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ABSTRACT

Service times at vehicle processing facilities (borders, weigh stations, landside marine port gates) are variable, thereby causing transportation planning challenges for carriers that visit them on a regular basis. Carriers must either build in more time than is necessary, therefore underutilizing their equipment, or risk missing delivery windows, which can result in fines or cause lost business opportunities. In this study, border crossing times at Blaine, Washington, are examined. The variability in crossing times at this border crossing, and the impact of this variability on regional supply chains is considered for bi-directional trade. Directional, daily, hourly, and seasonal variations are examined. Interviews with regional carriers were conducted to better understand the current response to variability, the benefit of a reduction in variability, and how this is related to the goods moved or to other business operating characteristics. This paper describes the level of variability in border crossing times and describes carriers' responses to this variability. It is demonstrated that the primary strategy used, increasing buffer times, reduces carrier productivity. However, this cost is negligible due to the current nature of the market.

1. INTRODUCTION

The US and Canada are each other's biggest trading partners. The value of trade between the two is the largest between any two countries worldwide. For the US, trade with Canada is larger than combined trade with all of the countries in the EU [3]. The volume of freight moved by the U.S. transportation system has grown dramatically in recent decades and is projected to grow nearly 50 percent between 2005 and 2020 [3], [15]. Supply chains in many manufacturing sectors span the Canada – US border daily, and bilateral trade agreements between the two countries made a point of reducing tariff barriers. The Pacific Highway border crossing at Blaine, Washington, is the main commercial crossing between Whatcom County, Washington, and the Lower Mainland of British Columbia. It is the fourth busiest commercial crossing on the Canada – US border [1], and the most significant commercial crossing for the Western portion of the US and Canada. The crossing is approximately 100 miles north of Seattle and 30 miles south of Vancouver, B.C., on Washington State Route 543 and B.C. Provincial Highway 15. The Blaine crossing, as well as many others, is congested during peak

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periods. Transit times can be long and unpredictable [20, 21]. The two major reasons for time delays are the lack of investment in physical infrastructure, and time consuming customs and immigration procedures, including Food and Drug Administration (FDA) inspections for goods entering the US.

International border delay is perceived as a major problem. The province of Ontario has carried out a significant amount of work in an attempt to quantify the impact of border delay on their economy [8]. Ontario and the states surrounding the Great Lakes area have formed a regionally integrated economy that is very dependent on the ability to move goods efficiently across the border. A recent report by the Ontario Chamber of Commerce finds that the US economy absorbs 40 percent of the current cost of border delays ($4.13 billion/year and $471,461/hour); unless improvements are made on regional border issues, the US stands to lose 17,345 jobs by 2020. With future trade expected to grow 180 percent by 2015, without investments and improvements in cross border trade, Ontario will likely "suffer tremendous economic and social costs." Because of this, Ontario has deemed it important that its border remain free from delays [20].

The terrorist attacks of September 11, 2001 focused attention on border security, and resulting legislation has changed security processes. Many changes have occurred at the border, including the Advanced Electronic Presentation of Cargo Information (ACE) under the US Trade Act, Customs-Trade Partnership Against Terrorism (C-TPAT), Free and Secure Trade (FAST), and US FDA prior notice arrival. In addition, there have been recent increases in cross-border trade. These changes drew attention to the question of border delay [14, 29]. At the same time, the liberalization of trade policies, such as NAFTA, internationalization of supply chains, and changes in transportation and information technologies have contributed to this growth in freight movement. North-south traffic between the US and Canada, fostered by NAFTA, has placed increasing demands on the domestic freight transportation system. US – Canada trade has grown by 152 percent since 1989 (growth in commercial traffic of 122.5 percent), and trucks move just over 70 percent of the value of exports from the US to Canada [21]. As a result, the nation's highway and rail networks, initially developed for the traditional east-west trade, are now strained, especially at border crossings such as those between Whatcom County and the Lower Mainland of B.C. (see Figure 1) which includes the Blaine crossing.

One of the most significant challenges for private industry is planning for uncertainty in travel time. Late arrivals can have significant economic

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Figure 1: Border crossings between Whatcom County, WA, and the Lower Mainland of B.C.

costs for factories waiting for parts to assemble, as well as for carriers who miss delivery times. This makes reliability one of the single most important performance measures from a private sector perspective [2, 22]. Uncertainty in travel times is caused by many factors including mechanical failures, bad weather, documentation delays, and traffic incidents, but also by unpredictable traffic congestion when demand for a transportation service is greater than the supply of that transportation service. This happens on roadways, as well as at our ports and borders. Provisions of infrastructure and staff resources at the Blaine border crossing do not allow capacity to meet demand during peak periods. When the transportation system becomes unreliable, freight-related businesses and their customers are potentially affected in several ways. First, freight assets such as trucks and drivers become less productive. Second, businesses put more trucks on the road to meet their customers' needs. Third, costs associated with warehousing inventory increase. The extent to which reliability affects the freight transportation system depends on how freight forwarders respond. For example, those with very low risk tolerance are more significantly affected, as they need to plan for worst case scenarios, but those more accepting of a late delivery see a smaller impact. Understanding the variability in border crossing times, and its cost

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to freight forwarders, is essential to matching infrastructure supply with demand, assessing potential operational strategies, and prioritizing investments.

The issue of border crossing time variability is therefore very timely, and it is anticipated that the issue will only become more pressing for the industry. The paper begins with a review of the related literature. The variability in border crossing times is quantified, assessing the impact of season, day of the week, and time of day. The results of in-person qualitative interviews with carriers that frequently move goods across the border are presented. Carriers employ a range of strategies, especially those that frequently cross the border, to reduce crossing time variability and the resulting costs and consequences for their business. Finally, the economic consequences of variability are considered.

An important distinction to emphasize at the outset is one between *average* time to cross the Canada – US border at a specific site and the *variability* around the average time needed to cross. The focus of this study is on the latter, although there is a statistical linkage between the two. As is demonstrated by empirical data, longer average crossing times are associated with greater variability around the average. In this paper, a distinction is drawn between the two, although interviewees were more inclined to discuss the average, due to the magnitude of frustration with the average delay, rather than the variability in delay. This in and of itself is an interesting result of the research.

2. CONTRIBUTIONS

This paper offers the following contributions to the existing body of knowledge:

1. Identify the level of variability in border crossing times and the relationship between variability and season, time of day, and border processing (FAST or nonFAST).
2. Identify the strategies used by carriers to manage border crossing time variability.
3. Evaluate the cost of crossing time variability given the nature of the industry in the Pacific Northwest.
4. Identify the differential impact of variability between US and Canadian carriers and carriers with various logistics structures.
5. Demonstrate that FAST lane wait times are shorter than nonFAST wait times due to processing time rather than arrival rate.
6. Present carriers' perceptions of the border and their relative value of border processes.
7. Provide data to support the conclusion that variability in border crossing times is not currently a significant cost for regional carriers to bear.

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3. LITERATURE REVIEW

The most relevant work to our research is a study for the Michigan, New York State and US Departments of Transportation concerning the total cost of highway border crossing delays as well as related costs of maintaining a border. Unlike other studies, this study includes uncertainties in transit times when estimating the cost to US and Canadian economies [25]. However, this study did not consider the structure of supply chains or the potential for employers to change their logistics operations in response to border travel time uncertainty.

The relevant literature for this project spans many topic areas including travel time reliability, metrics for supply chain management, the value of time for freight movement, reliability in freight transportation, and studies specific to border crossing. A summary of some representative articles from each of these topics is described below.

3.1 Travel time reliability

Travel time reliability is an element of transportation system performance that is generally measured according to buffer time or buffer time index [10, 19, 26, 27]:

- Buffer Time - a measure of travel reliability calculated by ranking crossing times of individual trucks at each port of entry. It is the difference between, say the 95th percentile time (any percentile could be used) and the average time for all trucks—it represents the 'extra time' a driver must budget to cross the border at the average time with a 95 percent certainty.
- Buffer Index - the buffer time expressed as a percentage of average time. This is the measure that will be most comparable on an annual basis and between crossings as it standardizes the measure by removing variables such as crossing length.

Travel time reliability has become an increasingly important metric for passenger transportation and has received significant research attention [5, 6]. For freight carriers, significant variations in travel time can impact inventory planning and the efficient use of transportation infrastructure, particularly for time-sensitive goods due to value, perishability or business operating characteristics (such as just-in-time operations) [30]. New technologies are being developed and tested as data collection methodologies to cost effectively measure transportation system performance characteristics such as truck volumes, mean travel times, and 80th and 95th percentile travel times.

3.2 Metrics for supply chain management

Modern supply chains are data

rich – for example, shipment dates, inventory levels, and dwell times are easy to calculate [24]. Companies that outsource transportation services to another provider often use these statistics to measure the performance of their contractor. However, there is very little literature available concerning system design and measures selection. Instead, the literature focuses on higher-level metrics. Recent papers suggest a systems-thinking perspective and process-based models are a more holistic perspective better employed in the use of performance measures in supply chain management because they span all business aspects involved in the supply chain [16, 18].

3.3 Value of time for freight movements

Significant work has been done to estimate the cost of delay (typically from congestion) to the goods-movement industry, although significantly less work has been done on the value of freight as compared to passenger time [17, 18]. While issues related to freight value-of-time are somewhat similar to passenger value-of-time, they differ in several important aspects [7]. For example, travel time savings for passengers may be a direct or indirect function of the utility as a resource constraint on traveling decisions. For freight, however, this is an indirect value—time is a resource used in the production function. Freight transport also has several actors, making it difficult to identify a single decision maker and the actual agent who will take advantage of time savings. Another reason why the topic has not been investigated in as much detail is that reliable and complete information on freight transport generally is not available. In addition, heterogeneity of shipments requires a higher number of attributes to characterize a shipment than passenger trips. Freight value-of-time is typically calculated using the following three components:

- value-of-time savings for the driver;
- savings of vehicle operating costs;
- value-of-time savings to the freight carried.

Unfortunately these estimates ignore the dynamic environment of freight transportation where delay such as variability might cost carriers through lost business opportunities, late fees, schedule changes or changes to their logistics structure. This is recognized in some articles [34], but a thorough classification of the impacts or an estimate of their value does not exist. One article [23] does provide a specific value for schedule delay. It is widely agreed that the measurement of time delay and its associated costs needs further refinement with rigorous analysis.

