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BENEFIT-COST APPROACH

The alternatives that are considered in this study would have various impacts on U.S. Customs and other government agencies, the trading community, and other segments of society. The impacts may be negative (costs) or positive (benefits), and to evaluate the alternatives it is desirable to sum the costs and benefits, which leads us to the realm of benefit-cost analysis.

In economics, a "benefit-cost analysis" is more or less what the name suggests: an analysis of the benefits or costs to society of some action. (To emphasize the societal perspective, the term "social benefit-cost analysis" is often used.) It is important in such an analysis to be clear on what population forms "society." Some analyses attempt to measure benefits and costs for the population of a particular nation, state/province, or locality. For example, some analyses of international airports or seaports have attempted to exclude the benefits or costs accruing to foreigners. Adopting this particularist perspective can greatly complicate the modeling and data requirements, however, and, if only for this reason, many benefit-cost analyses have taken a universalist perspective.

In this study, the researchers have taken the universalist perspective in estimating benefits from alternatives for improved coordination. To estimate only benefits for the United States would be inconsistent with the binational nature of this study and entail a large amount of speculation. It is one thing to estimate, for example, the savings in transportation costs for cross-border shipments that would result from a given alternative. To estimate how much of the savings would ultimately accrue to residents of different countries is a much taller order. The savings can be passed backward and forward along the supply chain through changes in prices, and these changes depend on market factors such as the price-responsiveness (elasticity) of demand and supply.

Transfer payments are not social benefits or costs

One of the pitfalls in benefit-cost analysis is mistaking transfer payments for social benefits or costs. A transfer payment is a zero-sum exchange between one segment of society and another. Tax payments, for instance, are government-arranged transfers of wealth between a taxpayer and other members of society. Suppose that some initiative were to reduce evasion of

the tariff revenues owing to US Customs; the additional revenue collected would represent a cost to those paying it and an equal benefit to those to whom the revenue is distributed. One cannot count the amount of the revenue as a social benefit.

Estimation focus

A border simulation model would quantify many of the alternatives mooted in this report. One such model, the Border Wizard, has been recently developed for the Border Station Partnership Council, a coordinating body of federal inspection services.[1] The General Services Administration has directed that that all ports of entry doing feasibility studies use Border Wizard for project justification and evaluation. Border Wizard is not yet available to the general research community, but we understand it will be made available in the near future to state departments of transportation. Reportedly, the model has been calibrated to information on each major POE, including traffic data that were collected electronically for this purpose. In view of the advanced stage of development of Border Wizard and its apparent sophistication, we decided it would be a poor use of time and resources to attempt to construct our own border simulation model for this study.

Instead, we have concentrated our modeling in directions that complement, rather than duplicate the capabilities of Border Wizard. In particular, while Border Wizard can simulate the effects of changes to border operations on vehicle-delay time, it does not place a cost on vehicle delay time, as we do below.

EXTENT OF CURRENT BORDER DELAYS

Before attaching a money value to border delays, we review the available information on their frequency and duration.

Delays prior to U.S. Customs Primary Inspection

U.S. Customs Estimates of Wait Times

U.S. Customs reports daily estimates of vehicle wait times at primary inspection at land border POEs. Wait times are measured once in the morning, generally between 8 a.m. and 8:30

[1] For a description of the Border Wizard, see http://www.ops.fhwa.dot.gov/freight/Border%20Wizard/Border%20Wizard.htm.

a.m., and once in the afternoon, generally between 4 p.m. and 4:30 p.m. The study team's field observations and public-sector interviews suggest that these collection windows are not strictly adhered to and that actual information collection times may not represent the peak traffic period at the port. The Customs field offices also have latitude in selecting a method of measurement as long as it is non-intrusive. Some offices have opted for camera measurement, but two simpler methods predominant in practice. One of them is to tag the last vehicle in line and to measure how long it takes to reach a primary inspection booth. Another method is for a Customs official to "eyeball" the queue, relating the position of the last vehicle in line to a point of reference, which could be, for example, the midpoint of a bridge. The official then estimates the time it will take for the vehicle to reach primary inspection based on the vehicle's position and past experience. To continue the example, past experience might be that a vehicle takes 20 minutes to progress in the queue from the midpoint of the bridge to primary inspection. U.S. Customs agents also reportedly interview drivers as they are processed through the Primary Inspection Module to determine preprimary wait times. The national office of Customs examines the estimates of wait time, whichever method is used, and may query a field office about the reasons for any unusual delays. The private sector speculates that this promotes underestimation of preprimary wait times at U.S. ports of entry although no independent wait-time data are continuously collected to support or refute this assertion.

