Investigation of Commercial Vehicle Parking Permits in Toronto, Ontario, Canada

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As the City of Toronto, Ontario, Canada, implements stricter parking enforcement in the city's downtown core, commercial vehicles (CVs) have become targets of increased ticketing and towing, often without alternate legal means of parking and loading. This paper investigates the feasibility of a CV parking permit to provide lawful and affordable parking options yet maintain a source of revenue for the municipality. Parking permits around the world are reviewed on the basis of their cost and scope. An analysis of historical parking citations in Toronto indicates clear patterns of parking behavior for which a permit would be beneficial. A nested choice model is developed to reflect the decision process of drivers searching for parking and calculate the revenue impacts of permit pricing schemes. This decision structure reflects a trade-off between permit pricing, legal parking costs (such as the value of walking time from distant loading zones), and the expected value of citations for illegal parking. The trade-off between permit revenue and parking ticket revenue shows that optimal permit pricing, in the order of Can$300 annually, can provide an improvement in municipal revenue and achieve widespread adoption (Can$1 = US$0.799 in March 2015). An improvement in social welfare is also achieved with permit adoption through the reduction of the cost of congestion, as permit holders are encouraged to park in legal zones away from congested arterials. The feasibility of a permit is contingent on the calibration of the price and rule structure in the fair appraisal of the value of parking in the downtown core and the needs of CV operators.

Freight transportation plays a key role in the urban economy. Although goods movement benefits society, curbside loading activities can adversely impact traffic congestion. As a result, urban transportation policies that support the freight industry may conflict with efforts to reduce congestion. In 2014, City Hall in Toronto, Ontario, Canada, initiated a zero-tolerance policy on illegal parking and stopping to improve peak hour traffic conditions. During ticketing blitzes, delivery trucks and couriers were among the vehicles commonly targeted (D. Turnball, personal communication, Feb. 12, 2015). Historical statistics on parking infractions highlight the prevalence of commercial vehicle (CV) citations in the downtown core. In 2012, CVs received 66% of all tickets issued in the central business district (CBD), in contrast to only 28% issued across the broader city (*1*). Although such tickets are reluctantly accepted as a cost of doing business, the Canadian Courier and Logistics Association has advocated for reforms to city policies on CV parking.

One approach has been the exploration of a CV parking permit, which would allow couriers and other CVs to park in most no-parking zones while on delivery, without the risk of ticketing or towing. In a 2011 staff report, the City of Toronto recommended the implementation of a permit system to facilitate legal CV parking. The report identified the permit system as a potential source of revenue for the city, offset by a likely reduction in ticket revenue (*2*). The program has yet to be implemented, in part because of objections put forth by the courier industry (*3*). In the interim, the City of Toronto has implemented a series of courier delivery zones (CDZs) that provide designated, free, short-term parking for delivery vehicles.

This paper analyzes the feasibility of a CV parking permit program to provide legal means for CVs to park without disrupting traffic yet maintain a revenue stream to municipal parking services. Program feasibility is evaluated on the basis of the program's fiscal impacts, ability to shift parking behavior, and effects on social welfare.

LITERATURE REVIEW

Urban pickup and delivery activities are responsible for approximately 500 million vehicle hours of delay in the United States annually and are the third largest cause of temporary road delays, below only crashes and work zones (*4*). The delays caused by urban freight can be made worse when there are illegally parked vehicles on roads designated for through traffic. However, Jaller et al. found that in the case of New York City, there were not enough parking spaces to allow delivery drivers to conduct their business legally (*5*). As a result, increased parking enforcement may not reduce the delays caused by CV activities. In light of this finding, Kawamura et al. used Chicago, Illinois, as a case study to investigate the factors that led to a large number of truck parking violations (*6*). The land use variable most significantly correlated with illegal truck parking was a high density of food business. The study also found that a high density of alleyways might be able to reduce the freight-related citations in a neighborhood, presumably because of the additional parking supply.

A survey of downtown commercial office building property managers in New York City found that insufficient loading dock capacity in buildings was associated with a significant increase in on-street delivery activity (*7*). As part of a comprehensive international survey on urban freight policy, Dablanc et al. found that as

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the demand for truck pickup and delivery exceeded the supply of loading and parking areas, enforcement became increasingly difficult and less effective because the risk of being ticketed for illegal parking became less costly to couriers than the delays caused by searching for a legal spot (*8*). Microsimulation modeling has been used to show that reserving some streets for freight parking may reduce the total delay in the system (*9*). Similarly, econometric modeling has shown that off-street freight parking facilities tend to reduce the incidence of illegal CV parking (*1*).

