TRUCK-ONLY LANES ON URBAN ARTERIALS: A VALUE OF TIME APPROACH

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Introduction

Recent rapid growth in employment and population in the Greater Toronto and Hamilton Area (GTHA), Canada, has led to increasing demands on the transportation network from both the goods movement and the passenger travel sectors. The GTHA has also experienced an increase in urban goods movements due to the increased adoption of just-in-time (JIT) delivery practices, which has resulted in a greater number of lighter weight shipments, and the increased use of air and rail intermodal shipments, each of which begin and end with a truck trip (iTRANS, 2004). The majority of urban freight trips in the GTHA occur on local or regional roads. Sixty-seven percent of truck trips in 2006 between the City of Toronto and the adjacent regions of York and Peel were not on freeways (DMG, 2006). Because of this high proportion of non-freeway truck trips in the GTHA, the local and regional road networks face increased pressures related to congestion, safety, delay and productivity losses for the trucking industry and other users (i.e. auto, bus, etc.) of the road, thereby negatively impacting the economic vitality of the region.

One potential strategy that has recently emerged to improve the efficiency of goods movement is the segregation of trucks from other users of the road. Studies done internationally have shown that truck-only lanes (TOL), which restrict trucks to certain lanes of the roadway, have the potential to alleviate congestion for both light vehicles and trucks (De Palma, 2008). Truck-only lanes impact three main aspects of the transportation system: safety, mobility, and cost.

First, large trucks pose a safety hazard in mixed traffic because of their lack of manoeuvrability, their larger size, and their unique acceleration characteristics (Middleton and Lord, 2005). Second, if trucks experience reduced traffic volumes on truck-only lanes, they will incur less congestion delay. Third, designing infrastructure for trucks requires higher road-design standards than for light vehicles, in terms of pavement thickness, grades, etc. (Holguin-Veras et al., 2003). If trucks travel in a dedicated lane, the rest of the road network can be built to a lower standard, thus resulting in cost savings.

Reich et al. developed a methodology to select potential sites for exclusive truck facilities based on the following criteria: truck-related crashes; truck volume; percentage of trucks; highway level of service; proximity to seaports; and proximity to other intermodal facilities (Reich et al., 2002). Abdelgawad et al. (2011) and Bachmann et al. (2011) used microscopic traffic simulation to assess travel time and safety impacts on freeways.

Little formal analysis has been done to quantify the economic benefits of truck-only lanes on arterial roadways. The purpose of this study is to evaluate truck-only lanes on arterial roadways from a travel cost perspective. To accomplish this goal, this research pursues three objectives. First, a simple truck-only lane arterial corridor is analyzed to identify compare travel time savings for trucks against travel time increases for non-trucks through the implementation of truck-only lane. Second, demand conditions (total volume and truck percentage) are identified that would be needed to justify the implementation of a TOL from a value of time perspective. Finally, these demand conditions, specifically truck proportions, are used to screen major arterials in the Region of Peel that have the potential to support TOL.

Literature Review

General purpose lanes (GPL) dominate road transportation systems for two main reasons. First, for road capacity in a single direction, two GPL permit higher throughput than two separate lanes (Poole, 2009). Second, if the number of vehicles permitted to use a dedicated lane is much higher or lower than the capacity of that lane, the dedicated lane may provide too little or too much capacity for the designated subset of vehicles (Poole, 2009). Poole refers to this as the "lumpiness" of a lane's capacity, implying that the risk of building the wrong amount of capacity is less if all the lanes can be used by all vehicle classes. Despite these factors, Poole argues that some corridors could benefit from truck-only lanes, given appropriate truck volume conditions.