Customs reports on its web site only the most recent day's estimates of wait times, but provided the study team with the complete historical series from September 15, 2001, when data collection commenced, through June 12, 2002.[2] Recorded wait times for commercial vehicles were normally longer in the afternoon than in the morning. Among the southern border POEs with the largest volumes of commercial traffic, the average afternoon wait time over the entire sample period reportedly ranged from 6.1 minutes at El Paso-BOTA to 22.7 minutes at Otay Mesa (Table E-1). Excluding the weekends, the average afternoon waiting times become 8.3 minutes to 31.5 minutes, with some ports at these extremes. The average morning wait time excluding weekends was under 7 minutes, except for the 18.1 minute average recorded at Otay Mesa. We were unable to obtain daily data on traffic volumes and, therefore, could not compute traffic-weighted average wait times; these would somewhat exceed the unweighted averages reported here and would better reflect the waits that trucks typically experience.

[2] The address for the web site is http://www.customs.ustreas.gov/news/sept11/sep11infof.htm

Table E-1. Commercial Vehicle Wait Times For U.S. Customs Primary Inspection at Major POEs on Border with Mexico.

Averages, Monday-Friday, Sept. 15, 2001-June 12, 2002

Average Wait Time	**Otay Mesa**		**Calexico East**		**Nogales**		**El Paso-Ysleta**		**El Paso-BOTA**		**Laredo - WTB**	
	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM	AM	PM
Sunday	0	0.3	0	0.1	0	0	0	2.0	0.4	0.5	0	1.8
Monday	10.4	16.2	3.6	11.3	1.0	36.3	0.4	13.3	5.4	7.3	0.6	19
Tuesday	14.9	35.3	3.6	17.8	4.2	15.4	0	19.2	4.5	10.3	0	37.1
Wednesday	21.9	36.0	3.0	19.5	2.3	15.8	0	25.8	7.1	9.5	0.5	24.2
Thursday	18.4	35.8	4.7	16.0	1.5	17.4	0	17.7	6.8	7.0	0.5	19.9
Friday	25.1	34.3	5.0	14.1	3.0	18.4	1.3	22.8	5.7	7.2	1.2	19.7
Saturday	0.8	0.8	0	0.9	2.2	11.8	0	7.7	0	0.9	0.4	3.3
All days	13.1	22.7	2.8	11.4	2.0	16.4	0.2	15.5	4.3	6.1	0.5	17.9
Weekdays (M-F)	18.1	31.5	4.0	15.7	2.4	20.7	0.3	19.8	5.9	8.3	0.6	24.0

Note:

Morning= 8-8:30 a.m.
Afternoon = 4-4:30 p.m.

Source: U.S. Customs

The lack of traffic weights may partly explain why these averages are substantially lower than the figures supplied to the study team when we asked carriers and others in the trading community to estimate the typical wait times for primary inspection at U.S. Customs. Preprimary wait times cited by the trade community were generally over an hour at the busiest U.S. ports of entry. The U.S. General Accounting Office found similar divergence between the private-sector representatives and U.S. Customs officials in their estimates of border delays. The clearest example cited pertained to the Lincoln-Juarez Bridge in Laredo, prior to the opening of the World Trade Bridge. Trucking representatives said that drivers faced an average wait of 3 hours to enter the United States, whereas the Customs port director at Laredo said that the standard wait time was 2 hours.

In other examples the GAO cited, the private sector and Customs differed in their delay time estimates partly because they were not referring to the same thing. At Otay Mesa, trucking

representatives said that delays in crossing the border could run 2 to 3 hours. Customs port officials noted that in an internal study conducted over nine days in 1998, the average wait time to enter the port was 76 minutes between 5 p.m. and 6 p.m. The study did not include, however, the time it took to be processed through the port. Other common crossing delays that are not accounted for in U.S. preprimary wait-time data include drayage carrier staging activities and transit times to and from the border, and line ups and processing at the Mexican Export facility. During peak traffic periods, delays generated by these activities could easily exceed 45 minutes to 1 hour.

In the estimates of wait times that Customs has been collecting since last September, there is substantial day-to-day variation and some extreme outliers (Figures E-1–E-5). At Nogales, where the average weekday afternoon wait was about 21 minutes, there were several days when the wait for primary inspection took 2 hours or more. According to Customs, exceptionally long waits are largely attributable to two categories of events:

- infrastructure problems, such as repairs to tunnels or bridges; and
- hazardous wastes spills or scares or other incidents such as bomb threats.

