A Study of the Commercial Vehicle Value of Time for Operation at Border Crossings

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Abstract

Commercial transport is one of the most important economic activities in the transportation industry. Significant proportion of Canadian trade volume with the rest of the world extends over the Canada-United States border. The mobility of freight movement across the border is vital for regional economies and cross-border businesses. Border delays constitute significant cost to the motor carrier industry as well as the end consumer. Recently, a renewed interest in border studies was focused on adopting advanced technologies to enhance inspection efficiency as well as reduce congestion at the border. One of the key determinants of social benefits of improved border management policies is the value of time for commercial vehicles operating at border crossings. Key studies in the literature about this issue are limited and outdated. Besides, little, if any, work has been done on measuring the value of time in the context of border operation. To address these shortcomings, a SP mail-in survey was conducted in collaboration with the British Columbia Truck Association to collect data from members of the motor carrier industry. On-phone interviews were also conducted as a follow up. Despite the limited response rate, the findings of this study suggest that the value of time for border operations is higher than the general-freight value of time available in the literature. Further work is required in order to gain a more precise estimate. This study presents the design, conduct, and findings of this survey.

Background

Commercial transport is one of the most important economic activities in the transportation industry. The gross domestic production of Canada in 2007 derived from the trucking industry was $15 billion which represented 26.7% of the output of all transportation and warehousing activities and approximately 1.2% of the total domestic production at basic prices [1]. In 2005 the trade with the United States accounted for 84% of Canada's total export and 57% of Canada's total imports [2]. Trucking is the dominant mode of freight transport between Canada and the United States with a transport share of 51% of exports and 77% of imports. In terms of value, 59% of the trade between the US and Canada was handled by the trucking industry in 2007 [3]. The second most important mode of freight transport was rail with a trade value share of 17%. Keeler and Ying [4] calculated the benefit share of the trucking industry and found that it justifies one-third to one-half of the cost of the Federal-aid highway system developed in the US.

From trade perspective, transport cost is classified as a non-tariff trade cost that influences prices of goods in a way different from traditional trade-related costs. Transport cost along with distribution and network costs are not directly observable from traditional merchandise trade. However, transport cost, or alternatively time, has a profound impact on consumer good prices as well as the related economies. Curtis and Chen [5] analyzed the effect of transport cost on Canadian trade patterns and found that the reduction in transport cost had contributed to expand trade in differentiated products between Canada and its trade partners.

Despite the economic importance of the motor carrier industry, transportation researchers and government bodies have paid little attention to this topic of research compared to passenger transportation [6]. There is a traditional research bias toward passenger transport which limited the focus on developing analysis tools and techniques related to CV transport. Brand et al. [7] remarked the limited information on time valuation in the literature of studies on commercial vehicle (CV) transport. They attributed this finding to privacy and competition in the CV market. One of the key ingredients of benefit assessment of transportation projects is the value of time (VOT) of the beneficiaries of the transportation service. Thus, the social benefit can be assessed in terms of the value of the freed time resources afforded to all beneficiaries of a transportation service.

One of the realms of freight transportation services is expedited border crossing for CVs. The measurement of the VOT for CVs within the period spent at international port of entry represents a gap in the technical literature that was not approached despite its political and economic significance. To the best of the authors' knowledge, this research is unique and lends strong support and reliability to benefit evaluation of expedited border crossing project. This paper provides a detailed review of the literature, a brief discussion of theory of time valuation, describes the design and conduct of a stated preference survey, and summarized the survey findings.

Value of time for commercial transport

DEFINITIONS

VOT has been analyzed for over 40 years in the freight transportation literature, mainly due to its importance in guiding transportation planning decision [8]. Reduction in travel time savings is single largest contributor to benefits of transportation projects [9]. Mackie et al. [10] estimated that 80% of

benefits derived from transportation investments are attributable to travel time savings. The relative magnitude of time saving benefit in the US is similar and constitutes the majority of the benefits that result from transportation project improvement VOT plays a central role in guiding public investment policies [11].

There are three units of analysis for VOT for CVs: Transportation time, travel time, and delivery time. Transportation time is the time required for goods movement from an origin to an intended destination including all logistic operations, e.g. loading, unloading, and warehousing, that are performed within this period. Travel time is the period that elapses from the departure of good from origin to their arrival at the intended destination. Delivery time is the time spanned by the arrangement for delivery to a consignee or a carrier and the actual arrival of the goods to their intended transporter. Most studies in the literature focused on studying only the value of travel time [12]. Similarly, the focus of this research, the VOT for CVs at border crossing, can be classified as value of travel time.

THEORY OF VALUE OF TIME

The VOT for CVs can be defined in theoretical terms as the marginal profit or benefit that is derived from a unit reduction in travel time. The benefit that accrues to the society from CV travel time saving stems mainly from the benefit components for drivers, carriers, and shippers [7]. The summation of the individual benefits does not necessarily add up to the net social benefit, but in most business cases this will involve double-counting. Hence a more dedicated theory of time valuation was the focus of studies in the literature. Winston [13] in which the freight VOT can be expressed in terms of the partial derivative of transport cost with respect to transportation time. The marginal benefit derived from travel time reduction can be also calculated using a Logit model for the firm's preference [6].

In previous model, there are several implicit assumptions that do not necessarily reflect real-world business conditions. First, the model is unable to represent difference in attributes among firms. Second, overlapping of different shipping alternatives cannot be represented in the model since irrelevant alternatives and error terms are assumed independent. As a remedy for these limitations, a modified version of the Logit model has been used by Kawamura [6] to evaluate the VOT for CVs. To address other issues with Logit models, recent studies proposed enhanced models for representing a firm's trade-off between cost and transportation time, e.g. [9].

VALUE OF TIME COMPONENTS

The VOT for CVs depends on various trip-specific and CV-specific factors. The benefit realized from travel time saving can be attributed to three main operational components: driver, shipment, and vehicle. The respective beneficiaries are the driver, the shipper/consignee and the motor carrier operator, with different valuation approach for each beneficiary. Kawamura [6] studied the VOT for carriers and identified the following elements that constitute and control the value of time for motor carriers:

1. Cost Elements: operating cost, fuel, maintenance, labour cost, licensing, and insurance fees, vehicle deterioration/obsolescence, opportunity cost of capital, garage, and property cost, including taxes.
2. Revenue elements: tariffs, customer charges, market demand, business strategy, and contractual details.
3. Trip length, cost of critical delivery contracts, and travel time sensitivity.