MUNICIPAL PERMIT PROGRAMS WORLDWIDE

A review of practices around the world was conducted to identify the challenges and opportunities associated with CV parking management policies. A proposal for a parking permit program was brought to the Toronto City Council in 2011 with the idea of exempting CVs from no-parking regulations for up to 30 min while the driver was in the active process of making a delivery or pickup (*10*). The fee was proposed to be set at Can$600 per vehicle per year or Can$5,000 for a fleet of up to 10 vehicles. (Can$1 = US$0.799 in March 2015).

As shown in Table 1, most cities that offer CV parking permits do so for substantially less than the Can$600 proposed for Toronto, albeit with differing policies about where parking is allowed. For example, in Vancouver, British Columbia, Canada, the Can$40 permit only allows for the use of loading zones and passenger zones; the Can$116 permit issued in Ottawa, Ontario, Canada, allows for parking in no-parking zones, similar to the policy proposed in Toronto. The price of the permit is closely tied to the value of the parking supply for that region. For example, two of the most expensive permits are those in Washington, D.C., and Houston, Texas, and these permits allow parking for up to 2 h. Conversely, none of the four cheapest permits allows parking in a no-parking zone. Because of the relatively small amount of parking on campus, the University of Oregon charges a high price of US$720 for its parking permit. There is wide variation in the time-of-day policies of parking permits. For example, the Minneapolis, Minnesota, permit allows for parking in any metered space before noon and therefore encourages couriers to carry out deliveries in the quieter morning hours. To date, Toronto has not explored this option, despite a high incidence of parking infractions occurring around 10:00 a.m., noon, and 4:00 p.m., a pattern that corresponds to the change in parking restrictions at these hours.

If the City of Toronto is to implement the parking permit as first proposed in 2011 and therefore allow CVs to park in no-parking zones, the city must weigh the cost of traffic disruptions in the busy CBD against the cost of lost revenue from reduced parking citations. This decision is especially important given the high demand for parking and the relatively high cost of parking in metered stalls downtown in comparison with other Canadian cities.

METHODOLOGIES

To evaluate the effectiveness of a parking permit program for CVs in Toronto, the types of illegal parking behavior, gathered from a historical parking citation database, are analyzed. Financial impacts to businesses and the municipal government are also assessed on the basis of projected revenue streams, and the equity of such a policy is discussed.

Illegal Parking in Toronto

The City of Toronto's Parking Enforcement Unit is a division of Toronto Police Services and is responsible for ticketing and towing vehicles engaged in illegal parking, stopping, or other curbside activities that violate city bylaws. The unit, which generated more than Can$100 million in revenue in 2014 (*24*), is among the city's top

TABLE 1 Courier Parking Permits in North American Cities

Municipality	Annual Cost	Detail
Vancouver, British Columbia, Canada	Can$40	Maximum of 30 min in loading zone or passenger zone and in any metered stall, except during peak hour (*11*)
Niagara Falls, Ontario, Canada	Can$50	Maximum of 30 min for active loading and unloading in loading zone (*12*)
Cairns Region, Queensland, Australia	A$86	Maximum of 20 min in CV loading zones (*13*)
Kitchener, Ontario, Canada	Can$100	Parking in any metered stall or loading zone for amount of time not exceeding the limit posted on the signage (*14*)
Ottawa, Ontario, Canada	Can$116	Maximum of 15 min for active loading and unloading in no-parking or loading zone (*15*)
Prince Albert, Saskatchewan, Canada	Can$150	Active loading and unloading in metered stall, rear alley, or loading zone (*16*)
Savannah, Georgia	US$160	Maximum of 30 min in loading zone, lane, or bagged meter (*17*)
Kamloops, British Columbia, Canada	Can$250 Can$100	Maximum of 2 h in metered stall or any on-street parking Maximum of 15 min in metered stall (*18*)
Lethbridge, Alberta, Canada	Can$272	Maximum of 15 min in metered space (*19*)
Washington, D.C.	US$323	Maximum of 2-h parking in CV loading zone during designated hours (*20*)
Minneapolis, Minnesota	US$400	Maximum of 30 min in loading zone, no-parking zone, or before noon in metered space (*21*)
University of Oregon	US$720	Maximum of 24 min at metered stall or loading zone (*22*)
Houston, Texas	US$1,285 US$321 US$161	Maximum of 2-h parking in loading zone or metered stall Maximum of 1-h parking in loading zone Maximum of 30-min parking in loading zone (*23*)

