, when made in the off-peak hours. Predictable delivery times were found to be helpful with staffing.

7.6 Safety, Security and Noise

No concerns were raised about any safety or security issues associated with OPD. All participating firms pointed out that drivers are trained to operate safely, and their loading docks are well-lit. It was noted by one firm that security was not an issue because stores were not located in isolated locations. All three participating firms confirmed that no noise complaints were made to the companies as a result of the OPD pilot.

7.7 Congestion at the Retail Stores

Logistics managers were asked about congestion at the retail locations in the off-peak. While it was noted that there are more customers in the evening hours, there was some diversity amongst firms about the how busy staff were in the evening. One firm noted that there is less congestion in the delivery bays in the evening, because most other carriers deliver during the day and pointed out that OPD allowed for a spreading of the receiving workload over the course of the day and easier management of space in the backroom. Another firm suggested that retail staff may be busier in the evening, and some conflicts happened with other carriers at that time.

7.8 Expansion of the OPD Program

All participating firms enthusiastically supported the continuation and expansion of the OPD program. Substantial expansion of the program to new retail stores was advocated by all three firms. Some limitation on which retail stores could participate were related to a) remoteness of stores (easier to deliver off-peak to stores that are not isolated), and b) stores that already had staff assigned to work in the off-peak. All three firms felt that the pilot was run effectively, and proposed few changes for expansion of the program. One suggestion was to include delivery arrival time predictability as an additional performance measure.

8. CONCLUSIONS

Three firms participated in the off-peak delivery pilot in the Region of Peel: LCBO, Loblaw Incorporated and Walmart Canada, involving deliveries to 14 pilot retail stores. The analysis shows that during the six-month pilot, from March to August 2019, 30.1% of deliveries to pilot retail stores were made in off-peak hours (7:00pm to 7:00am). The average speed of the trips that were made in off-peak hours during the six-month pilot is 18.1% faster than those that happened in day-time hours. Having higher speed in off-peak hours leads to lower emission factors. The total greenhouse gas emissions/km decreased by 10.6%, and emissions factors for air quality pollutants, including CO, NO_x, PM₁₀ and PM_{2.5} reduced by 10.8% to 15.0%. Results for service times varied between firms, but on average increased by 15.2%, indicating activities in the off-peak hours at the retail stores that prevented overall improvements in service time compared to day-time deliveries. Interviews with logistics managers identified that some delivery activities took longer for one company in the off-peak hours, in part because there was potentially busier staff at that time of day.

The pilot off-peak delivery program is considered to be a success. From a public policy perspective, the movement of delivery vehicles to times of day when congestion is lower makes better use of available roadway capacity and reduces congestion for other road users during the peak travel time. Increases in commercial vehicle travel speed leads to lower emission factors which benefits public health and helps reduce the regional contributions to GHG emissions. If any additional noise occurred as a result of the OPD pilot program, it was not enough to result in any noise-related complaints. From a business perspective, the improvements in travel speed reduce logistics cost and improve fuel efficiency and therefore enhance the business competitiveness of participating firms.

All three participating firms enthusiastically supported the continuation and expansion of the OPD program and expressed strong willingness to continue participation. All of the participating firms considered the program to be well-organized and well-run and proposed few suggested changes, aside from the program's expansion. Given the success of the Region of Peel OPD pilot, efforts are currently underway to develop a program to expand the Region of Peel pilot to encompass other municipalities in the Greater Toronto and Hamilton Area and to expand the number of firms involved in the program.

9. ACKNOWLEDGEMENTS

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Appendix A: Summary of Off-Peak Delivery Projects:

Location, Year	# of Carriers/ Shippers	# of Receivers	Duration ¹	Performance Measures	Strategy	Technologies used	Status of the Study	References
Sao Paulo, (FIFA), 2014	1 carrier (DHL) 1 shipper	2 retail outlets	2 weeks	- Speed (travel time) - Productivity (Unloading time) - Safety/Security risks (qualitative) - Noise complaints	- Staffed OPD - No cash incentive	Not mentioned	Project continued to second phase (next row)	Bertazzo et al, (2016)
Sao Paulo, 2014-15	Carrier: SETCESP syndicate	11 firms with 45 retail stores	12 weeks October 2014 - April 2015	- Speed - Productivity - Safety (incidents from Police data) - Noise (complaints and measurements)	- Staffed and unstaffed OPD - No cash incentive	- Shadowing (measuring noise) - Armed escort in 2 cases - Truck GPS	- OPD a City policy - Entire city implementation planned for 2016 - 16 large firms, 9 new	Yoshizaki & Barbieri Da Cunha (2016)
New York City, 2009	20 trucks (8 vendors)	35 receivers	3 stages (each 1 month)	- Speed/service time - Survey satisfaction	- Staffed (50%) and unstaffed (50%) - Cash incentives (\$2000/receiver and \$300/truck to carriers)	- GPS enable smartphones - Network models to assess to network wide impacts - Follow-up survey	- Continued to second phase (next row) - 50% (unstaffed) remained with OPD	Holguin-Veras et al. (2014b)
New York City, 2013		400 receivers	Unknown	- Speed/service time - Survey satisfaction - Noise		- Low noise trucks/equipment - Noise monitoring	- 175-200 companies have shifted to OPD	Holguin-Veras et al. (2014b)
Denmark (Copenhagen), 2012-13	7 carriers	Unknown	Unknown	- Speed - Fuel consumption (data was provided by the companies)	- No cash incentives		- Most companies were happy to have participated. - 2 decided to continue OPD	Kolstrup & Frank (2016)
Colombia, 2015	17		8 weeks	- Cost - Time - Logistics - Environment	- Workshops - Letters - Scheduled one on one meetings	Use of GPS data loggers - Truck GPS	- 5 firms (mostly supermarkets) are continuing with OPD.	Zambrano, et al. (2016)

¹ This duration does not include the preparation time (survey, outreach, etc.). It only reflects the duration of the pilot.

				- Safety	- Air quality measurements	- Air emissions sensors - Noise monitoring		
Stockholm, 2014	1 shipper 1 carrier with 2 trucks (1 hybrid, 1 biogas)	~ 30 restaurants and hotels in downtown Stockholm	2 years (including preparation)	- Driving efficiency - Delivery reliability - Energy efficiency - Service efficiency - Noise complaints - Route efficiency - Post surveys		- Trucks equipped with noise monitor - GPS data - Fuel level measurement	- OPD was extended for this carrier. - Noise, cost benefit analysis is on-going	Koutoulas et al. (2017)
Barcelona, 2003	One supermarket chain - 2 large trucks for OPD replacing 7 vans	2 supermarket locations	11 am-12 am & 5-6 AM For 4 months	- Noise measurements - Noise complaints	- Staffed delivery - No financial incentives - Use of larger trucks	- Noise monitor (Police)	- By 2010, the supermarket chain has expanded OPD to over 407 store locations across Spain. - Other supermarkets have considered OPD	Labelle and Frève (2016)
Orlando, FL	1 shipper: Orlando health	1 receiver: Central Florida hospital	9 months	- Air quality - Congestion - Walkability on campus and in the neighbourhood				LaBelle and Frève (2016)
Ontario, 2014 (Downtown Toronto)	5 carriers	Over 30 receivers	4 weeks	- Noise - Travel time - Participant experience	- No incentives		The downtown pilot was a successful test in advance of the Panam/Parapanam Games (next row)	Zimmerman and Wiginton (2017)
Ontario, 2015 (Panam/Parapanam Games)	Unknown	100 businesses	6 weeks	- Noise	- No incentives			Zimmerman and Wiginton (2017)
London Olympics, 2012				- Noise disturbance	- TFL Code of practice			Browne et al, (2014)

Appendix B: Post-pilot Interview Questions

- 1) What are the most important challenges / barriers to making more deliveries in the off-peak?
- 2) Were there any additional logistics costs associated with delivering off-peak? (e.g. staffing DC after hours, overtime pay).
- 3) Did your drivers prefer to work in the evening / early morning?
- 4) What challenges / feedback were expressed to you from the retail stores? Did the retail store managers have any additional expenses as a result of the pilot e.g. extra evening staff)?
- 5) What advantages were there from a logistics perspective?
- 6) Did you learn of any security issues?
- 7) Did you learn of any safety issues (e.g. backing up at night, visibility)?
- 8) Was there less or more congestion at the drop-off sites (e.g. conflicts with other carriers)
- 9) Do you see the potential to further expand on the off-peak delivery program (if the by-law exemption was made permanent)? Would this benefit your companies operations?
- 10) What proportion of your total operations do you think could be moved off-peak?
- 11) What changes would you recommend for the program (e.g. expand hours past 11:00pm?)
- 12) Did you ever receive any noise complaints?