In addition to VOT determinants that stem from motor carrier operator benefits, a distinct benefit accrues to the freight carried. For shippers, receivers, and/or consignees, the benefit from travel time savings results from the early, or non-late, arrival of shipments to their destination. In theory VOT for passengers and freight are the result of an underlying optimization process. Passenger VOT can be calculated by maximizing an individual's utility while freight value of time is calculated by maximizing the profit of an enterprise or an economic entity [9]. This economic entity can be the shipping company, the consignee or the receiver. In some circumstance, e.g. integrated logistic processes, it is difficult to identify a single entity responsible for planning and routing decisions.

ISSUES WITH INTEGRATING VALUE OF TIME COMPONENTS

The benefits derived from travel time savings for CVs can materialize to drivers, carriers, shippers/consignees, or any combination thereof. There is however a precaution for admitting benefits into a standard benefit-cost analysis (BCA): benefits should be comprehensive and representative of a genuine service to the society. Examples of benefits that are inadmissible are driver freed time resource that enables additional employment earning. This is a benefit transfer from the employing carrier to the driver. In addition, not all benefits that accrue to carriers are passed along to shippers and further to customers. For example, the carrier can select to charge the sample premium, if market conditions permit, even after the introduction of a specialized inspection service with reduced transit time. The benefit to the carrier in this case should not be counted since it represents a transfer of benefit from shippers/consignees. Rather, the degree of utilization of freed resources that results from shorter transit times is the genuine benefit to the society. Similarly, the shipper's ability to purchase additional freight service at the same cost of previously less service is what counts as a genuine benefit to the society. This depends on the capability of the shipping business to transform these benefits to an enhanced production and logistics network, tighter transport and delivery schedules, and reduced transit units. For further discussion of shipper-based benefits refer to Lambert [14]. Another perceivable, and often overlooked, benefit from expedited service is the reduction in the variability in travel time. The value of variability VOV concerns the user's willingness to pay for a marginal reduction in the uncertainty of travel time. Studies in the literature used standard deviation, e.g. [15], as well as difference between percentile values (90^{th} and median; [16]), in order to quantify variability in travel time.

In order to avoid double-counting of benefits, Brand et al[7] proposed the consideration of benefits to motor carriers and the marginal benefits that accrue independently to shippers (increased productivity) as well as drivers (leisure time). Many studies in the literature regard motor carriers as the major private beneficiary from improved CV transportation service. The current study follows a similar approach.

VALUE OF TIME IN THE TRANSPORTATION LITERATURE

One of the earliest attempts to obtain VOT estimates was conducted by Beesly [17] in which he proposed a graphical solution for the trade-off between travel time and travel cost. One of the first studies of an application that involved the value of time lost in traffic congestion was developed by Vickery [18]. The model describes a single road that operates at a suboptimal capacity. He calculated the average travel time based on the average in-queue time. He showed that if a priced alternative route is introduced a new equilibrium is reached at which users are indifferent between joining the queue and paying for a shorter travel time. Later studies of user's VOT employed discrete choice models based on revealed preference data, e.g. Lave [19] and Hensher [20]. In order to overcome several issues related to revealed preference data, e.g [21], discrete choice models developed to adopt stated preference data in order to gain a more accurate estimate of VOT. Some of these issues, as Small et al. 1999 criticized, is the traditional restrictive assumption in the literature regarding the homogeneity of the VOT in respect

to the travel attributes. For example, VOT is reported to be higher in congested traffic conditions than uncongested traffic conditions.

Despite the preeminence of VOT in the evaluation of transportation investments, VOT estimates found in the literature of passenger-oriented transportation are remarkably at variance [22] and [23]. Calfee and Winston [16] argue that the disagreement of VOT estimates in the literature are due to the limited methodology of data inquiry that always involves a choice between a predominant mode of travel and other modes. They argued that VOT of road users should be derived based on choices of free and priced services. Unobserved heterogeneity is another culprit in the wide variation in VOT estimates which, if not accounted for, can yield biased estimates [15].

The previous discussion concerns the VOT estimation for passenger trips. While the literature of VOT for commercial vehicles contains invariably a number of significantly different estimates, it differs from the passenger-oriented on the following accounts:

1. The CV literature is relatively limited in number of studies and data volume.
2. VOT for CV is typically higher than passenger vehicles [24]. Even when CVs are empty, their value of operation can be incorporated in a business productive cycle, e.g. a trip chain. Haning and McFarland [25] argued that CV time savings are most likely to be used for productive purposes, while passenger time savings can be used for leisurely or productive activities.
3. VOT for CV is directly related to the underlying business structure in which a CV unit constitutes a production input as opposed to passenger VOT which does not necessarily represent an element in an economic or production process. VOT is found to depend on the business and operational attributes of the commercial vehicle operator.
4. Goods movement is more complex than passenger travel. Collecting and organizing data to understand and model freight transportation is a daunting task due to the multitude of vehicle types, shipment, business structures, logistic supply chains, attributes of trade routes, and the secrecy of information due to business competition.

A detailed review of the literature of VOT measurement for CVs is summarized in Table 1. The monetary values are expressed in terms of 2008 (midyear) CAD Dollars per hour. The transformation from historical values reported in the literature is conducted in two dimensions. *First*, the VOT is transformed from the study year to 2008 using historical inflation data or operating cost trends for the country of study. Inflation data as obtained from the companies respective economic statistics. Cost trends for Canada and the US were obtained from the study of truck operating cost in Canada [26]. *Second*, the VOT is transformed to 2008 CAD Dollars using exchange rate reported by Bank of Canada [27]. It is noteworthy that one of the key studies in the literature was conducted in British Columbia, Canada by Waters et al. [28].