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Within this framework, typical estimates of the value of freight congestion range from $25 to $200 per hour depending on the product being carried. [32, 17, 16, 29, 28, 20]. It is recognized that the value of reliability for trucks is another 50 to 250 percent higher [32]. For example an NCHRP report estimates the cost of delay between $144.22 to $192.83 per hour depending on the commodity, and savings in late schedule delays at $371.33/hour [23]. An Australian survey used a contextual stated preference method to survey shippers about freight transit time and reliability. In this study, the value of time falls as the distance of the shipment increases. Results showed that metropolitan freight travel time is more highly valued than that of intercity or urban freight movements, and that intercity reliability is more highly valued than that of urban or metropolitan freight movements [33].

3.4 Reliability in freight transportation

Given recent terrorist activity and extreme weather events, a significant amount of attention has been paid in the literature to addressing the reliability of supply chains [4]. While relevant, this work has focused upon how companies should organize to anticipate and respond to disruptions, rather than on understanding the magnitude of recurrent delays such as border crossing times.

3.5 Border crossing time studies

There are several reports from efforts by government agencies on both sides of the border to quantify border delay. The US Federal Highway Administration conducted a detailed study in the summer of 2001 on traffic at the four major Canada – US and the three major US – Mexico crossings. The four Canada – US border crossings were the Windsor-Ambassador Bridge between Windsor and Detroit, the Peace Bridge between Niagara and Fort Erie in upstate New York, the Blue Water Bridge in Michigan, and the Pacific Highway-Blaine crossing. For each location the study computed a zero congestion time for both northbound and southbound traffic crossing the border. Blaine crossing travel times were computed over a single three-day period. Actual travel times start from the first queuing point before the border and end when the vehicle is released from inspection. Data used include average crossings per day, average delay per trip, and a buffer index (the difference between the average crossing time and the 95th percentile crossing time). The study shows a direct correlation between delays and the number of customs/immigration booths open—the greater the number of booths open, the shorter the delay. The data also suggest that staffing at a number of crossings is not responsive to traffic buildup in peak periods [30, 31]. The study does not

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consider the impact of variability on regional supply-chains or economies.

While this demonstrates the extensive amount of literature available on topics related to border crossing time variability, it also highlights the gap in the literature addressing border crossing time variability. The strategies used by carriers to accommodate variability in border crossing time have not been identified or confirmed by carriers, nor has their impact on these carriers' businesses or regional supply chains. To date these costs have been ignored in attempts to quantify the cost of border delay and congestion.

4. BORDER CROSSING TIME VARIABILITY

Typically the US border at Blaine, WA, operates with either two or three gates available for truck crossings (southbound into the US), including one FAST (Free and Secure Trade) lane. The FAST lane can be used by carriers who comply with procedures outlined by the FAST [36] program. Compliance with the FAST procedures offers shorter average wait times for carriers and more information about shipments for Customs and Border Protection [9]. [1]

Border crossing time data for this project comes from two sources: (1) a short duration but more detailed data collection southbound (entry into the US) at Pacific Highway sponsored by the Whatcom County Council of Governments (referred to as WCOG data), and (2) a longer duration but less detailed collection both southbound (into the US) and northbound (into Canada) using probe vehicles (referred to as probe data). The two datasets are described here:

1. The WCOG data was collected between the hours of 8:00 am and 5:00 pm from Monday, June 5, through Thursday, June 8, 2006. Using surveyors with electronic PDAs, time stamps were collected when trucks arrived in queue, entered, and exited processing at the border. The data is completely described in [35]. The usable dataset includes 579 FAST observations over 3 days (June 6 was removed as the FAST lane was opened to all traffic), and 1480 nonFAST observations. Only southbound data is available (vehicles entering the US)

2. The probe data was collected using a fleet of vehicles such that one vehicle crosses the Pacific Highway Border crossing in Blaine, WA, approximately every 30 minutes, 7 days a week, every week of the year. Border wait times both northbound and southbound were collected between August 1, 2005, and July 17, 2006 (excluding January 2006).

[1] *In this paper we use the term FAST to refer to a vehicle that can use the FAST lane when transiting the border (therefore transportation mode, company, driver, and owner of the goods must all be FAST approved).*

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Drivers work for a single company that moves fuel from Washington to B.C. Trucks cross the border northbound full and return to Washington empty. Drivers self-report arrival at the back of the queue at the border, and departure from the border. Drivers are paid by the hour regardless of whether they are waiting in a queue at the border or driving. The company and its drivers are FAST approved and use the FAST lane whenever possible. The FAST lane is only available southbound (vehicles entering the US). It is a Customs and Border Protection program and therefore not relevant for northbound crossings into Canada. The dataset includes 5658 observations southbound and 5805 observations northbound.

The WCOG dataset is used to validate the probe data. The WCOG data does not hold enough observations across day, week, and hour to analyze variability, but it does contain nonFAST vehicles. The probe data contains many observations, but only for FAST vehicles (southbound). The distribution of wait times in the two data sets is essentially equivalent, with average wait times for FAST vehicles of 22 minutes for the WCOG data and 23 minutes for the probe data. The standard deviation is 21 minutes in the WCOG data and 24 minutes for the probe data. Recall the WCOG data represents only three days in June 2006, whereas the probe data represents almost one year between August 2005 and July 2006. Given that the FAST vehicle distributions match in the two datasets, it is assumed that the nonFAST data for June 2006 is reasonably representative of average nonFAST crossing times. The average crossing time for southbound nonFAST vehicles is 1 hour 23 minutes and the standard deviation 26 minutes. While the average wait time for southbound nonFAST vehicles is distinctly longer than for southbound FAST vehicles, the standard deviation, or level of variability, is not significantly loner.

Over the three day period, the average arrival rate per lane (southbound) for the WCOG data is the same for FAST and nonFAST (21.5 vehicles per hour), but FAST service rates are shorter (86 seconds compared to 119 and 121 for the two nonFAST lanes). This means that differences in wait time are due to differences in service rates rather than differences in arrival rates.

5. PROBE DATA ANALYSIS

The average wait time across all trips (north and southbound) is 22 minutes 37 seconds; the standard deviation is 22 minutes 1 second; and the 90th percentile 47 minutes 5 seconds. The wait time data follow an approximately log-

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normal distribution, as expected. The two parameters of a lognormal distribution, μ and σ, were computed with μ equal to 4.53, and σ equal to 0.87.

Wait times are more variable southbound. The standard deviation of wait times southbound is about 23 minutes and the 90th percentile value is almost 50 minutes, whereas northbound the standard deviation is approximately 20 minutes and the 90th percentile is approximately 45 minutes. Northbound gate staffing tends to be more demand responsive than southbound gate staffing, which can help in reducing the frequency of especially long delays.[2]

Figure 2 shows the average wait time in each one-hour period. Note that each number represents a one-hour period following the start time designated by that number. For example, 8 means the one-hour period from 8:00 to 9:00. As we expected, average wait times tend to be higher during the morning, particularly southbound. Figures 3 and 4 demonstrate the variability by hour of the day. Broadly, the standard deviation and 90th percentile both trend with the average. Recall the southbound vehicles are using the FAST lane. There is no equivalent lane in the northbound direction.

Figures 5 and 6 show the variability across month. Generally, the southbound variability peaks in the late summer/fall (except for some large values in April). Northbound, the variability peaks earlier, in the summer, but with some particularly large values in February. These large values off-season may have been due to other issues such as mechanical or staffing failures.

Clearly, few would argue that border delays are a significant problem for FAST approved vehicles southbound, or for northbound vehicles. The average delay is on the order of 20 minutes, and delays of more than 1 hour are very infrequent.

6. BORDER CROSSING TIME VARIABILITY AND REAL OUTPUT

There are various ways to model the economic consequences of variability in the time required to cross an international border by truck.[3] One approach is to treat border crossings as an input to an aggregate production function, as in Equation 1:

$$Q_t = A_t L_t^a K_t^b C_t^{1-a-b}$$

where Q_t is real output in time period t ; A is a constant term representing potential (factor neutral) changes in technology that affect overall productivity; L_t^a is labor input in time period t, K_t^b is capital input in time period t, and C_t^c represents border crossings in time period t.[4] The exponents for the three inputs represent output elasticities.[5] In this broad framework, increased commercial border crossings contribute to increases

[2] Northbound gates are operated by Canada and are thus subject to different policies than the southbound gates operated by the US.

[3] At the moment, the direction of crossing is irrelevant.

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Figure 2: Average Wait Time by Time of Day