NOTE: A$ = Australian dollar. A$1 = US$0.781 in March 2015.

income streams, after property taxes and user fees. Over the past 25 years, the Parking Enforcement Unit has annually issued around 3 million parking tickets. A 2012 City of Toronto data set of parking tickets indicates that approximately one-quarter of all infractions have been by CVs. Of these tickets, the most common infractions have been

- Parking prohibited by time and day (18%);
- Parking prohibited without a permit (11%); and
- Parking in a paid spot without displaying a receipt (10%).

These infractions are in contrast to the most common infractions of non-CVs, which most often are attributed to an expired meter. For the years 2011 and 2012, the average fine per ticket issued to CVs was Can$44. It is important to distinguish between the issued fines and the actual payment; between 1990 and 2013, only 81% of issued ticket fines were ultimately collected as revenue for the city. Tickets can be withdrawn or reduced for a variety of reasons, including

- Cancellation by staff on the basis of city-approved cancellation guidelines;
- Ticket being issued to an out-of-province vehicle for which no ownership data can be retrieved;
- Cancellation in court; or
- Motorist driving away before ticket issuance is complete.

It has been estimated that Can$1.5 million worth of fines issued to courier and delivery truck drivers were canceled in court in 2009 (*25*).

Policy Proposals

One of the most significant challenges associated with the management of CV parking in the CBD is to match the locations of freight demand with street parking locations. The City of Toronto has recognized a need to provide parking in strategically important areas and has begun to implement a series of CDZs across the downtown (*26*). In January 2010, the city began creating designated CDZs through a pilot of seven zones at some of the most highly ticketed locations in the CBD. This measure was seen as a proactive step toward improving parking availability for couriers in the downtown core.

Two other projects, however, worked against the CDZ pilot. First, the effectiveness of some CDZ locations was reduced by a widening of the peak period parking restrictions on arterial roads; these restrictions superseded any CDZ designations. Second, the city introduced a zero-tolerance towing policy for illegally parked vehicles and faced strong backlash from CV operators, who claimed that the new rules made it very difficult for CV operators to work downtown. In response, the city returned to the expansion of the CDZ pilot project (*27*). Existing CDZs have had limited effectiveness, partially because of blockage by private vehicles. The restriction of CDZs to permitted vehicles, and making this restriction explicit (e.g., by appending "By Permit Only" to CDZ signage), may help reduce private vehicle blockages.

Data on CV parking citations in 2012 provided by the City of Toronto were coded and analyzed in a geographic information system and, as expected, the highest density of tickets was found in the CBD. The number of parking citations issued in the CBD can be used as a proxy for the number of CVs that stop illegally throughout the day and that may therefore cause traffic delays and safety issues. Figure 1 shows the density of CV citations, alongside the locations of the installed and planned courier loading zones in the CBD (*28*).

Fiscal Analysis

The analysis below considers the factors that can influence the financial viability of a permit program from the perspective of municipal revenue. The primary policy lever is the price of the permit, and the parameters are the types of parking offence that could be exempted (which would affect ticket revenue generation), as well as the expected popularity of the permit program.

Each CV operator is given the option of purchasing a permit. Each vehicle with a purchased permit is exempted from parking tickets for eligible offences. Vehicles without a parking permit may choose to park either legally or illegally. Legally parked vehicles incur an average walking cost of w dollars and are assumed to find free legal loading zones a certain distance from the vehicle's destination. Illegally parked vehicles incur an average citation fee of f dollars but are assumed to have negligible walking costs. The parking decision for each vehicle can be represented in a nested structure, illustrated in Figure 2.