Table 1: Value of Time for Commercial Vehicles in the Literature (Adjusted for mid-year 2008 Canadian dollars)

Study Authors	Value of time estimate (2008 CAN $)	Method of Measurement	Country/Region
Waters et al. [28]	15.4	*N/A*	Australia
"	19.2	*N/A*	Sweden
Bickel et al. [29]	19.3	*N/A*	Finland
Waters et al. [28]	21.85	*N/A*	Norway
Bickel et al. [29]	23	*N/A*	Germany
Waters et al. [28]	27.8	Average over several states	US
Adkins et al. [30]	30.1	Cost Savings	US-Pacific Region
Kawamura [6]	33	Stated Preference	US
Haning and McFarland [25]	36.5	Revenue	US
Waters et al. [28]	6.7 to 38.1	Revenue	British Columbia
"	37.5 (2-axle diesel truck-Bulk)	Revenue	British Columbia
"	45.7 (7-8 axle truck-Bulk)	Revenue	British Columbia
"	52.6 (7-8 axle truck-general freight)	Revenue	British Columbia
De Jong and Gommers [31]	46.1	Stated preference	Netherlands
Waters et al. [28]	46.4	*N/A*	Ontario
De Jong and Gommers [31]	48.8	*N/A*	UK
De Jong and Gommers [31]	48.8	Revenue	Netherlands
Smalkoski and Levinson [32]	54	Stated Preference (Adaptive)	US
Brand et al. [7]	80	Unidentified	US
Wynter [33]	123+/-85	Willingness to pay	France
	Average: CAD 47/hour		

METHODS FOR CALCULATING VALUE OF TIME

There are four methods reported in the literature for measuring VOT for CV [6]:

1. Cost Savings Method [34]: which equates the VOT to the reduction in operating cost per unit time saving that accrues to operators. It follows the concept that shorter delivery time of goods enables the delivery of the same business output at a reduced level of resource allocation.

Adkins et al. [30] found that the share to total CV transport cost is 74% for driver's wages, 16.2% for vehicle depreciation, 3.5% for interest on capital cost, 5.3% for other driver's benefits, and 1% property taxes.

2. Revenue Method [35]: which measures the VOT in terms of the additional revenue generated by freed resources, e.g. drivers and transportation units. The VOT calculated based on the revenue method is closely related to the level of time utilization of the evaluated carrier business as well as the market demand for the business service. Waters [28] estimated VOT based on the driver's valuation of leisure time (40% of average driver wage).
3. The Cost-of-Time Savings Method [36]: which estimates the VOT based on the additional business investment required to cut down travel time by a unit value.
4. The Willingness to Pay Method: which measures the perceived VOT by the motor carrier industry based on stated or revealed preferences that involve a trade-off between investment cost and travel time reduction. This method measures the cost that business operators are willing to incur in order to reduce travel time. Several data collection schemes can support this method, e.g. alternate mode of transport [37], alternate speed of travel [38], alternate route [39], and stated preference survey.

PREFERENCE SURVEYS

This is the most useful form of data for VOT estimation in the disaggregate form which enables the formulation of different VOT estimates for various data segments. Data can be stratified according to criteria such as business type and size, shipment information, contractual details, etc. One of the most straightforward VOT estimates can be based on business preferences revealed from examination of business choices and decisions. Disaggregate data is however expensive to collect and difficult to make public in all its components due to the competitive nature of the motor carrier industry.

One of the most suitable data collection methods is stated preference (SP) surveys, in which respondents are asked to indicate their selections of alternatives for hypothetical situations. Stated preference surveys enable the collection of multiple responses from a single subject in a short period of time, thus making the best use of available resources. Obtaining VOT estimates from the analysis of actual business decisions i.e. revealed preference (RP), with adequate representation of different business types is expensive. In addition, conducting revealed preference surveys by collecting real-world business data is especially challenging because of the competitive nature of the motor carrier industry in which business information can erode a firm's competitive edge. Calfee and Winston [40] discussed the bias in VOT estimates based on revealed preference surveys due to unobservable travel attributes. They indicated that the main objective of some roadway improvements is to derive VOT from the user preference for paid-uncongested over free-congested travel alternatives. Therefore, in a SP survey, there is facility to inquire about these travel alternatives that may not necessarily be available for the user at the current situation. In summary, developing VOT estimates based on revealed preference data involve the following issues: 1) lack of control for qualitative variables such as convenience, familiarity, and comfort which yield upwardly biased estimates, 2) Colliniarity between trip cost and value of time. SP survey can account for these challenges by asking about hypothetical situations that can by design control for travel attributes and thereby yield precise estimates. SP survey also enables the designer to control for external influence, thus the observed relationships are based on valid and reliable inferences [41]. This is possible by allowing the analyst to ask several questions about specifically designed cases instead of a single inquiry about extant cases. This study relies on a SP survey for data collection.

SP surveys however provide the previous advantages at the cost of several biases. First, collected responses may not reflect actual choices taken by a firm in real-world conditions. This may be caused by

the fact that a respondent does not consider the faced hypothetical decision case as seriously as in true practice. Second, respondents may willingly report inaccurate responses as a means of making a political statement, to influence the survey result, or to protect actual firm's information.

PREVIOUS STUDIES OF VOT USING STATED PREFERENCE DATA

Recent studies of the VOT for CVs have used the SPs of CV operators and/or planners in valuating CV time. Kawamura [6] conducted in-person interviews with CV operators in California. In this study, they indicated their preferences in hypothetical situations that involve a trade-off between travel time savings and business investment. The researcher tested the variation of VOT estimates among CV operators based on the CV fleet characteristics, cargo type, and business attributes. The response rate of the survey in this study was approximately 20%.

Brand et al. [7] reported the details of estimating the VOT for CVs in evaluating the benefits of ITS technologies in providing expedited inspection and clearance service for CVs. The study was based on operation and maintenance cost reported earlier by Fokenbrock [42]. An estimate of $10/hour was added to represent the value of freight. The final estimate was $80/hour in 1999 US Dollars. This value can be converted to 2005 US Dollars taking into account an accompanying 1.4% decline in operating cost from 2000 to 2005[2]. Furthermore, after converting the VOT estimate in 2005 to 2008 using inflation data and to Canadian dollar using average exchange rate in 2008, a final estimate is $80 in 2008 CAN Dollars. The same approach was used to convert VOT estimates in previous studies.

Smaloski and Levinson [32] performed a study for estimating VOT for CVs operating in Minnesota. The response rate in this study was 20%. A variant of SP survey was adopted in which the interviewee is faced with a list of questions of a specific question depend on the answers recorded for preceding questions. This adaptive strategy of formulating SP questions, in theory, enables the designer to bracket the true VOT quicker and with higher precision. Findings from this study are included in Table 1.

The Design and Conduct of a Stated Preference Survey

BACKGROUND

Limited number of studies can be found on estimating the cost of cross-border delays for commercial traffic. Fox et al. [43] used simulation analysis to estimate the cost of the border crossing activates on the Mexican-US trade. This study however was challenged on several accounts. *First*, the cost components included in this study consisted primarily of nontariff border crossing services that are paid for by shippers. *Second*, the warehousing and inspection activities considered in this cost measurement reflect, as argued by the authors, inefficiencies in the border clearance system. Third, the main target of the study was not to evaluate the general value of time for carriers or shippers, but rather cross-border trade barriers that can potentially be eliminated in order to create benefit to the cross-border economic activities.