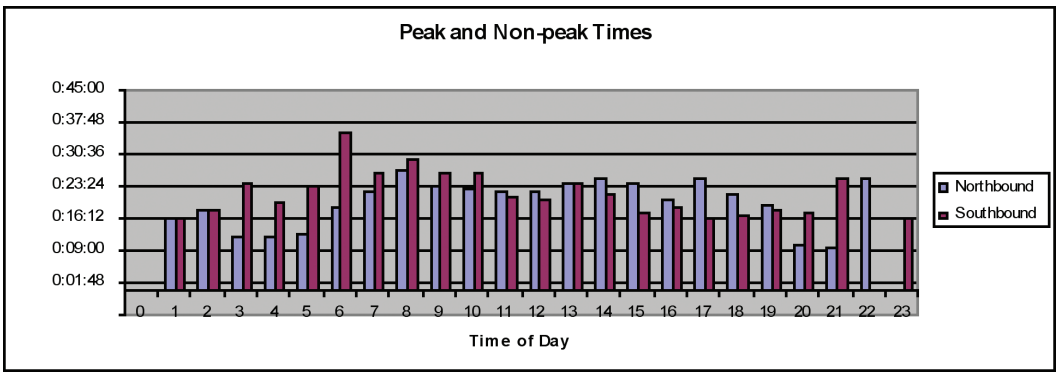

Figure 3: Standard Deviation of Wait Time by Time of Day

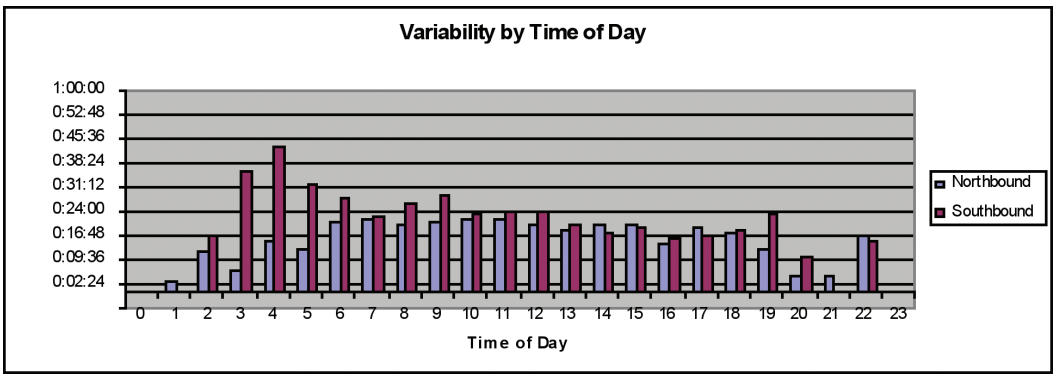

Figure 4: Ninetieth Percentile of Wait Time by Time of Day

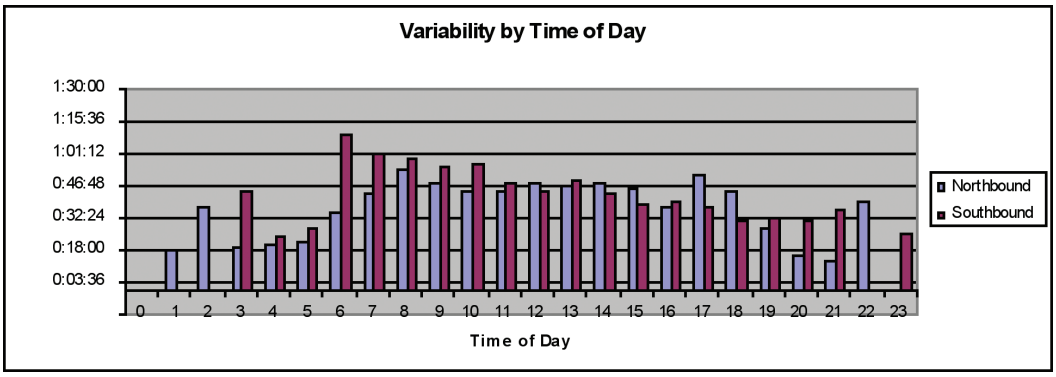

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Figure 5: Standard Deviation of Wait Time by Month

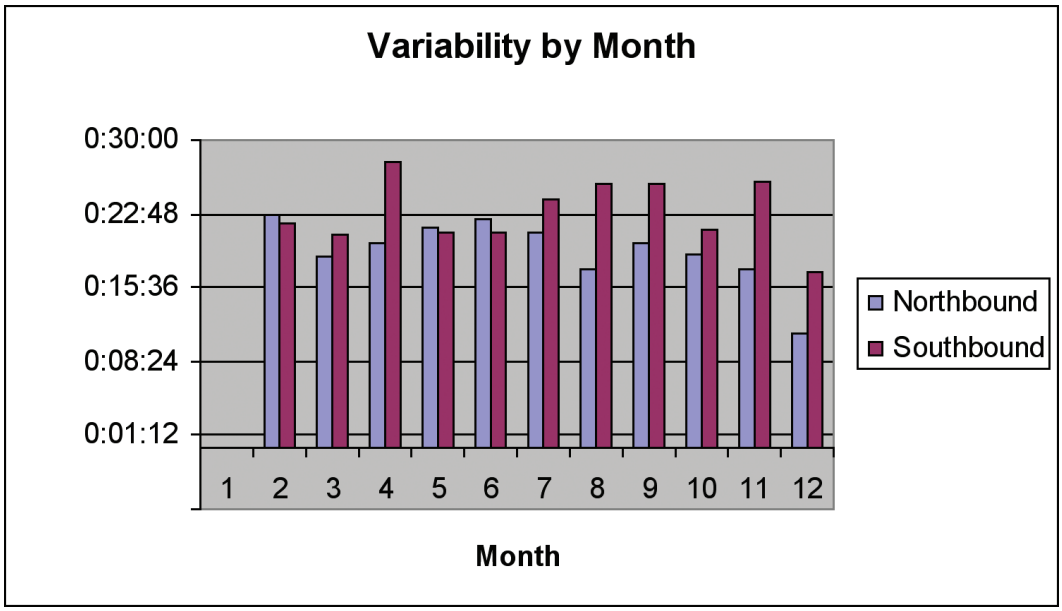
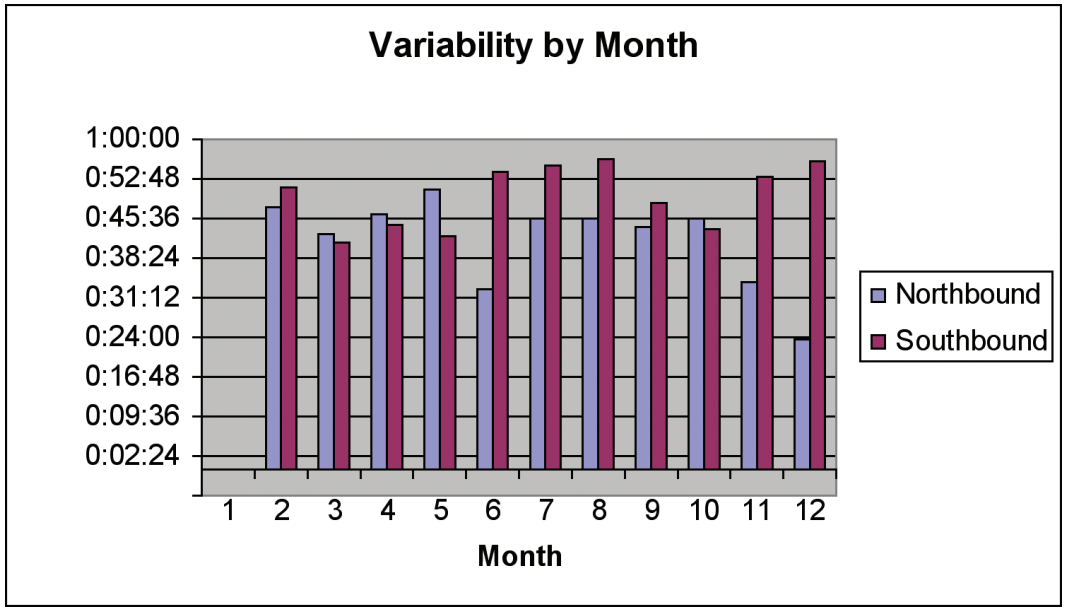


Figure 6: Ninetieth Percentile of Wait Time by Month



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in real output, holding labor and capital inputs constant.

Border crossings are, themselves, produced subject to a production function relationship. For example, transporting commercial cargo requires the services of labor (e.g., drivers, dispatchers, mechanics), capital (e.g., trucks, computers), and other inputs (gasoline, insurance). In this context, time can itself be considered an input. Specifically, it takes some amount of time to be "cleared" to cross the border.[6] The more time it takes to cross the border, the fewer the border crossings that will be produced holding other inputs constant. Similar to inputs in an aggregate production function, inputs to a production function for border crossings will have certain output elasticities associated with them. A border crossing output elasticity can be defined as the proportionate increase in the number of border crossings for any given proportionate increase in the input in question. Where time is the relevant input, the output elasticity of time would measure the proportionate increase in border crossings given any proportionate increase in time devoted to shipping goods across the border. In related fashion, variability of crossing times equates to variability of the output elasticity of time, i.e., the potential increase in border crossings for any given increase in time devoted to shipping goods across the border is more uncertain holding all other factors constant.

By extension, increases in the variability of border crossing times implies that it becomes increasingly difficult to predict the precise amount of time needed to produce any specific number of border crossings, holding other factors constant. Put slightly differently, the output elasticity of time coefficient has an increasingly large standard error as the variability of border crossing times increases. Therefore, if the time input is unchanged, greater variability of border crossing conditions results in greater uncertainty about the quantity of border crossings that will be "produced" for incorporation into the aggregate production function.[7] The end result is that there will be greater uncertainty about the resulting change in real output produced and distributed through the economy's aggregate production function.

Variability in possible outcomes is undesirable to risk-averse participants, such as those that incur significant penalties for late deliveries. In the context of uncertainties regarding border crossing conditions, participants have economic reasons to be risk averse. One reason is that the consequences of greater or lesser waiting times are likely to be asymmetrical. Specifically, delays (beyond the mean expected delay) in crossing the border are likely to have significant (adverse) economic effects,

[4] One can think of C conceptually as the number of times a truck crosses the border in either direction carrying a given volume of a "representative" basket of products.

[5] The production function is assumed to be characterized by constant returns to scale, although the precise structure of the production function is immaterial for our purposes.

[6] In effect, time represents a proxy variable for all of the inputs and activities that produce clearance to bring shipments across the border including manifests, driver documentation, and so forth.

[7] More precisely, it results in a wider range of possible outcomes that are governed by some appropriate probability distribution; however, the point remains that the time requirements for achieving any given confidence level, i.e. that crossings will be made, expand.

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while delays that are less than the mean expected delay are unlikely to offer similarly significant economic benefits. Clearing the border in less time than expected, on average, is the equivalent of an unexpected (and temporary) increase in shipping capacity; however, it may not be possible for shippers and customers to engage in spot contracting such that indirect increases in shipping capacity can be put to use. That is, imperfectly anticipated improvements in border crossing conditions are difficult to translate into increased commercial shipments across the border and, therefore, into increased real output. On the other hand, imperfectly anticipated delays in shipments that have already been contracted for are the equivalent of unexpected short-term reductions in shipping capacity which will have real (adverse) consequences for the number of commercial border crossings that take place in a given period of time, as well as for the real output produced during that period of time.

The adverse economic consequences (in terms of foregone real output) associated with imperfectly anticipated border crossing delays will depend upon the nature of the underlying economic transactions, among other things. For example, transactions involving perishable goods are likely to be more adversely affected by such delays than will transactions involving durable goods, since the former have higher opportunity costs of time for any given economic value of the shipments. In a related fashion, the economic consequences of unanticipated delays in border crossing times will depend upon the degree of "slack" in the economy's logistical network. Slack in this context can be thought of as inventories of the products that are shipped across the border, as well as in other inputs that are used to produce border crossings in addition to time.