When assessing the feasibility of TOL or any other managed lane strategies, the concept of value of time (VOT) is important. Value of time is defined as the opportunity cost of the travel time on a trip, and value of travel time saving is the maximum amount of money that travellers would be willing to pay, in order to reduce their travel time (Qing et al., 2011). In general, VOT for commercial vehicles is the marginal benefit that a driver derives from a unit reduction in the amount of time necessary to move a particular quantity of goods from origin to destination (Zamparini and Regianni, 2007). Three possible units of analysis are used: delivery time, transportation time, and travel time (Zamparini and Regianni, 2007). Delivery time is the amount of time from the moment in which there is an arrangement between a shipper and a carrier regarding the consignment of specific goods and the moment at which the goods arrive to the customer. Transportation time includes all logistics operations, such as loading, unloading, travelling, warehousing, and others, performed between the origin and destination. Travel time only takes into account the duration of the travel to move a good from an origin to a destination. Most commercial VOT studies have concentrated on travel time, because delivery time and transportation time may include aspects that are not directly linked to the VOT (Zamparini and Regianni, 2007).

Study Design

This study uses a test corridor to determine the combinations of total traffic volume and truck proportion that lead to conditions under which TOL on three-lane arterial roadways would be favourable in terms of total economic throughput, based on value of time. The test corridor TOL configuration is a three-lane, 1 km long arterial roadway. One lane is converted to a TOL with the other two lanes remaining as general-purpose lanes (GPL) for mixed traffic. The TOL is assumed to be dedicated to medium and heavy vehicles use only (light vehicles are restricted to the GPL), however, the TOL would be optional (medium and heavy trucks are not restricted from using the GPL). The definition of light, medium, and heavy vehicles is derived from the FHWA's Highway Economics Requirements Systems (HERS) model (Qing et al., 2011). Light vehicles refer to autos and 4-tire trucks. Trucks include medium vehicles (6-tire trucks and 3 to 4-axle trucks) and heavy vehicles (4-axle combinations and 5-axle combinations).

For modelling purposes, light vehicles are assigned a passenger car unit (PCU) of 1, trucks are assigned a PCU of 2. Multiclass generalized cost user equilibrium (UE) is adopted for this research because paths are based on the roadway operating costs (a function of travel time), and because the congested travel times are sensitive to the capacity and volume of the roadway. The term generalized cost reflects a conversion between travel time and travel cost using an assumed value of time. The behavioural assumption of generalized cost UE is that each vehicle travels on the path that minimizes that vehicle's generalized cost of travel. This implies that at equilibrium, for each origin-destination pair, all used routes have equal travel time, and no unused route has a lower travel time. If the TOL and the two GPL are considered as two routes having the same origin and destination, then the distribution of flows which makes the travel cost of the two routes equal is the user equilibrium solution, subject to the lane access rules. The volume delay function for each lane group in the simple TOL corridor is the BPR formula:

$$t = t_f \, (1 + (V/C)^4) \tag{1}$$

where t_f is the free flow travel time, V is the volume on the link in PCUs/hr, and C is the capacity of the link (PCUs/hr). For the test corridor, t_f is calculated assuming a freeflow travel speed of 60 km/hr over a 1 km corridor, and per lane capacity is assumed to be 1000 PCU/hr/lane.

Scenarios
Total vehicle volume and the truck proportions on the test corridor are varied systematically for each assignment scenario. Conditions are assessed where congestion related delays occur, since travel cost differences only manifest themselves when congestion occurs. The total demand on the test corridor is varied from 1000 PCU/hr to 3400 PCU/hr. The total truck percentage is varied from 22 to 38% of total vehicles, since this is the range in which interesting tradeoffs occur.

Determination of Truck Percentage Thresholds
After performing the multiclass generalized cost user equilibrium assignment for each scenario, the travel cost for vehicles using the corridor is calculated using the equation:

$$\text{Travel Cost} = \Sigma_k \Sigma_l \, t_l \, VOT_k \, V_{kl} \qquad (2)$$

Where t_l is the travel time on link l, VOT_k is the value of time of vehicle class k, and V_{kl} = the volume of vehicles of class k on link l. The travel cost is calculated for the corridor with and without the introduction of a TOL. The difference in the travel cost between the two corridors is calculated, making it possible to determine the truck percentage thresholds where the travel cost of an arterial road with a TOL is less than the travel cost without the TOL. If the travel costs on the two corridors are the same, then we are indifferent to whether a TOL is implemented or not. However, if the travel cost on the TOL corridor is less than the cost on the corridor without the TOL, then there is a potential travel cost savings with the implementation of a TOL.