One of the key questions regarding cross-border transit time is the cost of border delays imputable to the US-Canada economic activities. Taylor and Robideaux [44] estimated the economic cost of the impedance to cross-border commercial traffic. The cost categories of the cross-border trade in this study were as follows:

1. Carrier related cost (46.5%):
   1.1. Primary inspection transit time (17.4%)

1.2. Secondary processing time (40.5%)
1.3. Excess plan time (buffer time to account for transit time uncertainty, 23.3%)
1.4. Reduced cycle and other related costs (6.4%)
1.5. Driver documentation/fax time (13.4%)

2. Manufacturer related cost (49.5%):
   2.1. Manufacturer Lost Sourcing Productivity (77%)
   2.2. Benefits (23%)
3. Personal traveler related (4%)

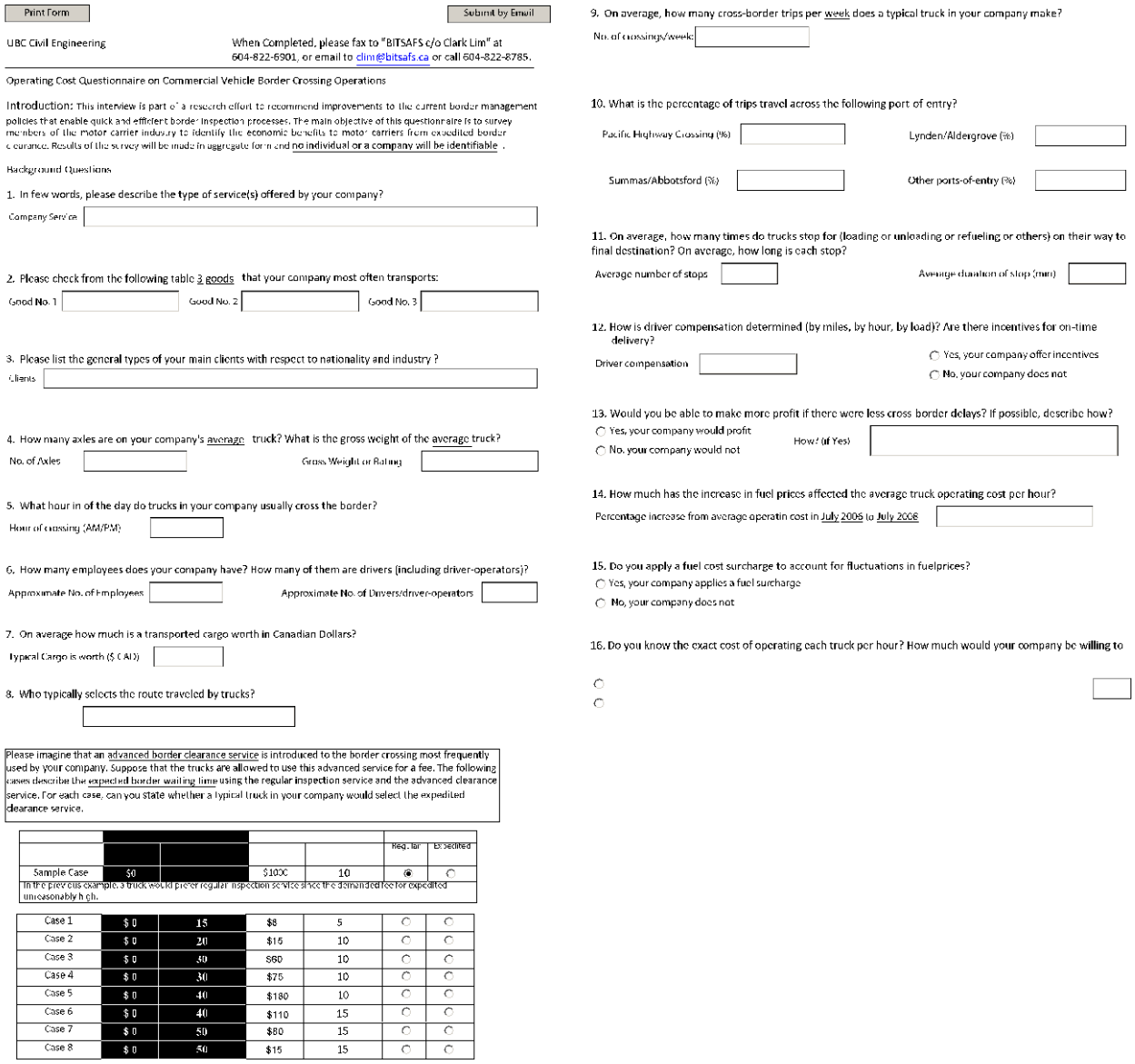
The estimated cost to the bi-national economies in terms of the foregone jobs and lost productivity were US $10.3 billion. The Canadian share of these losses is estimated based on her respective share in bi-lateral trade which amounts to 60% ($5.17 billion) of the total trade volume. Taylor and Robideaux [44] adopted a midrange hourly cost of transit time for commercial vehicles of US $150/hour (2008-CAD $161/hour). Another report, ICF Consulting [45] suggests a cost of US $371/hour (2008-CAD $400/hour) for unscheduled delay time. Roeolfs and Springer [46] investigated congestion pricing options for expediting border inspection service. In this study, the adopted VOT for CVs was US $200/hour (2008 CAD $194/hour). However, other studies of the benefit of border inspection time savings for CVs, e.g. Jensen et al. [47], adopted a much lower VOT – 2003 US $36/hour (2008 CAD $39/hour) for light CVs and 2003 US $45/hour (2008 CAD $49/hour) for heavy CVs.

As illustrated, there is limited and relatively inconsistent on the VOT for CVs at international border crossing. The few studies that explicitly indicated a valuation of time were based on anecdotal references to previous studies that were not mainly conducted for measuring VOT for CVs at border crossings. Furthermore, the majority of studies reviewed in previous sections that attempted to quantify the VOT for CVs were based on average driving conditions with no particular focus on the context of border delays. The following characteristics of cross-border CV traffic set the latter apart from other operational contexts of CVs:

1. Border delays are unavoidable in absolute terms. That is, CVs are bound to incur some delay at the border for declaring the minimum amount of information necessary for clearance. The duration of delay however is attribute-dependent not only congestion-dependent.
2. Security parameters play a vital role in CV inspection duration and decision.
3. The distinct business structure of cross-border motor carrier operators sets apart the measurement of the economic cost of border delays and other congestion conditions.