A threat or scare that disrupts Customs operations for only half an hour can lead to massive backups.

TTI-Battelle Estimates of Border Delays

The Federal Highway Administration FHWA commissioned Battelle and TTI to measure delay times for commercial vehicles at seven POEs. Data were collected for two or three days during 2001 at each of the ports surveyed. On the southern border, data collection occurred in the summer at El Paso-Ysleta and Otay Mesa and in the autumn at the Laredo World Trade Bridge, from port opening time through early evening (Table E-2). Travel time was measured between the point at the border crossing where delay may first occur–generally, a point upstream of the export inspection facility–and a point immediately after the primary inspection booth. Data collectors used handheld computers to record license plate information for all vehicles that passed their location. The computer also stored the time that each license plate was entered. From matching the license plates recorded at the two locations, the researchers could calculate the travel time between those locations.

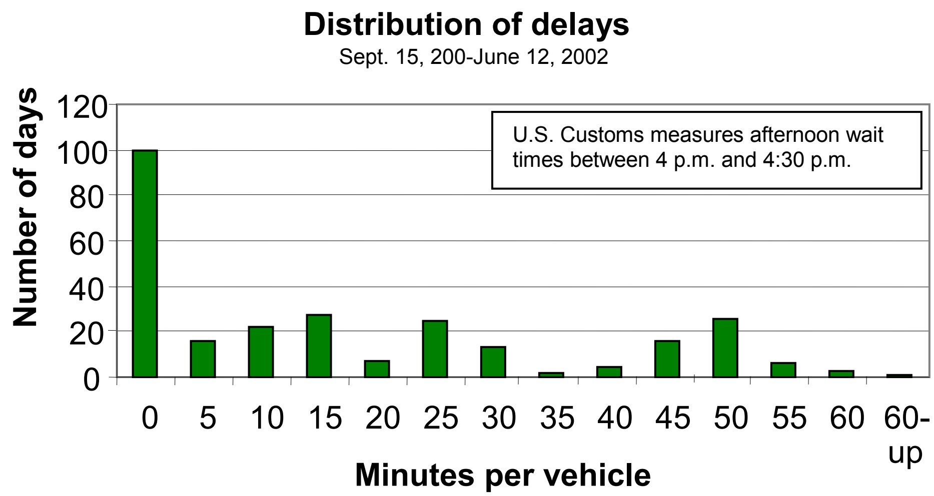

Figure E-1. Commercial Vehicle Wait Time for U.S. Customs Primary Inspection, Afternoons, Laredo World Trade Bridge.

Source: U.S. Customs

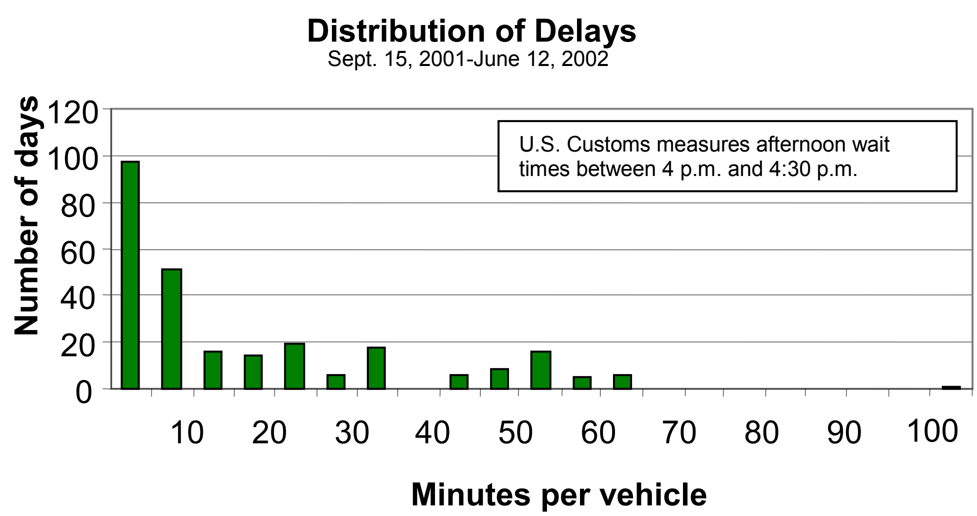

Figure E-2. Commercial Vehicle Wait Time for U.S. Customs Primary Inspection, Afternoons, El Paso – Ysleta Bridge.