The magnitude of potential savings is affected by the VOT assumptions. We assume a light vehicle value of time of $15/hr. Given the variability in estimates of truck value of time, we have assessed three cases for truck value of time. In Case 1, truck VOT is two times that of light vehicles ($30/hr). In Case 2, truck VOT is three times that of light vehicles ($45/hr). In Case 3, truck VOT is four times that of light vehicles ($60/hr). Clearly, if there is no difference between truck and light vehicle VOT, then there is no rationale for a TOL from the perspective of total travel cost.

Results and Discussion

Assignment Results

Traffic assignment results are shown in Tables 1 to 3. Table 1 shows the distribution of cars and trucks on the TOL corridor for all scenarios. The shaded cells indicate the scenarios for which some trucks choose to use the GPL due to congestion related delays. If the total volume is held constant and the total truck percentage is systematically increased, then for a truck proportions greater than or equal to 33% some trucks spill onto the GPL.

Table 1. Distribution of Vehicles on the GPL and TOL

		Total Volume (PCUs/hr)								
Total Truck %		**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	Cars (gpl)	780	1014	1248	1482	1716	1950	2184	2418	2652
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	220	286	352	418	484	550	616	682	748
0.24	Cars (gpl)	760	988	1216	1444	1672	1900	2128	2356	2584
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	240	312	384	456	528	600	672	744	816
0.26	Cars (gpl)	740	962	1184	1406	1628	1850	2072	2294	2516
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	260	338	416	494	572	650	728	806	884
0.28	Cars (gpl)	720	936	1152	1368	1584	1800	2016	2232	2448
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	280	364	448	532	616	700	784	868	952
0.3	Cars (gpl)	700	910	1120	1330	1540	1750	1960	2170	2380
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	300	390	480	570	660	750	840	930	1020
0.32	Cars (gpl)	680	884	1088	1292	1496	1700	1904	2108	2312
	trucks (gpl)	0	0	0	0	0	0	0	0	0
	trucks (tol)	320	416	512	608	704	800	896	992	1088
0.34	Cars (gpl)	660	858	1056	1254	1452	1650	1848	2046	2244
	trucks (gpl)	7	9	11	13	15	17	19	21	23
	trucks (tol)	333	433	533	633	733	833	933	1033	1133
0.36	Cars (gpl)	640	832	1024	1216	1408	1600	1792	1984	2176
	trucks (gpl)	27	35	43	51	59	67	75	83	91
	trucks (tol)	333	433	533	633	733	833	933	1033	1133
0.38	Cars (gpl)	620	806	992	1178	1364	1550	1736	1922	2108
	trucks (gpl)	47	61	75	89	103	117	131	145	159
	trucks (tol)	333	433	533	633	733	833	933	1033	1133

Tables 2 and 3 display the travel times on the corridor with and without a TOL, respectively. Travel times on the corridor without a TOL are as expected. As the number of PCUs (i.e. the demand) on the corridor increases, the travel time increases according to the volume delay function. As the truck percentage increases, the travel time remains the same because the overall number of PCUs on the corridor is unchanged.