It is assumed that the nested structure of Figure 2 follows a hierarchical logit–type choice structure. The dispersion parameter of the top-level choice (purchasing a permit) is denoted by θ_1, and the dispersion parameter of the lower-level choice (parking legally or illegally) is denoted by θ_2. The adoption rate (A_P), with domain [0, 1], reflects the proportion of drivers who purchase a permit and can be calculated as

$$A_p = \frac{\exp(-\theta_1 p)}{\exp(-\theta_1 p) + \exp(-\theta_1 L)} \tag{1}$$

where p represents the permit price and $L = -(1/\theta_2)\ln[\exp(-\theta_2 f) + \exp(-\theta_2 w)]$ is the logsum of the disutility of parking as perceived by drivers. Through the use of Equation 1, given N eligible vehicles, the total number of vehicles with a permit (V_p) is calculated as

$$V_p = NA_P \tag{2}$$

and the number of vehicles without a permit is $N(1 - A_P)$.

In the lower-level choice model, the probability that a vehicle without a permit chooses to park illegally (r) is

$$r = \frac{\exp(-\theta_2 f)}{\exp(-\theta_2 L)} \tag{3}$$

and the probability that a vehicle parks legally is $1 - r$. Therefore, the total number of illegal parkers (V_f) and legal parkers without a permit (V_g) can be computed as shown in Equations 4 and 5, respectively:

$$V_f = N(1 - A_P)r \tag{4}$$

$$V_g = N(1 - A_P)(1 - r) \tag{5}$$

For the municipal objectives, the parking revenue is generated from (*a*) parking permits and (*b*) citation fees. The generated revenue from parking permits can be calculated as pV_p dollars, which is the product of the number of permits purchased and the price of each

FIGURE 1 Point density of CV parking citations in 2012 and locations of existing and planned CDZs.

permit. Similarly, the generated revenue from illegal parking can be calculated as fV_f dollars. Therefore, the total generated revenue (R) is

$$R = pV_p + fV_f \tag{6}$$

Through the substitution of Equations 2 and 4 into Equation 6, the total generated revenue can be simplified to

$$R = N\left[f(1-A_P)r + pA_p\right] \tag{7}$$

Under a change in parking behavior, the impacts on congestion may be monetized in terms of social cost. The two main factors that influence social cost are (*a*) the impact of illegally parked CVs on through traffic and (*b*) the walking costs to CV drivers. Both costs are negative externalities. These costs are estimated as follows. Let γ_1 and γ_2 denote the annual marginal increase in travel time incurred by through traffic for each additional illegally parked vehicle and permit-holding vehicle, respectively. Assume for simplicity that γ_1 and γ_2 are fixed and that $\gamma_2 < \gamma_1$, since permit-holding vehicles are assumed to be less likely to block peak period traffic, in accordance with permit restrictions. Therefore, the total extra travel time of through traffic can be calculated as $\gamma_1 V_f + \gamma_2 V_p$. Non-permit-holding CVs that park legally are assumed to incur extra walking time, as legal spots might be farther away. The social cost (μ) is the summation of all three costs and is calculated as

$$\mu = \gamma_1 V_f + \gamma_2 V_p + wV_g \tag{8}$$

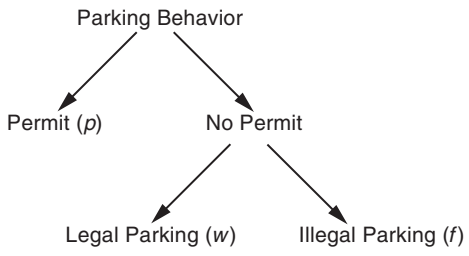

FIGURE 2 Nested parking choice structure for CV drivers. Costs are indicated in parentheses.

RESULTS AND DISCUSSION

Feasible permit pricing is explored below and has implications for municipal finances and businesses. Subsequently, a sensitivity analysis is conducted to illustrate the impact of behavioral parameters on permit effectiveness.

Of the 2.8 million parking tickets issued annually (*29*), parking citation microdata indicate that, on average, 23% of tickets are issued to CVs, and the average fine amount for each of these tickets is Can$44. On the basis of these values, the average number of tickets

issued to CVs (V_j) is 646,000, and the total fine amount for commercial parking tickets is Can$28.2 million.

According to the 2013 parking ticket activity report, only 81% of these tickets are actually paid; the remainder are canceled, rescinded in court, or issued to out-of-province drivers. As a result, the average gross revenue from parking tickets is calculated to be approximately Can$22.8 million.

The staff report that proposed the CV parking permit used 2010 data to determine that each CV received an average of 10 tickets per year (*10*). From this figure, it can be calculated that there are approximately 65,000 CVs on the road in Toronto (N). Therefore, the city collects an average of Can$350 annually in parking fines from each CV.