SURVEY DESIGN

Based on previous assessment of the relative merits of VOT measurement methods, SP was selected. The overall merit of the method is reflected in the preference for this analysis method in the majority of recent studies. The objective of the survey is to query motor carrier operators for information that can be subsequently used to infer their perceived VOT at the border. The SP survey was designed in the form of a series of questions that target the following objectives: first collecting enough information about each carrier subject's business structure and operation conditions. Second, the survey aims at drawing answers from interviewed operators that involve some trade-off between transit time saving and expedited service expenditure. The survey forms are shown in Figure 1.



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Operating Cost Questionnaire on Commercial Vehicle Border Crossing Operations

Introduction: This interview is part of a research effort to recommend improvements to the current border management policies that enable quick and efficient border inspection processes. The main objective of this questionnaire is to survey members of the motor carrier industry to identify the economic benefits to motor carriers from expedited border clearance. Results of the survey will be made in aggregate form and no individual or a company will be identifiable.

Background Questions

1. In few words, please describe the type of service(s) offered by your company?

Company Service

2. Please check from the following table 3 goods that your company most often transports:

Good No. 1 | Good No. 2 | Good No. 3

3. Please list the general types of your main clients with respect to nationality and industry ?

Clients

4. How many axles are on your company's average truck? What is the gross weight of the average truck?

No. of Axles | Gross Weight or Rating

5. What hour in of the day do trucks in your company usually cross the border?

Hour of crossing (AM/PM)

6. How many employees does your company have? How many of them are drivers (including driver-operators)?

Approximate No. of Employees | Approximate No. of Drivers/driver-operators

7. On average how much is a transported cargo worth in Canadian Dollars?

Typical Cargo is worth ($ CAD)

8. Who typically selects the route traveled by trucks?

Please imagine that an advanced border clearance service is introduced to the border crossing most frequently used by your company. Suppose that the trucks are allowed to use this advanced service for a fee. The following cases describe the expected border waiting time using the regular inspection service and the advanced clearance service. For each case, can you state whether a typical truck in your company would select the expedited clearance service.

	[redacted]	[redacted]			Regular	Expedited
Sample Case	$0	[redacted]	$100	10	◉	○

In the previous example, a truck would prefer regular inspection service since the demanded fee for expedited unreasonably high.

	[redacted]	[redacted]				
Case 1	$ 0	15	$8	5	○	○
Case 2	$ 0	20	$15	10	○	○
Case 3	$ 0	50	$60	10	○	○
Case 4	$ 0	30	$75	10	○	○
Case 5	$ 0	40	$180	10	○	○
Case 6	$ 0	40	$110	15	○	○
Case 7	$ 0	50	$80	15	○	○
Case 8	$ 0	50	$15	15	○	○

9. On average, how many cross-border trips per week does a typical truck in your company make?

No. of crossings/week:

10. What is the percentage of trips travel across the following port of entry?

Pacific Highway Crossing (%) | Lynden/Aldergrove (%)

Summas/Abbotsford (%) | Other ports-of-entry (%)

11. On average, how many times do trucks stop for (loading or unloading or refueling or others) on their way to final destination? On average, how long is each stop?

Average number of stops | Average duration of stop (min)

12. How is driver compensation determined (by miles, by hour, by load)? Are there incentives for on-time delivery?

Driver compensation

○ Yes, your company offer incentives
○ No, your company does not

13. Would you be able to make more profit if there were less cross border delays? If possible, describe how?

○ Yes, your company would profit
○ No, your company would not

How? (if Yes)

14. How much has the increase in fuel prices affected the average truck operating cost per hour?

Percentage increase from average operatin cost in July 2006 to July 2008

15. Do you apply a fuel cost surcharge to account for fluctuations in fuelprices?

○ Yes, your company applies a fuel surcharge
○ No, your company does not

16. Do you know the exact cost of operating each truck per hour? How much would your company be willing to

○
○

Figure 1 Stated preference survey 3-page form. Forms were distributed by e-mail to members of the British Columbia Truck Association.

In the third page of the survey, the carrier operator or trip planner is faced with the hypothetical inspection service that is able to reduce the border crossing time per truck in exchange of a participation fee. Each expedited service enrolment selection is based on an assumed VOT that is perceived as higher than the participation fee. If the carrier operators opted for regular inspection service, the underlying VOT is most likely less than the required participation fee. The VOT values used to create the SP questions, that is define the break-even VOT at which the interviewee are invariant to the purchase of expedited service or using regular inspection service, were selected within a range of values from $50 to $250. The rationale behind this range of selection is based on VOT estimates in the literature and preliminary phone interviews with personnel at provincial advocacy institution (BCTA).

Each Yes-or-No question in the SP survey probes the interviewee's VOT as to whether it is higher or lower than a specific value. Adaptive SP is an effective strategy that was employed in a similar study [32] in order to obtain VOT estimates at higher precision with the same number of inquiries. According to this method, a current VOT inquiry adapts to the information given in previous answers so that the assumed VOT of the inquiries is concentrated around the true value instead of being uniformly distributed along the entire range of values. This approach however cannot be followed without a prior setting of an on-phone or in-person interview with the company's representative. A feedback channel was embedded in the survey form that enables the subjects to contact the research team to arrange for an in-person or on-phone interview.

In order to elicit information from personnel unwilling to participate in an adaptive SP survey, a list of eight questions (revised from twenty) were prepared for the purpose of a regular SP survey. The underlying VOT were selected from equal intervals within the range of $50 to $250 CAD $/hour. The questions were then randomized and included in the survey form. The previous questions were compiled into a fillable form that can be faxed or e-mailed back to the research team.