Table 2. Travel Times (minutes) without a TOL

	Total Volume (PCUs/hr)								
Total Truck %	**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.24	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.26	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.28	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.3	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.32	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.34	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.36	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.38	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65

Table 3. Travel Times (minutes) with a TOL

		Total Volume (PCUs/hr)								
Total Truck %		**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	GPL	1.02	1.07	1.15	1.30	1.54	1.90	2.42	3.14	4.09
	TOL	1.00	1.01	1.02	1.03	1.05	1.09	1.14	1.22	1.31
0.24	GPL	1.02	1.06	1.14	1.27	1.49	1.81	2.28	2.93	3.79
	TOL	1.00	1.01	1.02	1.04	1.08	1.13	1.20	1.31	1.44
0.26	GPL	1.02	1.05	1.12	1.24	1.44	1.73	2.15	2.73	3.50
	TOL	1.00	1.01	1.03	1.06	1.11	1.18	1.28	1.42	1.61
0.28	GPL	1.02	1.05	1.11	1.22	1.39	1.66	2.03	2.55	3.24
	TOL	1.01	1.02	1.04	1.08	1.14	1.24	1.38	1.57	1.82
0.3	GPL	1.02	1.04	1.10	1.20	1.35	1.59	1.92	2.39	3.01
	TOL	1.01	1.02	1.05	1.11	1.19	1.32	1.50	1.75	2.08
0.32	GPL	1.01	1.04	1.09	1.17	1.31	1.52	1.82	2.23	2.79
	TOL	1.01	1.03	1.07	1.14	1.25	1.41	1.64	1.97	2.40
0.34	GPL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
	TOL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.36	GPL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
	TOL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
0.38	GPL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65
	TOL	1.01	1.04	1.08	1.16	1.29	1.48	1.76	2.14	2.65

Examining Table 3 leads to three observations. First, as the total demand on the corridor increases, the travel times on both the GPL and TOL increase. However, travel times on the GPL increase more significantly for scenarios with low truck percentages. Second, as the proportion of trucks increases, there is a greater demand for the TOL, and thus, the travel time on the TOL increases. Third, the shaded region of the table shows that for scenarios above a truck percentage of 33%, travel times on the corridor with the TOL are equal to travel times on the corridor without the TOL (as shown in Table 3). For these scenarios, trucks start to spill over to the GPL as there is no longer a travel time incentive to use the TOL because of congestion. This follows the principle of user equilibrium, whereby after a certain truck percentage is reached there are no time savings incurred by switching lanes as the travel times on the GPL and the TOL are equal.

Travel Cost Analysis

The differences in travel costs with and without the TOL are given in Tables 4 to 6 for different ratios of VOT between trucks and light vehicles. Table 4 shows the increased travel cost of implementing a TOL where light vehicle VOT is $15/hr and truck VOT is $30/hr. Tables 5 and 6 show the travel cost increases where truck VOT is then increased to $45/hr and $60/hr, respectively.

For the demand scenarios with no shading, there is no incentive to implement a TOL, from a travel cost perspective, because the TOL would be underutilized. If a TOL is implemented under these conditions, there is an increase in total travel cost. For the scenarios shaded in light grey there is also no rationale for implementing a TOL because there is no time or cost advantage for trucks using the TOL (both TOL and GPL are experiencing the same travel speed). The darker shaded cells highlight conditions where the travel cost with a TOL is less than without a TOL. Clearly, it is only under very specific demand conditions that a TOL would be warranted from a travel cost perspective.

For the case where truck VOT is double that of light vehicles (Table 4), there is no rationale for a TOL at all. This is because, although a truck's value of time is twice that of cars, it also has a passenger car equivalent of 2, so that each truck will supplant 2 passenger cars, cancelling out the higher VOT of trucks. For the case where truck VOT is three times that of light vehicles (Table 5) TOL are only justified if trucks represent between 30% and 33% of the total traffic flow. If truck VOT is four times that of light vehicles (Table 6), then the TOL is justified if the truck percentage ranges from 28 to 33%. Within this percentage range, the cost savings increase as the total demand increases. In the unshaded range the cost penalty also increases as demand increases, and the cost penalties of a TOL when truck percentages are too low, are much higher than the cost advantages when the in the truck percentages are in the desirable range.