CV citation data from 2012 were analyzed to determine the types of infraction that might be eliminated with the introduction of the CV parking permit. It was assumed that a vehicle with a permit would not be subject to citations for parking in no-parking zones or metered stalls but that the number of issued tickets for all other types of parking offence (such as parking in a peak hour no-stopping zone) would remain unchanged. On the basis of these assumptions, it was estimated that vehicles with a permit could reduce their parking citations by 61%.

On the basis of these parameters, the revenue impacts of various permit sticker prices are shown in Figure 3 as a function of the adoption rate (A_P). A fixed annual operating cost for the permit program is set at Can$100,000 and assumes the hiring of two Can$50,000/year clerks; variable costs are set at 10% of the sticker price and account for other administrative expenses. For the case in which no businesses opt in to the permit, the revenue is approximately Can$22 million, regardless of the sticker price; this value is the current revenue from CV parking tickets. Because each CV operator currently pays an annual average of Can$214 in fines related to no-parking zones and metered stalls, and these fines would be eliminated by the permit, this point is considered the break-even point for the permit sticker price. For any price above Can$214, the revenue for the city increases as a higher percentage of CVs purchase the parking permit. If the sticker price is set too low, the city would lose revenue as the program gains popularity.

Additionally, this graph shows the importance of considering the adoption rate when deciding on a sticker price for the courier parking permit. Under an assumption of nonmandatory purchase, the adoption rate is a response to several factors, and one of the most important predictors is the sticker price. Businesses will not purchase the permit if they think it is unfairly expensive. The graph illustrates that the revenue generated by a Can$400 permit with a 60% adoption rate is higher than the revenue generated by a Can$500 permit with a 30% adoption rate. It is necessary for the city to do a detailed market analysis of the willingness to pay for such a permit before settling on a price.

Although Figure 3 indicates the revenue generation at various permit prices and adoption rates, there is an inherent relationship between the latter two variables. As the permit price increases, more CV operators may elect to use pay-and-display parking or risk getting ticketed, rather than purchase costly permits. It is therefore important to capture the trade-off between the price and the adoption rate. In Figure 4*a*, permit and ticket fees are shown as components of total revenue and illustrate this trade-off. At a low permit price, almost all CV operators will purchase permits, and these purchases will result in revenue directly proportional to permit price. At a high permit price, no permits will be purchased, and the sole source of revenue will be ticket fees; this situation will result in invariant revenue as p becomes large. There exists an optimal permit price at which city revenue is maximized; that optimal price corresponds to an adoption rate that is dependent on CV operators' risk propensity for ticketing, as well as their value of time (w), which reflects their willingness to search for free parking further away from their destinations.

The dispersion parameters θ_1 and θ_2 in Equations 1 and 3 reflect the degree to which CV operators act rationally as cost-minimizing agents. The value of θ_1 relates to the variability in the decision of