Source: U.S. Customs

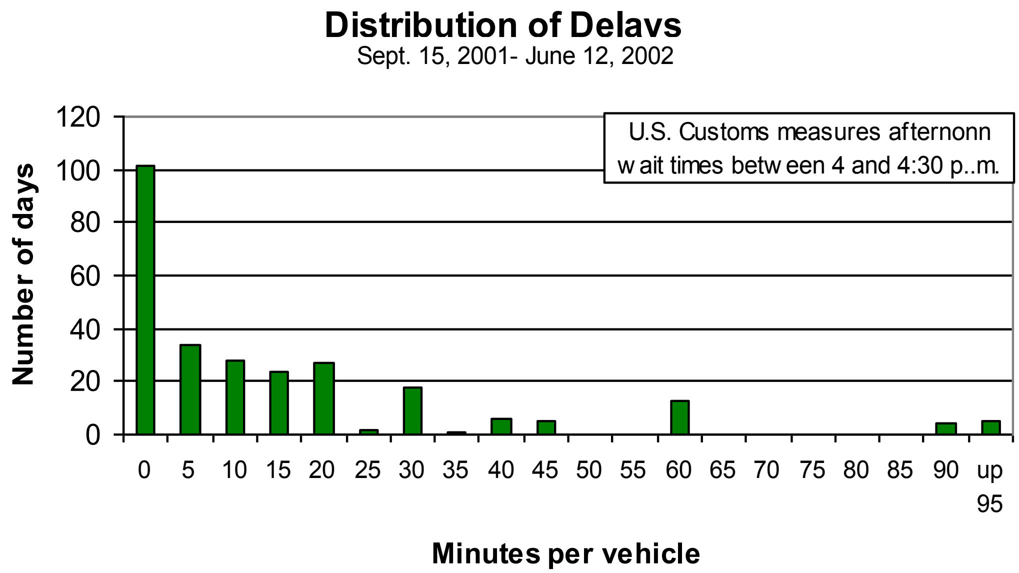

Figure E-3. Commercial Vehicle Wait Time for U.S. Customs Primary Inspection, Afternoons, Nogales.

Source: U.S. Customs

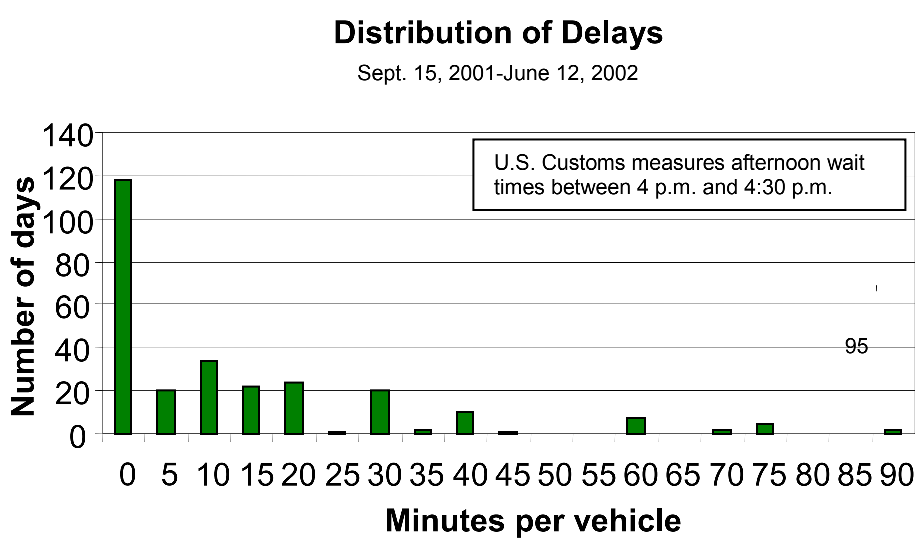

Figure E-4. Commercial Vehicle Wait Time for U.S. Customs Primary Inspection, Mornings, Otay Mesa.