Table 4. (Travel Cost With TOL) – (Travel Cost Without TOL)

Light Vehicle VOT = $15/hr, Truck VOT = $30/hr

	Total Volume (PCUs/hr)								
Total Truck %	**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	1.55	5.77	16.29	38.47	80.07	151.72	267.39	444.79	705.90
0.24	1.07	3.99	11.27	26.60	55.37	104.92	184.91	307.59	488.16
0.26	0.68	2.52	7.11	16.78	34.93	66.19	116.65	194.05	307.97
0.28	0.37	1.36	3.85	9.09	18.92	35.85	63.19	105.11	166.82
0.3	0.15	0.55	1.54	3.64	7.58	14.37	25.33	42.13	66.87
0.32	0.02	0.09	0.25	0.60	1.25	2.36	4.17	6.93	11.00
0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 5. (Travel Cost With TOL) – (Travel Cost Without TOL)

Light Vehicle VOT = $15/hr, Truck VOT = $45/hr

	Total Volume (PCUs/hr)								
Total Truck %	**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	1.28	4.75	13.41	31.66	65.89	124.86	220.04	366.04	580.91
0.24	0.80	2.98	8.43	19.90	41.41	78.47	138.30	230.05	365.10
0.26	0.43	1.58	4.46	10.53	21.91	41.51	73.16	121.70	193.14
0.28	0.15	0.56	1.57	3.72	7.74	14.67	25.85	42.99	68.23
0.3	-0.01	-0.04	-0.13	-0.30	-0.62	-1.18	-2.07	-3.45	-5.47
0.32	-0.05	-0.19	-0.53	-1.24	-2.59	-4.90	-8.64	-14.37	-22.80
0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Table 6. (Travel Cost With TOL) – (Travel Cost Without TOL)

Light Vehicle VOT = $15/hr, Truck VOT = $60/hr

	Total Volume (PCUs/hr)								
Total Truck %	**1000**	**1300**	**1600**	**1900**	**2200**	**2500**	**2800**	**3100**	**3400**
0.22	1.00	3.73	10.52	24.85	51.71	97.99	172.70	287.28	455.93
0.24	0.53	1.98	5.59	13.19	27.45	52.02	91.68	152.52	242.05
0.26	0.17	0.64	1.81	4.27	8.88	16.83	29.67	49.35	78.32
0.28	-0.07	-0.25	-0.70	-1.65	-3.44	-6.52	-11.49	-19.12	-30.35
0.3	-0.17	-0.64	-1.80	-4.24	-8.83	-16.72	-29.47	-49.03	-77.81
0.32	-0.12	-0.46	-1.31	-3.08	-6.42	-12.17	-21.44	-35.67	-56.60
0.34	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.36	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.38	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

These conclusions can be extended to any absolute VOT, provided that the ratios between light vehicle VOT and truck VOT are consistent with these two cases. For example, if light vehicle VOT were $30/hr and truck VOT were $90/min, then all values shown in

Table 6 would be multiplied by two and the demand scenarios that justify TOL would remain the same.

Screening of Corridors
Using the thresholds in truck proportions determined, potential corridors in the Region of Peel that warrant further consideration for their potential to support a TOL were selected. The Region of Peel was selected as the site for applying these thresholds as it is a major freight hub for the GTHA, Southern Ontario, and the rest of Canada. Seven major freeways go through Peel, including 401, 410, 403, 427, 409, QEW and 407. Moreover, Lester B. Pearson Airport, the largest cargo airport in Canada, in located in Peel, and it is in close proximity to two intermodal terminals in Brampton (CN) and Vaughan (CPR).

Cordon Count Data from 2006 for various time periods of the day for the Region of Peel was used for this part of the analysis. Corridors with truck proportions between 28 to 33% were identified as potential candidates for TOL and are shown in Table 7. As traffic conditions change throughout the day, it is expected that at certain times, it is more beneficial to implement a TOL due to higher utilization than at other times of the day. For this reason, Cordon Count data were analyzed from several time periods (AM peak, PM peak, midday peak, and entire day-15 hour period).