DATA COLLECTION METHOD

The survey was sent out via the communication network of BCTA, a non-profit association that advocates the trucking industry in British Columbia and holds the membership of 273 Individuals (companies – motor carriers) that operate across the border. Based on previous mail-in and e-mail surveys, the expected response rate was from 10 to 15%. The actual number of responses was 15, which represents approximately 4% of the total number of cross-border carrier members. Based on on-phone discussions with subjects that indicated willingness to follow up on the survey, the following reasons could be behind the relatively low response rate:

1. The subjects perceived the hypothetical situations presented in the stated preference survey as an overture to additional charges for new or current special border inspection service. Since many respondents indicated that they had already enrolled in one or more special border crossing service, they were explicit in indicating that their businesses cannot absorb additional charges.
2. The original list of question was too long (20 questions). Although, the second version included only 9 questions, it is likely the survey form was not reviewed twice my some potential subjects.
3. The true VOT of the carriers was outside the assumed range (CAD $50-$250/hr) - likely less than the lower value. The majority of BCTA carrier members are small- to medium-sized operators and their VOT, if expressed in terms of operating cost per hour, could be comparable to lower end VOT estimates in the literature. None of the respondents however reported a VOT less than CAD $50, which leaves this explanation undecided without further investigation.

RESULTS

The responses to both survey versions were received primarily by e-mail. Follow-up phone calls were conducted with subjects who expressed willingness to provide further data. Responses to the first question confirmed broad business background that the survey subjects possessed. Three respondents have no particular specialty and offer general freight service. Two respondents carry bulk commodities and a similar number of carriers operate tank trucks and heavy equipment. The rest of the respondents carry an assortment of trucking service such as roll-off containers, flat-deck services, fuel, dangerous goods, hazardous and non-regulate chemicals, biomedical waste, seasonal liquid asphalt, and propane.

Responses to the second question are summarized in Figure 2. Based on the reported number of axles and gross vehicle weight, the majority of respondents operate heavy CVs. This finding is consistent with previous traffic surveys at the border in which there were nine times as many heavy trucks (> 24 tons) for light trucks [47]. The majority of CVs operated by the surveyed companies departs in early hours. Consistently, the majority of interviewees indicated that arrival times at the border are earlier than the start time of the expedited inspection service. The interviewed company representatives represented a medium to large size enterprises which is reflected in the total number of employees and drivers shown in Figure 3 and Figure 4 as well as the cargo worth shown in Figure 5.

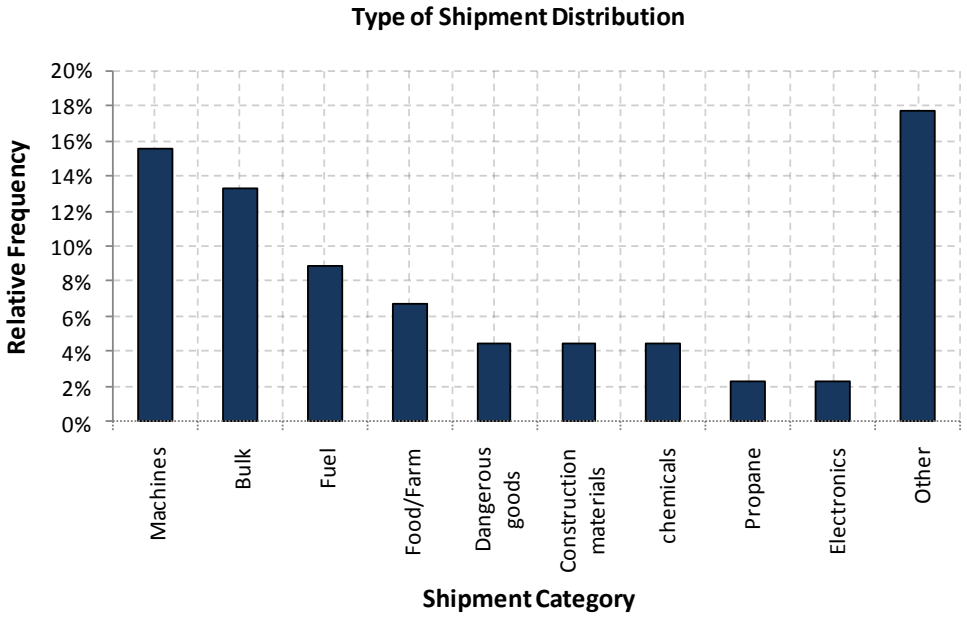

Figure 2 Distribution of the type of shipments among respondent carriers.

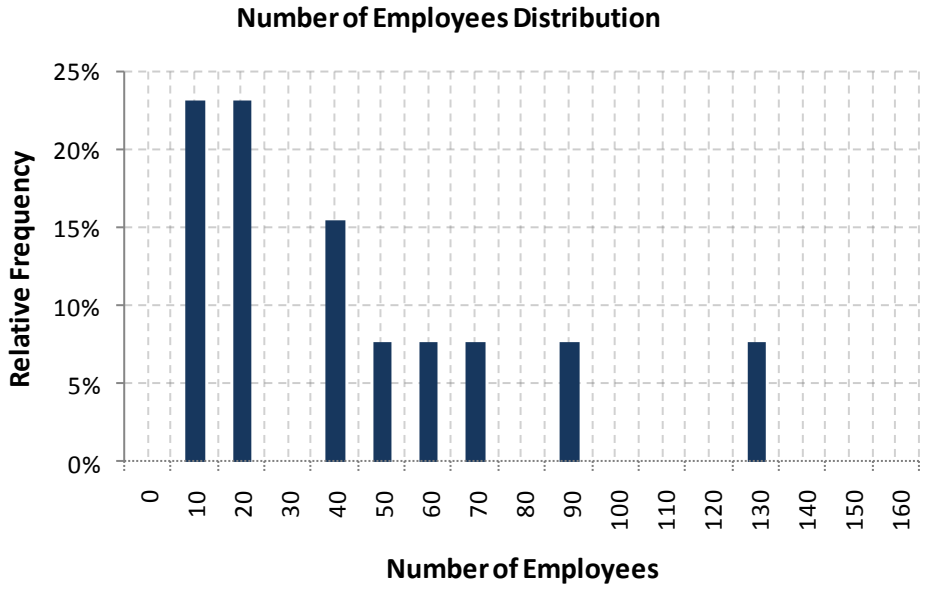

Figure 3 Distribution of the total number of employees in a company.