Source: U.S. Custom

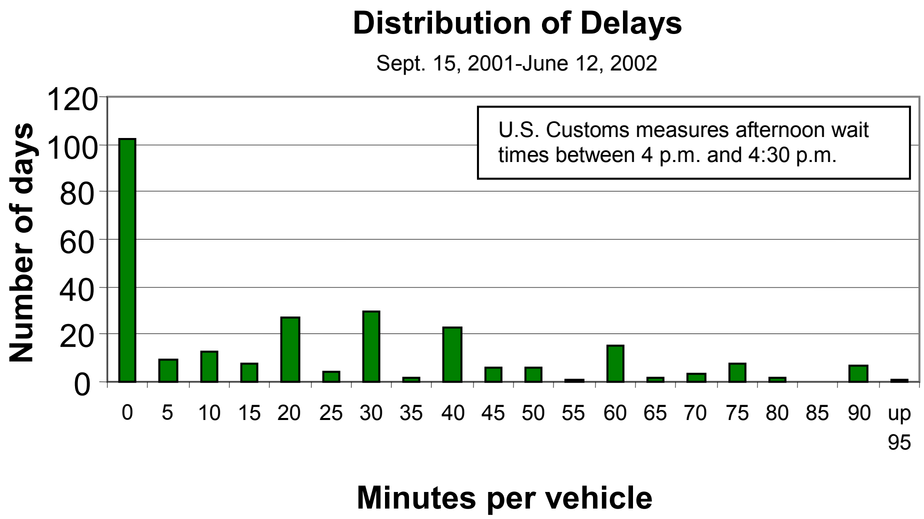

Figure E-5. Commercial Vehicle Wait Time for U.S. Customs Primary Inspection, Afternoons, Otay Mesa.

Source: U.S. Customs

Table E-2. Battelle-TTI Survey of Commercial Vehicle Delay at U.S. Border: Summary Information for Vehicles Entering from Mexico.

Port of Entry	Survey Date(s)	Survey Time(s)	Average daily times for inbound traffic (in minutes)
Otay Mesa, CA	July 17-19, 2001	6:00 a.m. to 8:00p.m.	28.6
El Paso, TX	June 26-28, 2001	8:00 a.m. to 8:40 p.m.	29.6
Laredo, TX	October 30-November 1, 2001	8:30 a.m. to 7:00 p.m.	18.9

Minutes per vehicle

Note: Travel time was measured between the point at the border crossing where delay may first occur–generally, a point upstream of the Mexican export inspection facility–and a point immediately after the US primary inspection booth. Delay time was defined as the difference between actual and free-flow travel time, the latter being the lowest hourly travel time measured over the course of the day.

Source: Texas Transportation Institute (The Texas A&M University) and Battelle Memorial Institute, *Evaluation of Travel Time Methods to Support Mobility Performance Monitoring, FY 2001 Synthesis Report*, final report to Office of Freight Management and Operations, Federal Highway Administration, U.S. Department of Transportation, 2002.

Delay time was defined as the difference between actual and free-flow travel time, the latter being the lowest hourly travel time measured over the course of the day. Border delay time, thus defined, is not quite the same as the wait time in the queue for primary inspection at U.S. Customs. In particular, delays that result from Mexican export inspection will add to the TTI-Battelle measure of northbound delay but not to the U.S. Customs measure of wait time. That said, it is generally primary inspection at U.S. Customs, rather than Mexican export inspection, that is the real bottleneck for traffic flowing between the two data collection locations in the TTI-Battelle study. A previous study put it this way:

A border crossing system can be considered like a pipeline. Each section of the pipeline has a certain diameter and a capacity based on that diameter. The capacity of the entire pipeline is equal to the lowest capacity of any one section–the bottleneck. The same is essentially true for a border crossing system. If we consider all on-line components (those which every vehicle must pass through), the system capacity becomes that of the lowest capacity segment…. The section with the lowest capacity is the U.S. primary inspection booths *(1)*.

In view of this, it is not too surprising that despite the differences in what was measured and how, and in when the data were collected, the estimates from TTI-Battelle (Table E-2) and those from U.S. Customs (Table E-1) are of broadly similar magnitude. It should be pointed out, however, that travel time in the TTI-Battelle study decreased dramatically after the first day of data collection in some instances, despite relatively constant traffic volumes per booth. This raises questions as to the reliability of border-crossing data collected over short 2- to 3-day periods.

Another pattern evident in both data sets is the substantial day-to-day variation in the timing of peak delays. The variation in the TTI-Battelle data (Figures E-6 –E-8) is such that the longest delays do not necessarily occur at a particular time of the day. At Otay Mesa, the peak in measured delays on the first day of observation, a Tuesday, was 42 minutes between 5 p.m. and 6 p.m.; the next day, the second of 3 days of data collection, the peak was 64 minutes between 10 a.m. and 11 a.m.