Inventories of the products that are shipped across the border can be drawn upon in place of new shipments of those same products in the event of imperfectly anticipated delays in new product shipments. While random drawdowns of inventory create additional risk for supply chain managers, they need not result in a permanent loss of real output as long as inventory levels can be restored to their "steady states" before actual shortages in intermediate and final products emerge. Likewise, to some extent, inputs such as truck drivers can be substituted for time. For example, in the limit, drivers can be kept on call to undertake border crossings when imperfectly anticipated favorable crossing conditions exist to the extent that slack exists at the receiving end of the shipment, e.g. unused warehouse space available to the receiver of the shipment. If the drivers would be otherwise unemployed and have relatively low opportunity costs

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of leisure time, they can effectively be considered a slack variable that can reduce the variability of the output elasticity of border crossings with respect to time.

The existence of slack capacity in transportation supply chains is not necessarily an indication of inefficiency. Indeed, a degree of slack is efficient much as it is efficient for individuals to purchase various types of insurance policies whose expected values (in terms of payoffs) are less than their costs to the acquirers; however, to the extent that the "optimal" level of slack capacity can be reduced by reducing the variability of border crossing times, resources can be freed up to be used in other ways to increase real output. Whether it pays society to incur costs in order to reduce slack capacity, as well as other manifestations of variable border crossing times, ultimately depends upon the seriousness of the consequences of the variability. From the qualitative interviews it is possible to gain a perspective on how broadly significant these economic consequences are. Before evaluating this evidence, it is important to stress that the relevant consequences can take a variety of forms besides increasing spare capacity in the supply chain network. Indeed, one might expect firms affected by imperfectly anticipated delays in border crossings to adopt the least expensive "remedy" to the associated increase in the standard error of the output elasticity of border crossings with respect to time. The range of possible responses itself makes it difficult to be precise about the economic consequences of variability of border crossing times.

7. OTHER SOURCES OF DELAY

While these costs are significant, it is important to put border delay into context. On a trip between Vancouver, B.C., and Los Angeles, CA, the variability in travel time due to congestion in major cities (Vancouver, Seattle, Portland, etc.) will overwhelm the variability due to border crossings. In addition there may be mechanical failures, road closures or construction. Variable delays are also incurred at the origin or destination due to a variety of reasons.

Through the interview process, perceptions of various kinds of delays were discussed with carriers. Recurrent delays are a source of significant frustration, whereas infrequent delays are seen as unavoidable. The perception amongst carriers is that border delays could be distinctly improved with changes that are perceived to be low cost to implement, such as increasing the level of staffing at key border crossings. On the other hand, congestion in major cities is recognized as a very difficult issue to solve.

So, for all carriers, and in particular

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those with origins and destinations outside of the Vancouver and Seattle regions, the variability in travel times due to border delay is much less significant than the variability due to other sources, but is a source of more frustration as it is seen as easier to solve.

8. RESPONSES TO VARIABILITY AND ECONOMIC CONSEQUENCES

A series of interviews have been conducted with commercial carriers to investigate the responses to variability in border crossing times, and the economic costs of this variability. 20 one-on-one interviews were carried out with firms that engage in regular cross-border shipments. Screening criteria for these interviews and suggested interview questions can be found in Appendix I. Of these interviews 13 have been with US firms and 7 with Canadian firms. Summaries of these interviews can be found in Appendix II.

The primary commodities crossing at Blaine are wood, pulp and paper products, food and farm products, metals, and petroleum products. Approximately 15 to 20 percent of the trucks are empty vehicles. These are not typically moving in a particularly time critical environment. This differentiates the border between BC and Washington from that between Ontario and Michigan,where a significant number of automotive plants exist on either side of the border that exchange parts and operate in a Just-In-Time manufacturing environment.

Increases in the standard error of the elasticity of border crossings with respect to time may impose expected losses in real economic output upon participants in the economy. Risk-averse participants can therefore be expected to react to those potential losses. The magnitude and nature of the reactions will be a function of: (1) the magnitude of the increase in the standard error; (2) the economic consequences of the increase in the standard error. The larger the magnitude of the increase in the standard error, the larger the associated economic losses. Larger economic losses make it more likely that participants will undertake (costly) actions to mitigate either the increase in the standard error and/or the economic losses associated with increases in the standard error. The interviews identified several strategies that carriers use for minimizing the impact of variability of border crossing times on their operations. These strategies are identified in Table 1 and discussed further below.

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Table 1: Carrier responses to variability in cross border travel times

Strategy	Consequence
Increase buffer times	• Reduces capacity of existing infrastructure or requires additional hires and equipment • Increases transportation and inventory cost • Reduces late arrivals and stock-outs
Increase dwell times at intermediate handling facilities	• Reduces impact of delay on outbound vehicles, particularly relevant for LTL (less than truckload) operations • Increases total transit time and therefore inventory cost
Routing Changes	• Reduces the impact of variability on operations
Schedule changes	• Reduces the impact of variability on operations
Reduce level of activity in cross-border trade	• Reduce impact of variability on operations • Stop providing courier or same day service • Reduce revenue to carrier and level of cross border economic activity
Change transportation mode	• Change border procedures which, depending on local circumstances, may improve travel time reliability

8.1 Increase Buffer Times

Although the average crossing time southbound for nonFAST vehicles is about 1 hour and 23 minutes, most carriers leave 2 hours to cross the border. In doing so, they are building in 37 minutes of buffer time to accommodate longer than average crossing times. This is the most common response to variability. FAST approved vehicles typically allow an hour for border crossing (significantly more than the average of approximately 20 minutes). Increasing buffer times reduces the possibility that the driver will arrive late for an appointment. None of the respondents incur specific fees for late arrivals, but there are other significant consequences:

- Customer dissatisfaction with late deliveries leading to loss of business (in one case a carrier operating within a Just-In-Time framework that is contractually obligated to arrive on time at least 94 percent of the time).
- With LTL carriers the possibility that outbound trucks from a handling facility will be delayed by incoming trucks. Delay to one vehicle can therefore impact many outbound vehicles, and customers whose goods were not delayed in the original shipment. These customers have little sympathy for the delay and will not bear the

financial consequences of delay (missed business opportunities, staff overtime, perished goods, etc.).

- Missed appointments at the Port of Vancouver can lead to a loss of future appointment times.
- If outbound rail cars are not filled at a trans-load facility the company is charged demurrage for empty rail cars.
- If trips are particularly long and a driver cannot make the return trip due to hours of service regulations a replacement driver may need to be hired or overnight accommodation expenses may be incurred.

There are also consequences of arriving too early, which happens on the majority of occasions. These are primarily underutilization of the driver and rolling-stock.

Typically drivers are paid per trip (rather than per hour), so as individuals would bear the cost of increasing the buffer time, but in many cases drivers are compensated for border wait times over some threshold. This cost is borne by the transportation company and passed on to their customers through increased rates. In the case that drivers are not specifically compensated for border delay, the carrier may keep the increased revenue. One company estimates a 7 percent increase in their freight rates over the last year due solely to border crossings. Again, long border delays can be an additional source of revenue for the driver or carrier.

One carrier moves goods between Seattle and Vancouver (approximately 140 miles), but also between Seattle and Portland (approximately 170 miles). Although the distance is fairly similar, and congestion would be expected in the three metropolitan regions, the carrier allows 12 hours for a round-trip between Seattle and Vancouver, but just 8 hours for a round-trip between Seattle and Portland. The additional 4 hours (50 percent) required is due to the border crossing, and the rate is 81 percent higher.

8.2 Increased Dwell Times at Intermediate Handling Facilities

For an LTL firm that uses an intermediate handling facility, longer than expected inbound delays can disrupt outbound trucks. The firms interviewed have therefore increased the dwell time of goods at the handling facility to reduce the possibility of delay to the outbound trucks. This increases the time between pick-up and delivery, reducing the quality of service offered by the provider.

For carriers with handling facilities where goods are moved between vehicles, in order to minimize the impact of very long delays, it is best to cross the border after handling goods and loading trucks to their final destinations (Figure 8), as opposed to crossing the border

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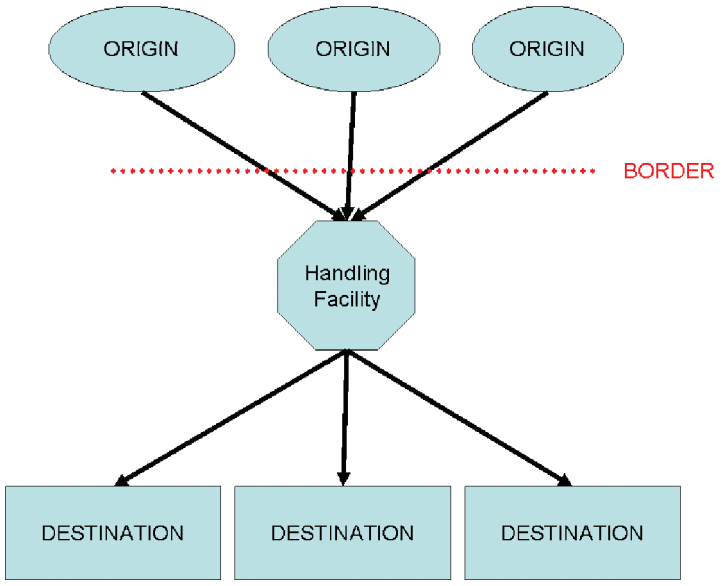
before handling goods (Figure 7). For south-bound supply chains this benefits Canadian firms with handling facilities in the Lower Mainland. For north-bound supply chains this benefits US firms with handling facilities in Washington State. The net effect given trade in the region is probably to favor Canadian carriers. If the level of variability in border crossing times could be reduced, this benefit for Canadian firms would be removed.

8.3 Routing Changes

When feasible, some carriers have decided to use border crossings that offer both a more reliable and shorter crossing time. For example, if the variability of border crossing times at Blaine increased relative to the variability of border crossing times at Sumas (a commercial port-of-entry 25 miles east of Blaine), some shippers who previously used Blaine might shift to Sumas. Presumably it was more expensive to use the latter crossing prior to the assumed change in border crossing conditions; otherwise Sumas would have been used in the first place. Average distances traveled between origins and destinations might be longer using Sumas, nevertheless, given a sufficiently large difference between the two crossings in the predictability of border crossing times, it might be economically worthwhile for some shippers to change their routing.

By changing their border crossing

Figure 7: Logistics network where border crossing occurs before handling goods and loading vehicles for their final destinations.