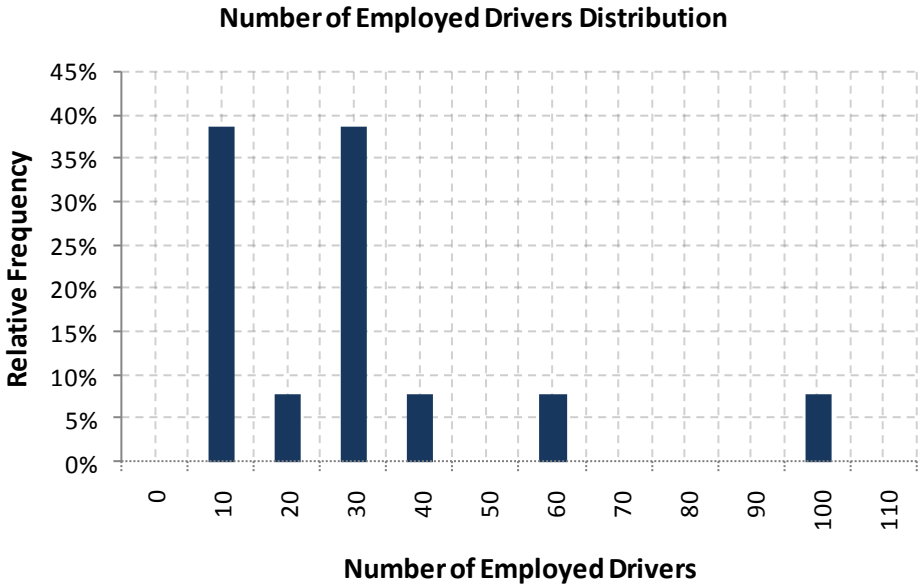

Figure 4 Distribution of the total number of drivers and owner-operators hired by the company.

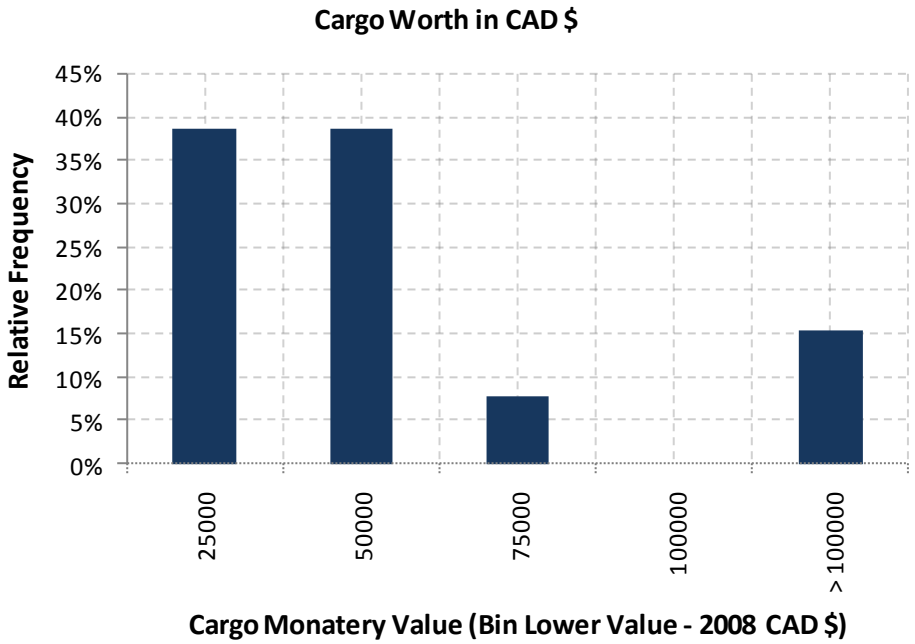

Figure 5 Distribution of the monetary value of shipments.

One of the objectives of collecting carrier background information is to investigate the variability in VOT perception depending on the personnel responsible for trip planning and scheduling. The subjects were asked to indicate the trip planning personnel of mechanism in their companies. The majority of subjects (42%) dispatches CVs to the point of loading and hence follows a prescribed route as requested by the client. There was an almost even distribution of planning role among managers and drivers as well as adherence to fixed routes.

One of the likely determinants of the perceived VOT at the border is the frequency of border crossing. From a business perspective, the benefit that materializes to the carrier from a fixed investment in expedited service program will be multiplied by the number and frequency of service utilization. Carriers that operate frequently across the border are more likely to enroll in expedited service, and the opposite is correct for low-frequency users. The degree to which this preference is based on benefit multiplication or an intrinsic relationship between the VOT and the frequency of border crossing can be investigated based on data obtained in this survey. Figure 6 shows the distribution of trip frequency per week.

Drivers may not be able to derive benefit, aside from leisure time, if they are compensated per unit distance. On the other hand, drivers compensated per unit time may fail to receive benefit from expedited service. As was obtained from in-person interviews, some carriers structured their compensation method such that drivers are paid a fixed share from the generated revenue. In this compensation mechanism, carriers may not incur any additional salary-related cost from border delays and, therefore, may possess different VOT. A similar determinant of driver compensation is whether they receive additional revenue by on-time delivery. In this compensation mechanism, drivers may derive yet more benefit from expedited service since, as discussed before, some of the benefit of expedited service is the ability to prepare tight delivery schedules based on shorter buffer time. Based on the type of compensation, 57.1% of drivers were compensated per hour, 35.7% were compensated per load and the rest compensated per mile. 71.4% of drivers do not receive incentive for early delivery.

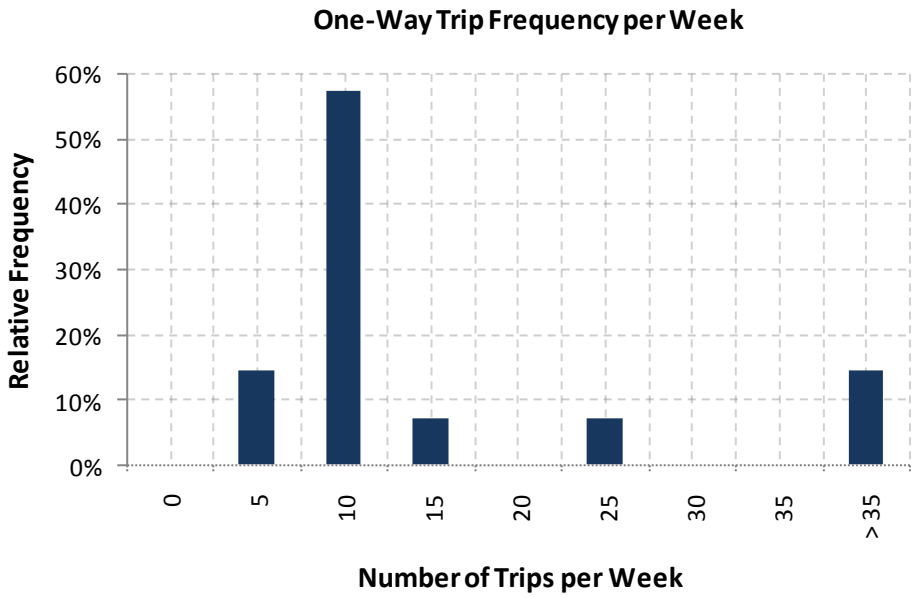

Figure 6 Distribution of one-way trip frequency per week.