Several of the arterials identified in this analysis are well known truck routes in Peel. For example, Dixie Road in proximity to Highway 401 has some of the highest truck proportions in the Region. Analyzing this corridor in more detail, one can see that it is located in industrial areas and in close proximity to major freight traffic generators. In general, the Dixie Road and Highway 401 area is characterized by significant truck traffic and land uses that serve the trucking industry, such as fuelling stations, restaurants, and lodging. These supporting land uses provide an important function as a "stopover" for essentials for truckers prior to entering the highway system. Furthermore, Dixie Road, and the arterial roads in the area, such as Derry Road, provides a contiguous route from the transportation land uses around the Lester B. Pearson Airport, including major distribution centres to the 400-series highways. Other sites identified for further research include

Bovaird Drive near Hurontario Street and Goreway Drive near Highway 407. In close proximity to Bovaird Drive near Hurontario Street, there are various industrial uses. Moreway, Goreway Drive near Highway 407 is located next to the airport and to the CN

Table 7. Peel Corridors with 28-33% Truck Traffic

AM Peak (6:30am-9:30am)		PM Peak (3:30pm-6:30pm)	
59	Dixie Rd South of Highway 401	84	Torbram Rd South of Highway 407
78	Queen St West of Highway 50	86	Bramalea Rd South of Steeles Ave
87	Dixie Rd South of Steeles Ave	151	Dixie Rd South of Mayfield Rd
89	Mavis Rd South of Highway 407	161	Tomken Rd South of Highway 407
91	Mississauga Rd North of Highway 407	181	Airport Rd South of Mayfield Rd
134	Steeles Ave West of Highway 50	188	Bovaird Dr East of Hurontario St
161	Tomken Rd South of Highway 407	199	Highway 50 South of Ebenezer Rd
176	Hurontario St South of Mayfield Rd	304	Dixie Rd South of Bovaird Dr
184	Gore Rd South of Mayfield Rd	307	Airport Rd South of Bovaird Dr
192	Bramalea Rd South of Highway 407	319	Britannia Rd East of Dixie Rd
195	Winston Chruchill Blvd South of Highway 401	332	Goreway Dr South of Castlemore Rd
199	Highway 50 South of Ebenezer Rd	333	Gore Rd South of Castlemore Rd
260	Dundas St East of Highway 403	338	Airport Rd North of Highway 407
274	Dixie Rd SOuth of Eastgate Parkway	339	Goreway Dr North of Highway 407
328	Derry Rd East of Highway 410	340	Bovaird Dr West of Highway 410
332	Goreway Dr South of Castlemore Rd		
333	Gore Rd South of Castlemore Rd		
337	Steeles Ave at Highway 407		
339	Goreway Dr North of Highway 407		
357	Steeles Ave East of Airport Rd		

Midday Peak (11am-2pm)		15 Hour Period (5:30am-8:30pm)	
58	Hurontario St South of Highway 401	83	Dixie Rd South of Highway 407
85	Airport Rd South of Steeles Ave	86	Bramalea Rd South of Steeles Ave
89	Mavis Rd South of Highway 407	87	Dixie Rd South of Steeles Ave
91	Mississauga Rd North of Highway 407	151	Dixie Rd South of Mayfield Rd
95	Highway 10 South of Highway 24	152	Airport Rd South of Highway 9
103	Dundas St at the Etobicoke Creek	153	Tomken Rd South of Highway 401
107	Airport Rd West of Highway 427	184	Gore Rd South of Mayfield Rd
182	Goreway Dr South of Mayfield Rd	187	Highway 50 South of Mayfield Rd
184	Gore Rd South of Mayfield Rd	210	Highway 9 West of Peel/York Boundary
220	Highway 50 North of Albion Townline Rd	299	Mississauga Rd South of Bovaird Dr
221	King St West of Highway 50	307	Airport Rd South of Bovaird Dr
222	Highway 50 North of Columbia Way	328	Derry Rd East of Highway 410
307	Airport Rd South of Bovaird Dr	332	Goreway Dr South of Castlemore Rd
332	Goreway Dr South of Castlemore Rd	333	Gore Rd South of Castlemore Rd
333	Gore Rd South of Castlemore Rd	337	Steeles Ave at Highway 407
339	Goreway Dr North of Highway 407	338	Airport Rd North of Highway 407
348	Derry Rd West of Highway 410	339	Goreway Dr North of Highway 407
361	Bovaird Dr East of Creditview Rd	356	Queen St East of Airport Rd
368	Mayfield Rd East of Airport Rd	368	Mayfield Rd East of Airport Rd