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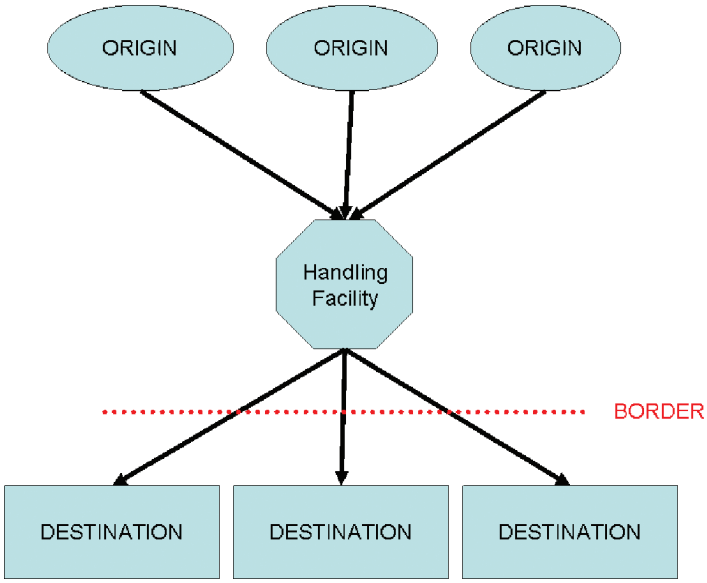
route, commercial shippers might be able to reduce the variability of border crossings "produced" per unit of time (holding other inputs constant), albeit at a higher cost in terms of real inputs per border crossing produced. In effect, changing the border crossing location(s) is tantamount to buying insurance against imperfectly predictable disruptions to the "production" of border crossings. The effective cost of the insurance is the additional expense associated with utilizing more fuel, drivers' time, and so forth.

To the extent that little to no switching among border crossing locations is observed to take place among shippers, at least two inferences are plausible: (1) that there are few differences in the variability of border crossing times across different border crossing locations, and (2) that the variability that does exist is not of sufficient consequence to warrant incurring the additional expenses associated with altering traditional transportation routes. Hence, if little or no switching behavior is observed, it does not necessarily mean that variability of crossing times has no economic significance; however, it does suggest that the related costs of variability may be no greater than the costs associated with altering border crossing transportation routes.

Our interviews suggest to us that the risks associated with imperfectly anticipated border crossing times are likely to be of modest economic

Figure 8: Logistics network where border crossing occurs after handling goods and loading trucks to their final destinations.



consequence against the background of other determinants of the costs of producing cross-border shipments, and that the routing changes that do take place are in a response to average wait times rather than the variability in wait times.

8.4 Schedule Changes

Another way to mitigate increases in the elasticity of border crossings with respect to time is to spend more resources monitoring border conditions on a "real-time" basis and create the flexibility within the organization to alter time patterns of shipments such that shipments can be moved forward in time to take advantage of unexpectedly favorable border crossing conditions. After learning about favorable periods, schedules can be permanently adjusted to cross at favorable times.

When shippers are hauling freight under long-term business arrangements, as opposed to spot contracting, it might be difficult to accelerate shipments in terms of time of delivery, since there may be other capacity constraints in the relevant logistics systems that make it uneconomical to accelerate shipments in order to take advantage of border crossing "windows of opportunity." For example, customers taking delivery of shipments may have warehouse capacity constraints which make it impractical to unload and store expedited shipments on the customer's premises. Nevertheless, regular schedule changes can be made to exploit consistently reliable crossing times.

Customers (or intermediaries such as independent warehouses) could invest in "spare capacity" such that there is always some additional slack to accommodate accelerated shipments between suppliers and customers who do business on something other than a spot contracting basis. Presumably these types of investments would be economical if the risks associated with variable border crossing times were of a significant economic magnitude. In effect, investments in redundant capacity in order to alleviate "bottlenecks" to accelerated shipping enhance the viability of implementing more "real-time" management of the border crossing production function, thereby mitigating the impact of variability of crossing times on the elasticity of border crossings with respect to time.

Carriers were observed shifting their regular schedules to take advantage of shorter and more reliable crossing periods. For carriers that do not shift their schedules, it suggests that increased variability of crossing times had only modest impacts on the elasticity of border crossings with respect to time or that the requisite investments to allow substantially more real time expediting of shipments are prohibitively expensive. Several of our survey participants indicated that they engaged in real time

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(internet) monitoring of border crossing conditions and were able (at relatively low cost) to alter shipping times in order to take advantage of "favorable" crossing conditions. While the ability to engage in real time management of border crossings will not be identical across all shippers, many of our respondents are located relatively close to the Canada – US border. Furthermore, all have access to relatively low cost internet monitoring of border crossing conditions.

However, these schedule changes were primarily in response to average delay rather than the variability in delay because the costs associated with variability in border crossing times are of modest importance.

8.5 Reduce Levels of Activity in Cross Border Trade

Another approach to mitigating the adverse consequences of variability of border crossing times is to reduce the number of border crossings. In particular, companies that acquire inputs from foreign suppliers might switch to domestic suppliers of those inputs. In like manner, companies that sell final output to foreign customers might seek to replace those foreign sales with sales to domestic customers. In effect, variability of border crossing times might lead to a reduction in the geographic specialization of production within North America.

Clearly, the costs associated with replacing foreign sources of input supply with domestic sources and/or replacing foreign customers with domestic customers can be quite substantial. To the extent that our survey respondents indicated that they have engaged in such replacement activities, it would signal that the costs of variability are quite high. In fact, there was no indication from our survey interviews that carriers were cutting back on cross-border shipments in any significant way in response to changes in their customers' value chain management.

Several Canadian carriers have decided to exit the business of cross-border trade partially or entirely. Several firms that, two years ago, offered same-day courier services between the Lower Mainland of B.C. and the Puget Sound region of Seattle have discontinued this service due to their inability to reliably deliver and return to B.C. on the same day. This was primarily due to the magnitude of border delay, rather than its variability. In addition, the two carriers that move containers between the ports and rail yards in Vancouver and destinations in Washington have moved from doing so within one day to two-day operations. Only two years ago it was possible to pick-up containers at the rail yards very early in the morning, cross the border, drop-off a container, pick up a container, and return to

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Vancouver on the same day. Now this trip requires two days, so the rates have increased significantly.

8.6 Change Transportation Mode

In the Whatcom County/Lower Mainland region, it may be possible to substitute rail or marine transportation for truck transportation. For example, one fuel company that delivers fuel in trucks from a coastal refinery in Washington to Vancouver International Airport faces competition from a barge company that can serve the same route but is subject to less average border delay and less variability in travel times.

9. INTERPRETING THE EVIDENCE

As suggested by the preceding discussion, a number of empirical issues are relevant to evaluating the economic consequences of variability of border crossings with respect to time. While it is impossible to provide quantitative estimates of the costs of variability to the North American economy, several empirical issues bear upon the qualitative importance of those costs.

One empirical issue is the magnitude of the observed variability. That such variability exists at the Pacific Highway crossing was established earlier in this report. It was also established that the average crossing time for nonFAST vehicles is more than three times longer than for FAST vehicles, while the standard deviation of crossing times for the two types of vehicles is virtually identical. These observations lead to the inference that variability of crossing times is of relatively limited importance to carriers compared to average crossing times. Specifically, it is costly for carriers to join the FAST program.[8] Carriers will incur the relevant costs only if the expected benefits of qualifying for and joining the program exceed the related costs. The border crossing data described earlier suggest that those joining the FAST program can expect to save time, on average, crossing the border but cannot expect to reduce the variability of border crossing times. To the extent that the latter is of significant economic consequence to carriers and those hired to ship their products, one would expect the FAST program to focus on reducing variability as well as average crossing times. Certainly, one cannot conclude from the border crossing data that variability is of no economic importance to participants in the North American economy; however, it does seem reasonable to conclude that the economic costs associated with variability are likely to be modest in comparison to the costs associated with average waiting times.

A second empirical issue is whether or not variability is a significant economic concern on the part of carriers and/or their customers. In this regard,

[8] It is particularly costly relative to total revenues for smaller companies to join the program given certain fixed costs associated with filing the relevant documents and so forth.

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our survey respondents provided little indication that variability of border crossing times was a matter of substantial concern to them. In fact, several of the respondents were explicit in stating the opposite. For example, one stated explicitly that border variability has not caused them any problems. Another survey respondent stated that a few minutes difference in border crossing times is insignificant. A third respondent indicated there is a high degree of flexibility regarding border crossing time; this implies that imperfectly anticipated delays are unlikely to impose serious costs or disruption on certain firms.

Canadian carriers are more likely to identify wait times at the border as a problem than are US carriers.[9] This is consistent with evidence from other studies identifying longer wait times for south-bound cross-border commercial shipments than for north-bound commercial shipments (particularly when nonFAST southbound vehicles are compared to northbound vehicles).[10] However, most Canadian carriers participating in our interviews also did not mention variability of border crossing times as an important issue in their logistics planning and management. A respondent from a lumber company that ships wood products from Canada to the US notes that modest unanticipated delays are of no material consequence, as the industry ships primarily by rail, and rail product is quoted for delivery for a specific week, rather than for a specific day.

A third relevant empirical issue is whether carriers have implemented any significant changes in their production or logistical systems in response to variability, indicating that the consequences of variability are of sufficient magnitude to justify incurring additional costs to mitigate the variability or to mitigate the consequences of variability. While a number of survey respondents indicated that they took some action to address border delay problems, the actions were fairly modest. For example, a number indicated that they check internet web cameras to see what border lineups look like and whether there are any "unusual" delays.[11] Two respondents stated that they will occasionally change border crossings in response to delays, and one also indicated that it will change hours at which its trucks cross the border. The broad conclusion one might therefore draw is that variability of border delays is not generating additional risks and costs sufficient to motivate a significant number of carriers to implement even fairly modest changes in their logistical operations.

10. CONCLUSIONS

The overall conclusion that might

[9] In this regard we are talking about average wait times and not variability around average wait times.

[10] The relevant evidence is discussed in Globerman and Storer [14].

[11] One respondent indicated that they can literally look out the window and check the border traffic lineups.

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be drawn from the interview evidence is that border delays, on average, are not of great concern to US carriers, although they are of greater concern to Canadian carriers. Variability in border crossing times, *per se*, does not appear to be a significant concern to the firms that were interviewed. Many of the interviewees mentioned that there was "slack in their logistics systems" such that variability of the magnitude identified in the earlier part of this study, i.e. a standard deviation of less than half an hour in crossing times, is not considered to be a serious problem. In some cases, truck drivers are the effective slack variable. In particular, in many cases they are paid by the trip, so the truck drivers absorb the incidence of any unanticipated border crossing delays in the form of uncompensated time spent on the job. The magnitude of this cost from a social perspective depends upon the opportunity cost of the drivers' time. If the opportunity cost is relatively low, the social cost of the slack associated with using drivers' time as a "buffer" is correspondingly low.