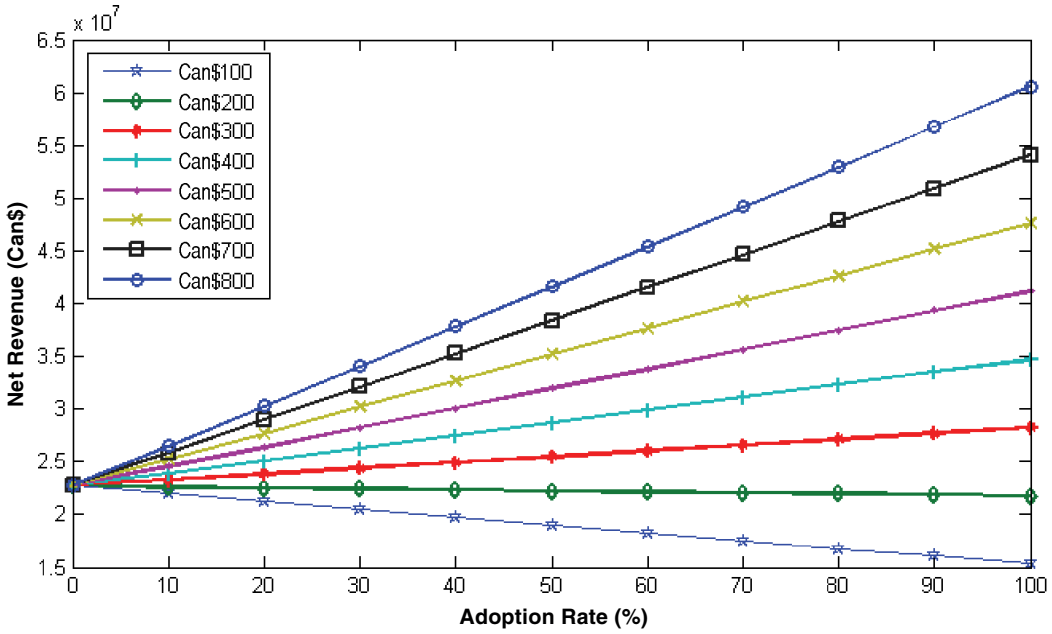

FIGURE 3 Net revenue from permit sales and ticket issuance as function of adoption rate and permit sticker price.

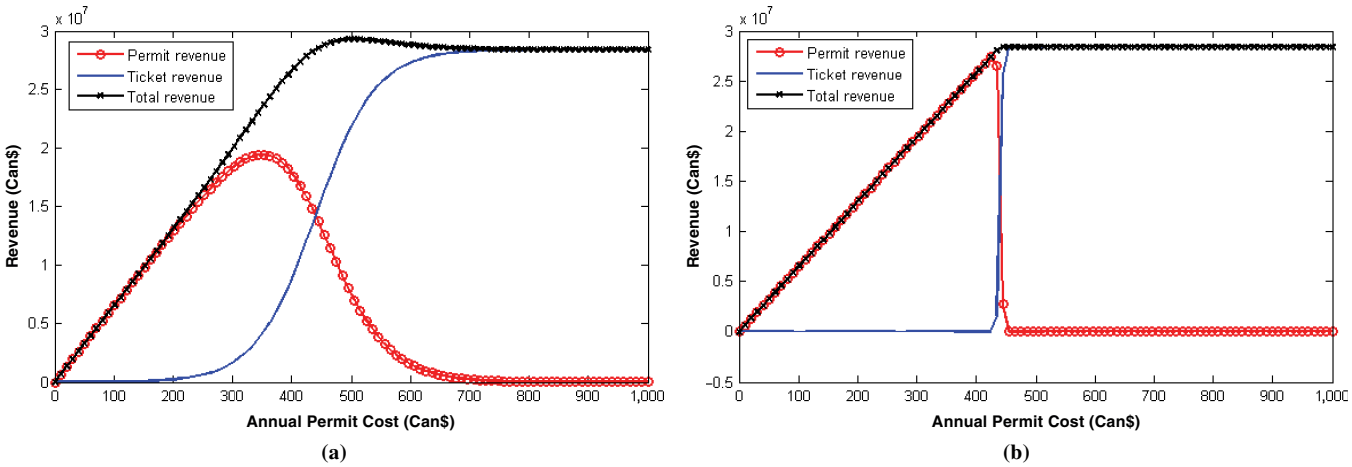

FIGURE 4 Revenue sensitivity to dispersion parameter: (*a*) low dispersion and (*b*) high dispersion.

businesses to purchase permits; the value of θ_2 relates to the variability in the decision of individual non-permit-holding drivers to park legally or illegally. In Figure 4*a*, low values of θ indicate that in the case of large spreads in behavior among CV operators, a wider range of permit prices will result in maximized revenue for the municipality. In Figure 4*b*, high θ values lead to reduced stochasticity and a more sudden shift in behavior when permits are priced too high.

Figure 5 illustrates the sensitivity of generated revenue to four walking cost scenarios that reflect the varying degrees of disutility associated with walking to one's destination. Each scenario presents a ratio of the baseline walking cost. The ratios are 0.2, 0.4, 0.6, and 0.8. As shown in Figure 5, when the walking cost increases, greater revenue is generated because more drivers are willing to pay a higher price for the permits to avoid the walking costs. The maximum revenue is illustrated by Point *A* in Figure 5. The higher walking cost also induces more drivers to park illegally. The total revenue generated from citations alone is illustrated by Line *B* in Figure 5. This line (i.e., the flat part of the curve) occurs when the permit is prohibitively expensive and therefore encourages illegal parking. Figure 5 also shows that the maximum increase in generated revenue (illustrated by Segment *C*) decreases at higher walking costs and indicates that the permit program is less influential when walking costs are high.