Amid an increasing fuel prices, during the survey time, it was important to investigate the effect of fuel price increase on CV operating cost. The survey included inquiries regarding the escalation in operating cost over the past two years. The average reported increase in operating cost attributable only to fuel price escalation was 28%. As also shown in Figure 7, the average rise in fuel prices from June 2006 to June 2008 is about 24% [48]. Given the low response rate to this survey, the previous comparison does not attempt to investigate the impact of fuel prices on operating cost, but it confirms that the latter was

significantly influenced by escalation in fuel prices despite that fact that two third of respondents pass some fuel expenses to clients.

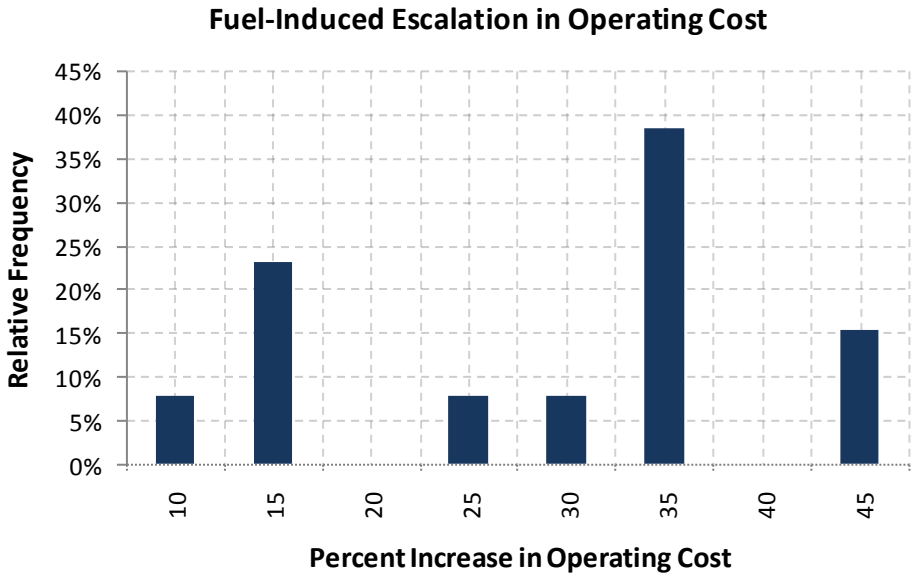

Figure 7 Distribution of how survey subjects reported the escalation in their company's operating cost per truck due to concomitant increase in fuel prices.

A preliminary inquiry into the VOT of the surveyed subjects was included in order to assess the reliability of the SP expressed in ensuing section. A trip planner that bases her decision on an estimate, irrespective to the accuracy thereof, of the CV operating cost is likely to give more reliable answers in the subsequent section. In addition, the value of time that is readily obtained from this inquiry can be contrasted with the VOT deduced from SPs. Approximately, two third of respondents indicated they know the operating cost per hour.

For each question in the SP survey, there is an underlying VOT that disables the subject from preferring regular service over expedited service and vice versa. Among all the received responses, there were only three informative answers (20% of total responses) for the SP section. For each of these answers the switching point VOT was estimated within a specific range. This range is defined as the interval bound by the underlying VOT for the two successive, in terms of the underlying VOT, questions that have different preference as to expedited inspection service compared to regular service. The interval for each response was therefore determined as shown in the first three entries in Table 4.2. In addition, the charge per hour for border delays that carriers pass to clines was used as an estimate of the market VOT. These values were obtained from follow-up on-phone interviews with willing carrier representatives. The range of estimates obtained from the on-phone interviews is shown in the second three lines of Table 2.

Due to the low response rate experienced in this survey, the research team was unable to use more advanced statistical methods, e.g. [32], to measure the VOT from the SP responses. Instead, a weighted average was calculated for the midrange VOT value of each response. The weights were selected as number of employed drivers, the numerical value of the cargo monetary worth, and the number of

border crossings per week. The per-hour weighted average VOT estimate approximated to the nearest $10 is $100-$125.

Table 2: Value of Time Estimates (2008 CAD $ per hour) Obtained from the Stated Preference Survey and On-Phone Interviews

VOT (CAD $ per hour) High Value	VOT (CAD $ per hour) Average	VOT (CAD $ per hour) Average	No. Drivers	Cargo worth (CAD	Crossings per week
$100	$110	$120	23	$2,000	1
$80	$80	$80	52	$33,000	14
$68	$77	$85	9	$30,000	7
$103	$112	$120	8	$30,000	7
$93	$116	$138	25	$20,000	5
$120	$135	$150	12	$350,000	3
			99.1	124.9	95.4
Approx. Weighted Average (CAD $/hour)			**100**	**125**	**100**

Conclusions

To the authors' knowledge, this study is the first of its kind that attempts to measure VOT specific to border delays using a stated preference survey. Estimates available in the literature, as discussed previously, were not obtained from a user survey specific and dedicated to border crossing operations. The estimated VOT in this study is at variance with values adopted in similar studies in the literature. In addition, the general-freight VOT found in the literature, as summarized in Table 1, represented by the average value of 2008 CAD $ 47 per hour, is almost half the VOT estimated in this study (CAD $100-125 per hour). This finding suggests that the adoption of general VOT for CVs in evaluating border studies may result in underestimating the benefits that accrues to motor carriers, and therefore the society, from implementing expedited border inspection programs. This study however is based on a small sample size drawn from a yet limited segment of motor carriers operating in Canada. This study could remarkable benefit from an increased response rate as well as inclusion of other segments of the motor carrier industry, e.g. driver-operators, in the surveyed sample. Three main conclusions can be drawn from this study:

1. The questions of the stated preference survey should avoid giving the false impression of forthcoming increase in border crossing service charge.
2. The evidence obtained in this study suggests that there is a difference between value of time for transporting general freight and that spent at border crossings.
3. The survey should be distributed to a wider base of commercial vehicle operators that includes owner operators. For instance, this class of operators runs a relatively small business size, makes less profit, and may therefore have lower valuation of time.

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