What does seem clear from our interviews is that truck drivers are becoming an increasingly scarce input. Part of this has to do with demography, as the average age of truck drivers has been increasing in recent years and large numbers are on the verge of retirement. It also has to do with drivers reacting to their providing slack for the logistics networks of North American firms. In the short-run, effective reductions in real wages will be largely absorbed by the drivers themselves. Over time, the supply curve for truck drivers becomes more elastic as younger drivers leave the industry for other forms of employment, and older drivers choose retirement rather than work an incremental year or two. The point here is that the consequences of variable border crossing conditions are likely to be more economically significant in the future if variability persists.

Truck drivers do not absorb all of the effective costs of variable crossing times. This is indicated by the fact that some of our interviewees build anticipated border crossing delays into their pricing structure. If truck drivers absorbed all of the relevant costs of variability, firms in a competitive market would not be passing on costs of variability in the form of higher prices. It is unclear from our interviews whether the higher (resulting) prices are calibrated on the mean expected delay or whether they are calibrated for intervals around the mean expected delay, e.g. one standard deviation unit around the mean expected delay. In two cases, interviewees reported that an average time delay (e.g., 3.5—4 hours) is built into their flat rate (per haul) pricing structure, which suggests that carriers are making an allowance for

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variability of crossing times within their pricing. On the other hand, several other interviewees mentioned that they incorporate the estimated costs of specific assumed time delays, e.g. one hour, into their pricing schedules.

What should be emphasized is that variability in border crossing times can be caused by a variety of factors. While this research considered the variability in border crossing times, which includes only the amount of time waiting in queue at the border, many respondents were eager to discuss other delays, such as those caused by FDA inspections and "paperwork problems" related to customs documentation. The point again underscored is that variability in the time spent waiting in queue to cross the border may add only a marginal additional amount of risk into the North American logistical network. Against this background, the impact of variability in border crossing time associated with security-related disruptions is arguably relatively small in economic terms, particularly given existing slack in the trucking portion of the transportation network.

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APPENDIX I

Interviewees should include some firms who operate within a JIT operation, and who move a perishable commodity, high value commodity, and low value commodity.

We plan to conduct the interviews in two phases. First we will interview Shippers (companies that move goods for customers), Private Carriers (companies that operate their own transportation fleet) and 3PLs (companies that provide broader transportation services such as UPS and FedEx). After these interviews are completed we will interview Sellers (companies that contract out their transportation services to another firm).

We will try to achieve a sample of 25 total interviews in the Shipper/3PL/Private Carrier category, and 10 interviews with Sellers. These will all be one-on-one interviews carried out by Anne, Susan, and Steve. Our goal is to carry out the first phase of interviews by the end of October, and the second phase of interviews before Thanksgiving. Companies located in Northwest Washington and the Lower Mainland of B.C. that move goods across the US-Canadian border will be interviewed.

In order to identify the correct person at each firm we will ask the following questions:

Shipper/3PL

Who is responsible for making strategic decisions about your service? For example, how frequently to make shipments, how to time shipments, how to route shipments, or how to price services?

Seller

Who is responsible for making decisions about who provides your transportation services, and the structure of this contract?

Private Carrier

Who is responsible for making strategic decisions about transportation within your company? For example, how frequently to make shipments, how to route shipments, how much inventory to hold, and the structure of your supply chain?

Suggested Shipper/Private carrier/3PL interview questions

Please briefly describe your transportation service and the logistics structure.

1. Who decides how frequently shipments are made and how they are routed?

2. Who determines whether the company will store inventory for customers and the levels of any stored inventories?

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3. How do border crossing conditions get factored into decisions regarding shipment scheduling, shipping routes and inventory levels?

4. Define variability. It currently takes, on average, about 20 minutes to cross the border at Blaine. This required time varies between 0 and 4 hours, but it is typically (90% of the time) less than 45 minutes. How important is variability of crossing time to your company in scheduling shipments, choosing border crossing sites and determining inventory levels?

5. How would your company respond to a 10% change in variability of crossing times (i.e., 90% of the time the required crossing time was less than 50 minutes)? In particular, how would the change affect your costs? Which costs, in particular, would change? How would it affect your prices? How would it affect the volume of your shipments?

    - Would you build extra time into trips?
    - Would this cause you to hire additional drivers, purchase additional trucks?
    - How would this affect your pricing?
    - Reduce the amount of business you carried?
    - How would this additional variability in travel time affect the level of inventory you hold? What are the ramifications of this?

6. How would your company respond to a 50% change in variability of crossing times (i.e. 90% of the time the required crossing time would be less than 70 minutes)? What about a doubling of the variability, so that it took up to 1.5 hours to clear 90% of shipments through the border?

    - Would you build extra time into trips?
    - Would this cause you to hire additional drivers, purchase additional trucks?
    - How would this affect your pricing?
    - Reduce the amount of business you carried?
    - How would this additional variability in travel time affect the level of inventory you hold? What are the ramifications of this?

7. How large would this variability need to be before it caused some reaction by your company?

    - What would this response be? E.g. charging a higher price to your customer, relocating warehousing/distribution facilities, increasing inventories in the supply chain?
    - How would these decisions be made?

8. What is the goal of the border? Does the border provide a useful service?

9. What else causes variability in trip length? Congestion? How do you deal with this? How is this different from border crossing time variability?

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10. Pricing: how do you pay your drivers? How do you price your service? How much has border crossing delay increased your cost base? Do you incur specific fees for delay?

Suggested Seller Interview questions

Please describe your transportation requirements and how they are currently served.

1. Who determines how frequently shipments are made? How much and where inventories are held? Who is responsible for your inventory in transit, and at the destination?

2. Do you require that your transportation provider meet delivery deadlines? How tight are the deadlines? What is the penalty for missing deadlines?

3. Define variability. Then state the background delivery time information and ask: If the variability increased by x%, how would your transportation provider likely respond?, e.g. increase rates? Increase levels of inventory in transit or at the destination? (Increase the x% as in the case of shippers to get at the sensitivity of the relationships). Discuss.

4. How would your company react to the responses of shippers identified in your answers to Question 3? e.g., would you reduce the amount of shipping that you contract for? If so, by how much? Would you increase average inventory levels? What are the cost implications of increasing inventory levels? Would you reconsider your choice in a transportation firm? How would this increase in cost be absorbed by your company? How would the cost of this inventory be absorbed by your company? Would you reduce production levels? How would these decisions be made?

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APPENDIX II
PART I: U.S. COMPANIES

1.

LTL or TL: TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Aircraft parts, electronics, food, and agricultural products; move both air & regular ground freight; they use own trucks	Description of logistics (do they return empty; do they use a consolidation center): Terminal in Richmond; high demand for Vancouver's air freight to be moved to Seattle (they have bigger airport & cheaper landing rights & Seattle is more expensive); a truck may be loaded in Seattle, the destination is direct to the airline, and then it goes back to the terminal; they may return empty (depends on the pay scale as some trucks are leased)
Is it time sensitive? Yes, a truck may hold both time critical airfreight goods and non time critical goods; terminal operations do not interfere with time critical air freight	If yes, what is it? Goods are loaded according to importance, ie if airline freight has 8am cutoff, will be loaded first in order not to miss the cutoff.
High value products or not: Yes, some	If yes, specify: aircraft parts
Do they have flexibility to change route, schedule, shipment size, or frequency? The schedule is set; trucks are not always full; charge by the density; they have not changed the time they depart; it's more important for their customers for them to get the freight there by 8am than it is for the company to push the deadline; they always have extra trucks.	If yes, to what extent: Trucks leave between 1-3am to have plenty of time to reach terminal; most of the freight comes from Vancouver, ideally the driver starts trip there and goes back (instead of from Seattle-Vancouver).

If goods are delayed, cause is usually the goods and not having the proper paperwork; pay the driver by the trip, so it doesn't cost them if he gets delayed; they charge the customer $55/hr for expenses caused by the delay of the run; they do hire lease operators, who will charge them, and are more expensive; there is no financial penalty for being late, other than possibly losing the customer's business (this didn't seem likely); they leave Seattle at 3am in order to reach terminal by 8am, so there is a lot of slack in the system—there is no pressure to push that later—the company doesn't want to, and drivers want to get back home; if they don't get to the airline by 8am they will miss the flight, other than an explanation for missing the flight, there are no consequences; this happens once/wk or once every two weeks with airline freight, but they "rarely" miss the deadline up there (because of the company's experience, and ability of the drivers), delay is usually not having the proper paperwork at customs, so they will go back and bill the customer (re example of grass seeds).

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2.

LTL or TL: TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Aircraft parts, agricultural products	Description of logistics (do they return empty; do they use a consolidation center) All airline freight is dropped off at the dock, in a pallet, and is consolidated at the company
Is it time sensitive? Yes, some	If yes, what is it? Agricultural products-cherries bound for Asia & Europe.
High value products or not: Yes	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? They have two guaranteed schedules from Canada every night; they leave Canada at 8pm, arrive in Seattle 1-2 am and are flipped back around; they have two good Canadian drivers who make the border run, both O/Ps; occasionally they will need more than two drivers (they have 40 O/Ps & 37 or 47 company drivers); the schedule is set, with built in time and border delays built into it; they do not cross at busy times.	If yes, to what extent: "99% of the time you can go right on through into Canada without any trouble"; schedule is determined by their carriers and when they need the freight at their dock (by 7am, 6am if it's a larger shipment); loads are prioritized depending on when their flights are taking off—if a truck is running late they'll take the freight that has the earlier flight departure.

The two Canadian truckers are paid by the trip; employees are paid by the hour, and any Seattle O/P is paid by the trip; if employee gets stuck at the border the company eats the cost; their pricing system has that built in to absorb some of the cost; if there is a specific border delay caused by parts failure, they will charge the customer; air freight is charged $70/hr delay time, trucking is $80/hr.

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3.

LTL or TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Their carriers transport air parts & military articles, aircraft engines.	Description of logistics (do they return empty; do they use a consolidation center)
Is it time sensitive?	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? They use carriers #1 & #2; only a small percentage goes up to Vancouver, it may go out of Seattle, Portland, San Francisco, or LA depending on the freight weight and airport availability.	If yes, to what extent: They use performance based evaluations to evaluate the carriers, but the carriers are not penalized monetarily (if they don't perform well they may lose firm's business, but this is overall performance and not related to border crossing times).