The impact of permit price on social cost may also be considered. Figure 6 shows that, given $\gamma_2 < \gamma_1$, the social cost is minimized when permits are inexpensive and thus ubiquitous. This impact results from the City of Toronto's proposed permit guidelines, which restrict permit parking on major arterial roads during peak periods. It is assumed that permit holders will seek to use their permit legally, and less traffic blockage will result. At high permit prices, social costs increase as drivers do not purchase permits and instead opt to park anywhere and receive tickets; this situation more closely reflects the status quo in Toronto.

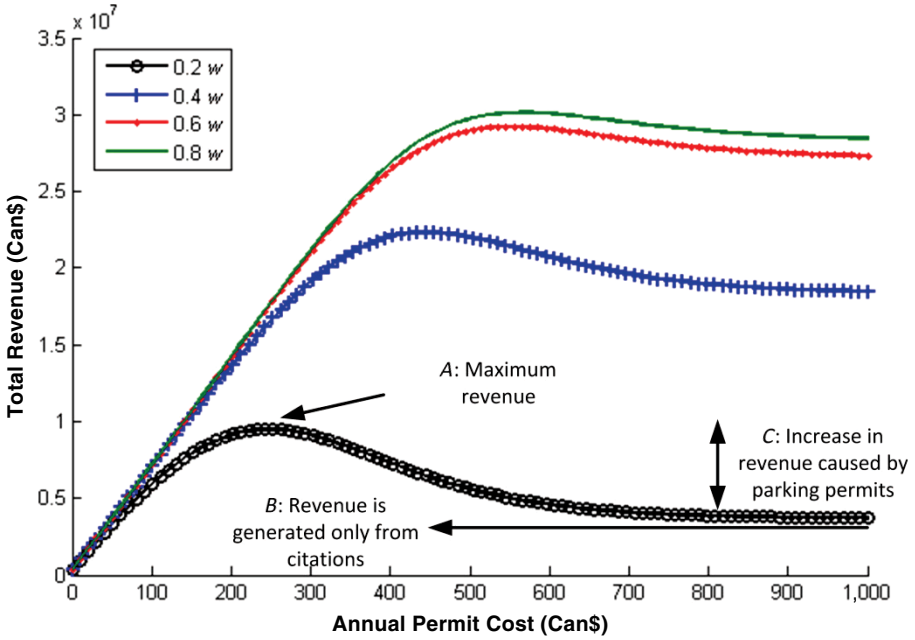

FIGURE 5 Revenue impacts of reduction in walking penalty (*w*).

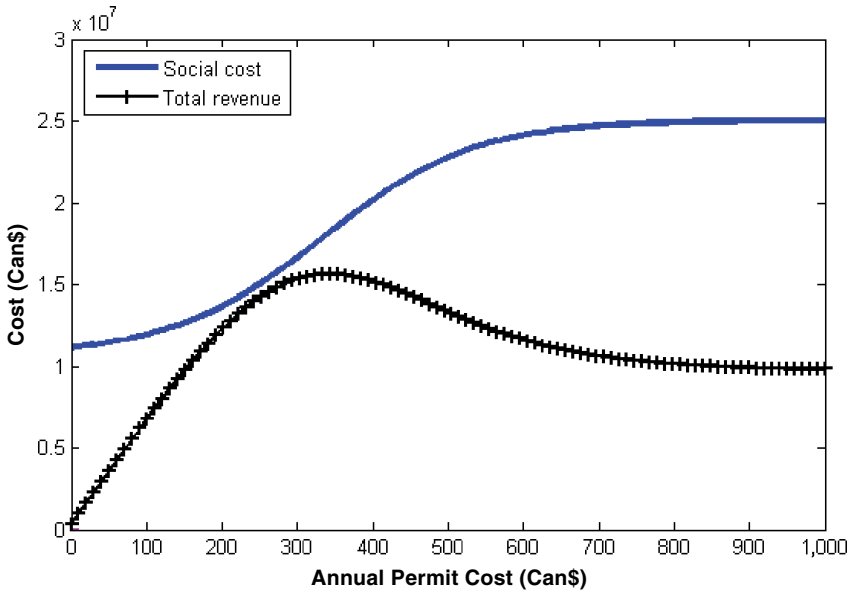

FIGURE 6 Sensitivity of social cost and revenue to permit cost.