Intermodal Terminal lands. This corridor, like Dixie Road near Highway 401, lies in the industrial heart of the Region of Peel. A TOL here could provide direct linkage to CN or the Airport and even Highway 401 located just a few minutes south.

It is important to note that the suitability of these corridors for TOL implementation rests of many factors, not investigated by this study, such as safety, design, and operational considerations. This analysis only provides initial guidance for screening potential corridors that warrant further investigation.

Conclusions

This study has identified thresholds of truck percentage for different total demand and VOT scenarios that would justify the implementation of a TOL on a 3-lane urban arterial on the basis of travel cost. In particular, the following conclusions can be drawn:

- A significant factor in determining whether there is a travel cost saving is the VOT of the vehicle classes using the roadway. As the VOT of trucks increases relative to that of light vehicles, the magnitude of potential cost savings increases. Furthermore, the greater the VOT for trucks, relative to light vehicles, the lower the proportion of trucks needed to justify implementing a TOL, from a travel cost perspective.
- Appropriate demand conditions are needed to warrant a TOL. If not enough trucks use the TOL, the corridor is not operating at its maximum efficiency. However, if too many trucks wish to use the lanes, leading to TOL delays, the benefit of these lanes is lost.
- Implementing a TOL on an arterial that does not meet the thresholds established in this research results in higher travel costs than if all the lanes are left as general purpose lanes. This observation highlights the importance of establishing appropriate criteria for the selection of corridors that can support TOL.
- While truck travel times can improve slightly through the implementation of a TOL, light vehicle travel times potentially increase much more.

- Further, this study identified arterials in the Region of Peel with truck proportions between 28 to 33%, using Cordon Count data. Many of these routes are in industrial areas, close to the airport, intermodal terminals, and various distribution centres, thus emphasizing that proximity to key freight traffic generators is key in determining corridors that warrant further analysis.

This study has limitations that could be addressed with further analysis, as follows:

- This study is for a single corridor and does not take into account system-wide effects caused by the implementation of a TOL. For example, implementation of a TOL may draw trucks from other parallel corridors, which could result in better utilization of the facility. System-wide effects could be assessed using a more extensive network model incorporating parallel routes.
- The study does not explicitly consider the impact of time-of-day restrictions on TOL usage. For example, enforcing TOL only at times when the truck percentage is in the preferred range could be an effective strategy.
- This research only looks at an urban arterial case study, however, could the same method could also applied to examine TOLs on freeways, which carry a significant portion of truck trips. We would expect similar conclusions.
- The analysis for this study was performed using a macro-level trip assignment model (user equilibrium). Micro-effects, such as lane-changing, car-following, and queuing behaviour are ignored. If the right lane is designated as a TOL, it would be useful to examine how cars and trucks interact, particularly in congested conditions, when a truck or car needs to change multiple lanes in order to make a turn or to access the appropriate lane. A microscopic traffic simulation model could be used to analyze this behaviour.
- The analysis only considers the cost of travel time as justification of TOL. Total economic impacts of TOL should also include the value of reliability, potential for accidents, etc. The cost of implementation (i.e. lane construction, pavement rehabilitation,

signage, lane striping, etc.) would also be part of the economic equation.

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