Border delay or variability has not caused any problems; a problem might be that there is a new trucker who is unfamiliar with the correct process for the brokerage and the border; main problems at the border are restricted to which customs broker they use, issues about who is the best broker and who can get stuff across the border the quickest with least amount of trouble, but the process is usually 'seamless' and if it takes an hour to cross it is not a concern to them, if it took 24 hrs that would be different.

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4.

LTL or TL: LTL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments: They offer storage for refrigerated goods at handling facility (by border) at additional cost; other decisions are based on available routes, volume, equipment, and driver availability
Description of what they carry: Frozen seafood from BC, some from WA.	Description of logistics (do they return empty; do they use a consolidation center) They leave BC and go through a re-handling facility before arriving, where the goods may be reloaded onto trucks bound for CA and points in between, to Phoenix, and Chicago.
Is it time sensitive? Yes	If yes, what is it? Farm fish
High value products or not: Yes	If yes, specify: Caviar ($200,000 to $1million est truckload worth, depending on product).
Do they have flexibility to change route, schedule, shipment size, or frequency? Set schedule all year; they don't have the option of building extra time into trips, but frequent border delays would reduce the amount of business they carry;	If yes, to what extent: Pick up cutoffs are the major factor resulting from cross border conditions; as a carrier, they are caught in the middle between shippers and deliveries (production and consignee time schedules); variability would need to be at least 2 hours before the company would react by reducing shipping volumes and changing schedule requirements from the consignees.

A few minutes border delay either way is insignificant; they don't build extra time into trips, and any border delay would not cause them to hire additional drivers; FDA inspections at the border can cause significant delay, but inspections are random and not frequent yet border delay is a "huge" problem; this may cause fish spoilage so that the product may be refused or have to be sold at a lower price; there is no financial penalty if late; drivers are paid by trip to CA, and by the mile to Chicago; they run sleeper teams of two, who are paid per trip if it's an outbound trip, and hourly if a local pickup; demand for seafood is fairly constant; they have ownership of inventory, and suffer the cost if spoilage results from "temperature abuse" but are not at fault if there is a road closure, etc.

by Anne Goodchild, Ph.D., Steven Globerman, Ph.D., and Susan Albrecht, MAPS

5.

LTL or TL: TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Lumber from Canada	Description of logistics (do they return empty; do they use a consolidation center) Customer brings lumber across border via truck or rail (mostly by truck); they ship out by truck (20%) and rail (80%).
Is it time sensitive? No	If yes, what is it?
High value products or not: Yes	If yes, specify: Carry own insurance in case of fire
Do they have flexibility to change route, schedule, shipment size, or frequency? They must order specific # of RR cars, and are charged for all cars even if they do not fill them; must coordinate with RR every day; they are on a tight schedule	If yes, to what extent: A truck is booked once they receive an order with specific amount of wood for a RR car.

As a lumber re-load, they depend on the RR to ship product; the resolution of the softwood lumber dispute has resulted in it being more expensive for their customers to send across the border now (it used to be cheaper to bring across by truck over the border and put on the rails); in the current slowdown, they survive by looking for business elsewhere and possibly diversifying and not relying only on lumber; they used to do 20 rail cars/day, now approx 250/month; they provide free storage for 30 days then they charge for storage, what they charge for this storage varies by customer and if the customer has an on going rail plan or not; they may hold an inventory for select customers, who can also bring in product without actually having to place an order; customers are charged a freight rate (includes cost of facilities and overhead); border travel time affects trucks only and the timing of the wood coming in; if a truck gets stuck at the border, they have to wait and incur a cost in waiting; there is no reload competition on the US side, more competition on the Canadian side—perhaps because of more RR options.

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6.

LTL or TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Supplier of fuel.	Description of logistics (do they return empty; do they use a consolidation center) Firm uses one company to truck fuel across the border to Vancouver airport; occasionally will use a barge, 1-2/month, or as needed in an emergency.
Is it time sensitive? Yes	If yes, what is it? Fuel needed at Vancouver airport
High value products or not: Yes	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? Although it's cheaper to move fuel by barge, they are constrained by availability of barges, and "structural limitations" on how many they are able to fill (each barge is 30,000 barrels)	If yes, to what extent:

7.

LTL or TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Jet Fuel	Description of logistics (do they return empty; do they use a consolidation center) Round trip up to 3X/day.
Is it time sensitive? Yes	If yes, what is it?
High value products or not: Yes	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? No; but fuel demand at airport changes according to time of year.	If yes, to what extent: Main problem is finding enough drivers; many have to work OT.

The border is not an issue, but congestion is more demanding during summer and spring; they pay drivers OT, they are paid X amount for one trip and they usually do 3/day, but they are also paid hourly for sitting and waiting; supplier of fuel (#6) pays #7, who will pass any costs on to supplier; there is a fee related to border crossing based on the truck rate and the hourly rate.

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8.

LTL or TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry:	Description of logistics (do they return empty; do they use a consolidation center) Dealer network & distribution centers in US & Canada; plant locations in Mexico and US.
Is it time sensitive? It depends on what the part is.	If yes, what is it?
High value products or not: Yes, some.	If yes, specify: Truck parts
Do they have flexibility to change route, schedule, shipment size, or frequency? Yes, they have NASA like computerized inventory & tracking system.	If yes, to what extent: They have an extremely high degree of flexibility and ability to respond quickly.

Manufacture trucks; have plants (specific to products) and distribution network; their strategy is to respond quickly if a dealer needs a part; they carry less inventory at the dealers now but because they can respond so quickly to replace a part it is not a problem; border delays are not a problem, biggest problem is with congestion; problems at the border concern 'sub-assembly' of parts (originate with many parts to make one piece means invoice may list a different number of parts); Canadians do better at consistency regarding border issues and crossing.

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9.

LTL or TL: TL FAST approved? No	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Produce, house packages, telephone poles, refrigerated storage units.	Description of logistics (do they return empty; do they use a consolidation center) Empty if returning from Canada; they may load at company and go south; they don't have a warehouse
Is it time sensitive? No; If produce, Yes,	If yes, what is it?
High value products or not: No	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency?	If yes, to what extent:

They have a lot of flexibility regarding border-crossing time; they charge by the hour (especially for Canadians), but also do contracted work, majority by the hour but by the mile if they are O/P.

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10.

LTL or TL: Both FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Machinery, presses, pipes, steel	Description of logistics (do they return empty; do they use a consolidation center)
Is it time sensitive? Sometimes	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? Yes, firm will give a general idea of arrival, especially for LTL; but may be very precise especially if need to cross to Victoria (ferry crossing times).	If yes, to what extent: Check the internet web cameras at the border in the morning so see what the lineups are like.

Pay light haul drivers by mile, pay local drivers by the hour (local is anywhere between WA, OR, ID, and B.C.); there may be financial penalties for being late; bad planning can cause a miss reload and loss of revenue, increased costs from coming back empty; border crossing times depend on day of week—Mondays are very heavy; everything is priced by the job; fleet of 100 trucks, O/P, fleet needs to be working at "80% to maintain profitability"; border crossings have gotten easier with FAST; schedule jobs a month in advance for long haul, and other stuff is day to day, needing a week's notice; in general, delays are rarely caused by border delays.

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11.

LTL or TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Pipes	Description of logistics (do they return empty; do they use a consolidation center) Manufacture in Bellingham
Is it time sensitive? No	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? They do little shipping across the border.	If yes, to what extent:

Border delays are rare; they have experienced delays as long as a day, but this was due to improper paperwork by the broker, and had nothing to do with border security or border congestion.

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12.

LTL or TL: TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Produce, aircraft parts & machinery, backhaul cargo from BC to WA/OR (pasta & meat products); donuts & sandwiches for 7/11 chain.	Description of logistics (do they return empty; do they use a consolidation center) They are sub-contractors for other truckers not licensed to go into B.C.
Is it time sensitive? Yes, if food and produce, mainly for national convenience chain customer.	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? Will occasionally change border crossings in response to delays (bring backhauls thru different crossing).	If yes, to what extent: Monitors internet web cameras at border, if there is an 'unusual' delay, will notify time sensitive customers, especially for the national convenience store chain customer.

They 'live with' delays; employ a flat-rate pricing structure with customers; contract prices cover costs including those of border crossing; if there were no delays in border crossing the flat rate price of the national convenience store chain customer contract might be 20% lower than it is currently; for other customers there is an hour delay time built into the flat rate—with an average time per haul of 3.5—4 hours, this is a 25% premium built into the average contract for an unanticipated delay; will occasionally bill a customer for extra time for improper paperwork.

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13.

Company Name LTL or TL FAST approved? No (typical for package carriers)	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Packages.	Description of logistics (do they return empty; do they use a consolidation center) Pickups in Richmond BC for delivery to Seattle by 5 or 5:30pm.
Is it time sensitive? No.	If yes, what is it?
High value products or not: Depends on package.	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency?	If yes, to what extent:

Because they move ground freight, there are no guarantees of delivery times, so if goods are delayed at the border there is no penalty (except losing business in the long-term): "If people have very time critical goods they should move them via air freight." Border is congested between 10am—9pm, and times are longer in the summer when more trucks are crossing; company had experienced longer delays after 9-11 from increased inspections.

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PART II: CANADIAN COMPANIES

14.

LTL or TL: both, but majority is TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Truck parts, paper products, and steel pipe and tubulars	Description of logistics (do they return empty; do they use a consolidation center)
Is it time sensitive? No	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? For JIT products the time windows are tight; if product is not time sensitive then it's less of a concern.	If yes, to what extent: Visual check of Sumas/Huntington border lineups.

Cross border 850X/month; strategy is to head south with enough buffer time; the Sumas border gets less traffic at border crossing so this is less of a concern for them than when they go thru Pac HWY border (if a truck is headed to LA it will go thru this border); for a 3000 mile trip, gauge 5 days of traveling and one day picking up load and crossing border, so it turns into a 6 day trip (600 miles/day, adding one for delivery activities), would still add a day even when not crossing a border; vast majority of drivers paid by trip and it's generally by the mile (have very few town drivers, they get paid hourly), they are also paid to cross the border—have been making additional payment for border crossings to drivers for two years; border crossing is harder now than 5-10 years ago; anticipate the ACE program will cost $200,000/year; freight volume and traffic congestion is more of a concern than border crossings.

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15.