As illustrated in Figure 6, varying the permit price affects both the total revenue and the social cost. Developing policy on the basis of one of these objective functions is not wise as the other objective function may be abandoned. In Figure 6, for instance, the permit cost of Can$334 maximizes the total revenue, but the permit cost of Can$0 minimizes the social cost. Therefore, the Pareto optimality of permit pricing may be considered. The Pareto front (Figure 7) indicates the policies that are Pareto optimal. That is, a deviation from any policy that falls on the Pareto front cannot simultaneously improve both objective functions. The Pareto front can help municipalities understand the trade-off between the two objectives when imposing a policy.

In addition to the calibration of the pricing scheme of a CV parking permit, the importance of fair and equitable program implementation should be noted. For example, permit eligibility is a contentious issue. Toronto city staff proposed a permit specifically for courier vehicles (*10*), although some cities allow other CV operators to purchase permits, and other cities allow any vehicle to carry a permit. The Canadian Courier and Logistics Association, which expressed support for a permit system, expressed concerns that mandatory permits would be unfair to CVs that seldom park in the downtown core (*3*). The association advocated for an opt-in program instead, such that only drivers who frequented the CBD would be advised to purchase a permit.

Finally, there remains a need to provide parking and loading zones where permit holders may legally park. The implementation of CDZs has been recognized as a beneficial measure, although these zones are still few in number (*28*). There has been concern over conflicts

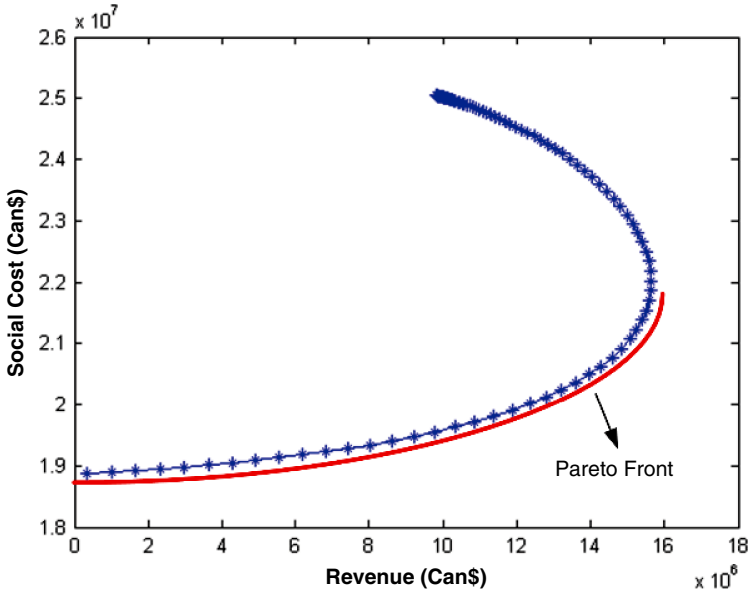

FIGURE 7 Pareto optimality.

between bicycle lane implementation and a reduction in curbside loading zones. These concerns emphasize the need for freight industry consultation in the design of road infrastructure and the provision of off-street loading docks.

CONCLUSION

This paper investigated the feasibility of a CV parking permit as a reform to the current practice of the widespread ticketing of illegally parked CVs in downtown Toronto. A permit system can reduce the frequency of tickets issued to CVs and alleviate driver frustration associated with the search for legal loading zones. For the municipality, such a program incentivizes legal parking, which may help reduce congestion, and provides a steady revenue stream to the city.

A behavioral model of parking activity captures the decision process employed by CV drivers and shows a trade-off between walking time, parking costs, and risk aversion to parking tickets. From parameter estimates based on historical data from parking citations, it was found that a permit system could lead to increased revenue for the City of Toronto, as well as reduce congestion and streamline the parking services bureaucracy. On the cost of congestion, the permit provides an improvement in social welfare in the case of widespread adoption, although this improvement involves a trade-off with municipal revenue.

A CV parking permit, combined with recent projects such as downtown CDZs, can improve the efficiency of freight industry operations and provide benefits to city finances and the traveling public. Such benefits are contingent on the minimization of overhead costs and the sufficient attractiveness of the permit to achieve widespread adoption.

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