LTL or TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Timber, manufacturing products, chemicals, ocean containers, produce	Description of logistics (do they return empty; do they use a consolidation center) Lower Mainland to Seattle, OR, eastern WA
Is it time sensitive? No; if produce, yes	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency?	If yes, to what extent:

O/P company, 26 owner operators, 2 company trucks; flat decks are 'cut-throat.'

16.

LTL or TL: LTL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Lumber & steel	Description of logistics (do they return empty; do they use a consolidation center)
Is it time sensitive? No	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency?	If yes, to what extent: Use border cameras.

Rely on backhaul for extra revenue; is dispatch service for O/P; fleet is O/P; raise rate 15% for border delays; charge by hour; one hour at border; average delay is 2 hours—that's what is put into the schedule; cost incurred to customer for delay; drivers don't want to cross border.

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17.

LTL or TL: **used to be LTL but gave it up because of logistics of managing.** FAST approved? **Yes, but clients are NOT**	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: **Containers, mainly**	Description of logistics (do they return empty; do they use a consolidation center) **Yes, return empty; pick up at CP & CN rail; deliver to all points in WA in 1-2 days; would cross more often at Sumas, but there are limited hours of service there (frequently go through Sumas northbound; southbound go thru Pac HWY because the customs brokers are there).**
Is it time sensitive? **Yes, if FDA product**	If yes, what is it?
High value products or not: **No**	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? **Estimate when arriving at rail yard**	If yes, to what extent:

Are experiencing 100% FDA inspections; drivers are paid by trip and paid for border time, this adds cost, up to $100 additional cost, they charge for anything over two hours (unloading, loading, and border time: $58.00 CND/per hour); also accommodating for delays at the port; clients are shipping lines; move 5-10 boxes across the border; border delay has been increasing; they've hired an extra person to prepare for ACE; no penalties at rail yard for being late; drivers are O/P; have two company drivers; rate increases a year ago were 5%, now a 12% increase because of border delays; fuel surcharge of 20%.

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18.

LTL or TL: **TL** FAST approved? **No**	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: **general cargo**	Description of logistics (do they return empty; do they use a consolidation center)
Is it time sensitive? **No**	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency?	If yes, to what extent:

Depending on traffic, it takes 2 hours to cross the border; cross at Pac HWY during business hours; know it will take 1.5—2 hours to cross and write it in the schedule; drivers paid by trip; do not factor anything in for border crossing; it's gotten harder to cross the border.

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19.

LTL or TL FAST approved?	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Wood products	Description of logistics (do they return empty; do they use a consolidation center) Don't ship product until customer plans to buy it—a make & sell industry; may truck across or ship to a reload facility; rail cars generally return empty.
Is it time sensitive? No	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? While the timing is very loose; the schedules are timed.	If yes, to what extent: Have booking times, but trucks generally come from a rural area and phone ahead when leaving a mill to the crossing, give customs number and book a certain time so that customs broker will have paperwork ready.

Border crossing times not a big issue in terms of logistics planning; most lumber companies ship product by rail, rail is looser than truck deliveries because the product will get quoted for a certain week; rail is more consistent, and cheaper too, although rail is getting more expensive.

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20.

LTL or TL: TL FAST approved? Yes	If LTL, note frequency & volume & flexibility in terms of shipments:
Description of what they carry: Food products, lumber, paper products, machinery & ammunition.	Description of logistics (do they return empty; do they use a consolidation center) "Irregular route carrier" will haul freight on a one time basis
Is it time sensitive? Perhaps 10%	If yes, what is it?
High value products or not	If yes, specify:
Do they have flexibility to change route, schedule, shipment size, or frequency? They cross during off hours, may cross at Sumas rather than Aldergrove, even though Aldergrove is closer to main terminal.	If yes, to what extent:

Bill on a flat rate basis, also bill on per mile basis, also bill by hour; unanticipated delays are passed on to the customer in form of added hourly rates; operates on tight profit margins; difficult to find drivers who are FAST approved.

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REFERENCES

1. 2005 IMTC Resource Manual, International Mobility and Trade Corridor Project, 2005, Whatcom Council of Governments.

2. Murray, D., 2003. Director of Research for the American Transportation Research Institute, Personal Comments.

3. The Freight Story: A National Perspective on Enhancing Freight Transportation, November 2002. Federal Highway Administration Research Report.

4. Sheffi, Y., 2005. "The Resilient Enterprise: Overcoming Vulnerability for Competitive Advantage", MIT Press, Cambridge MA.

5. Nee, J., J. Ishimaru, and M. Hallenbeck, 2002. "HOV Lane Performance Monitoring," Washington State Transportation Center Research Report.

6. Chao, C., A. Skabardonis, P. Varaiya, 2003. "Travel Time Reliability as a Measure of Service," Transportation Research Record 1855, p. 74-79.

7. Bates, John, John Polak, Peter Jones, and Andrew Cook, 2001. "The Valuation of Reliability for Personal Travel," *Transportation Research Part E*, 37, pp. 191-229).

8. Belzer, Michael H, 2003. *The Jobs Tunnel: The Economic Impact of Adequate Border-crossing Infrastructure.* The Jobs Tunnel, Detroit River Tunnel Partnership.

9. Bonsor, Norman. 2004. "Fixing the Potholes in North American Transportation Systems." *Choices*, Vol. 10, no. 8. Institute for Research on Public Policy, Montreal, Canada.

10. Brownstone, David, and K.A. Small, 2005. "Valuing Time and Reliability: Assessing the Evidence from Road Pricing Demonstrations." *Transportation Research Part A-Policy and Practice* 39 (4), pp. 279-293. eScholarship Repository, University of California. http://repositories.cdlib.org/postprints/699

11. Chan, Felix T.S., and H.J Qi, 2003. "An Innovative Performance Measurement Method for Supply Chain Management." *Supply Chain Management,* 8, 3/4, pp. 209-223.

12. Department of Homeland Security, Bureau of Customs and Border Protection, 2003. *Regulatory Impact Analysis Advanced Electronic Filing System,* November 13, 2003.

13. Farris, M. Theodore II, and Paul D. Hutchison, 2002. "Cash-to-cash: The New Supply Chain Management Metric." *International Journal of Physical Distribution & Logistics Management,* 32, 3/4, pp. 288-298.

14. Globerman, Steve, and Paul Storer. Forthcoming, 2007. *The Impacts of 9/11 on Canada-U.S. Trade*. University of Toronto Press, Toronto, Canada.

15. Jones, Crystal, Daniel Murray and Jeffrey Short, 2005. *Methods of Travel Time*

Measurement in Freight-Significant Corridors. American Transportation Research Institute, Alexandria, VA.

16. KPMG, 2002. *Report on the Survey of Canadian Commercial Carriers on Border Crossing Issues*.

17. Mackie, P.J., S. Jara-Diaz, and A.S. Fowkes, 2001. "The Value of Travel Time Savings in Evaluation," *Transportation Research Part E*, 37, pp. 91-106.

18. Mackie, P.J., A.S. Fowkes, M. Wardman, G. Whelan and J. Nellthorp, 2003. "Value of Travel Time Savings in the UK - Summary Report." Institute for Transport Studies, University of Leeds, United Kingdom.

19. McCormack, Edward, and Mark E. Hallenbeck, 2005. *Options for Benchmarking Performance Improvements Achieved from Construction of Freight Mobility Projects*. Report WA-RD 607.1. Washington State Transportation Center, University of Washington, Seattle, WA.

20. Ontario Chamber of Commerce (OCC), OCC Borders and Trade Development Committee, 2004. *Cost of Border Delays to Ontario*.

21. Ontario Chamber of Commerce (OCC), OCC Borders and Trade Development Committee 2005. *Cost of Border Delays to the United States Economy.*

22. Schrank, David, and Tim Lomax, 2005. *The 2005 Urban Mobility Report*. Texas Transportation Institute, Texas A&M University. http://mobility.tamu.edu

23. Small, Kenneth A., Robert Noland, Xeuhao Chu, and David Lewis, 1999. *Valuation of Travel-time Savings and Predictability in Congested Conditions for Highway User-cost Estimation*. National Cooperative Highway Research Program Report 431, National Academy Press, Washington, DC.

24. Stank, Theodore P., and Michael R. Crum, 1997. "Just-in-time Management and Transportation Service Performance in a Cross-border Setting." *Transportation Journal*. 36, 3, pp. 31-42.

25. Tayor, John C., and Douglas Robideaux, 2003. *The US-Canada Border: Cost Impacts, Causes and Short to Long-term Management Positions*. Michigan Department of Transportation, US Department of Transportation and New York State Department of Transportation.

26. TRAC-University of Washington (Washington State Transportation Research Center), 2003 (update 2005). *Central Puget Sound Freeway Usage and Performance Report*. Seattle, WA.

27. TRAC-University of Washington (Washington State Transportation Research Center), 2004 *HOV Lane Performance Monitoring: 2002 Report*. Seattle, WA.

28. TRAC-University of Washington (Washington State Transportation Research Center), 2005. *Options for Benchmarking Performance Improvements Achieved from Construction of Freight Mobility Projects*. Seattle, WA.

29. Transport Canada, 2005. *The Cumulative Impact of U.S. Impact Compliance Programs at the Canada/U.S. Land Border on the Canadian Trucking Industry.* DAMF Consultants Inc, and L-P Tardif & Associates Inc.

30. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) 2002a. *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring: International Border Crossing Truck Travel Time for 2001.* Texas Transportation Institute and Battelle Memorial Institute.

31. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) 2002b. *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring: Border Crossing Freight Delay Data Collection and Analysis 2001 Data Collection-Pacific Highway (Blaine Border) Crossing.* Battelle Memorial Institute.

32. U.S. Department of Transportation (USDOT), Federal Highway Administration (FHWA) 2002c. *Creating a Freight Sector within HERS.* HLB Decision Economics.

33. Wigan, Marcus, Nigel Rockliffe, Thorolf Thorensen, and Dimitris Tsolakis, 2000. *Valuing Long-haul and Metropolitan Freight Travel Time and Teliability.* Bureau of Transportation Statistics.

34. Zhang, Anming, Anthony E. Boardman, David Gillen, and W.G. Waters II, 2004. *Towards Estimating the Social and Environmental Costs of Transportation in Canada*. Transport Canada.

35. Halcrow Consulting, 2006. Whatcom Council of Governments Pacific Crossing Commercial Vehicle Border Delay Survey Final Report.

36. FAST program website: http://www.cbp.gov/xp/cgov/import/commercial_enforcement/ctpat/fast/

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