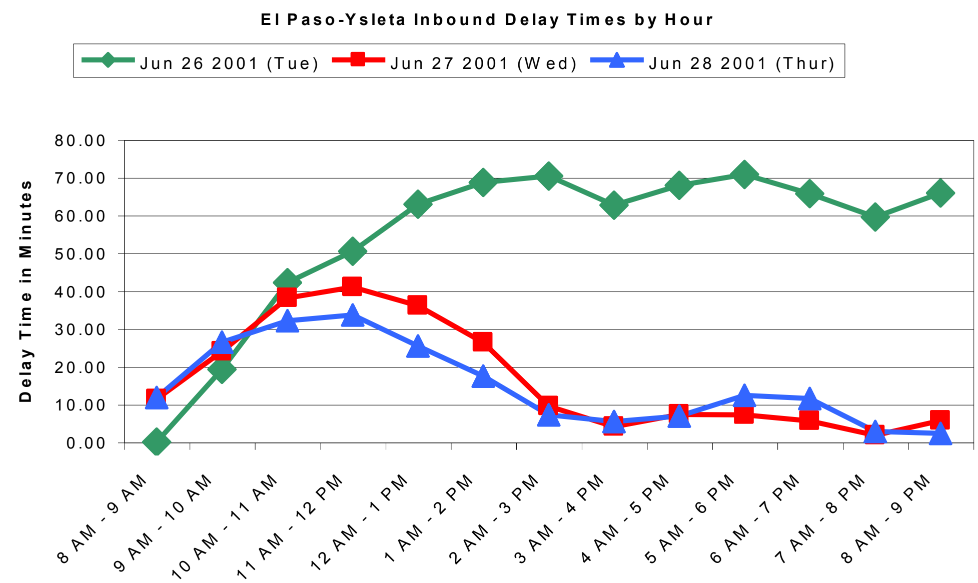

Figure E-6. Estimated Border Delay Time by Hour on Surveyed Days, Commercial Vehicles Entering the U.S. from Mexico, Laredo World Trade Bridge, 2001.

Source: 22

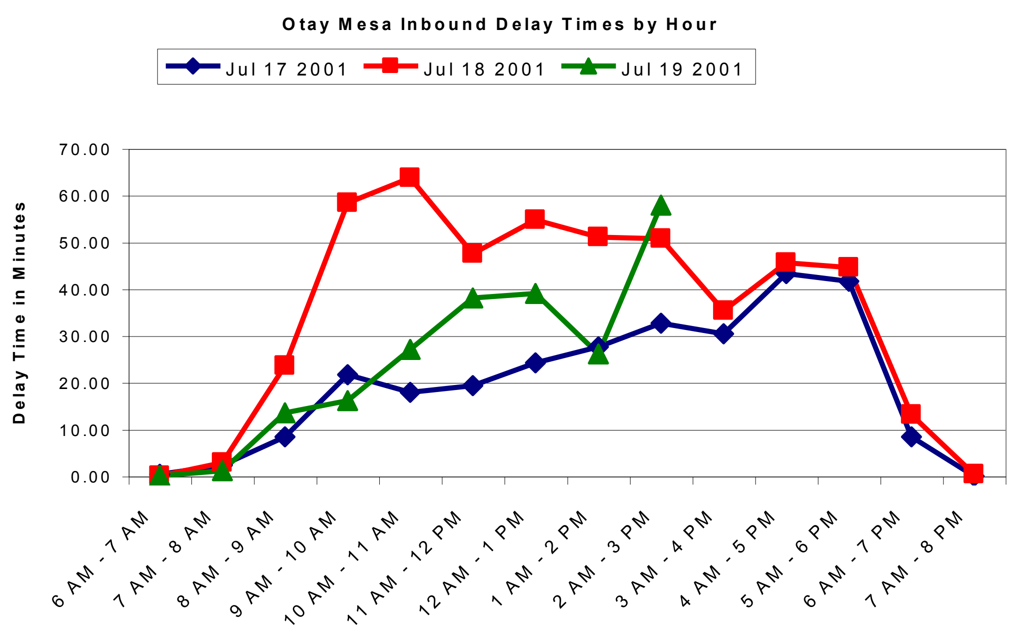

Figure E-7. Estimated Border Delay Time by Hour on Surveyed Days, Commercial Vehicles Entering the U.S. from Mexico, El Paso-Ysleta Bridge, 2001.

Source: See source note to Figure E-6.

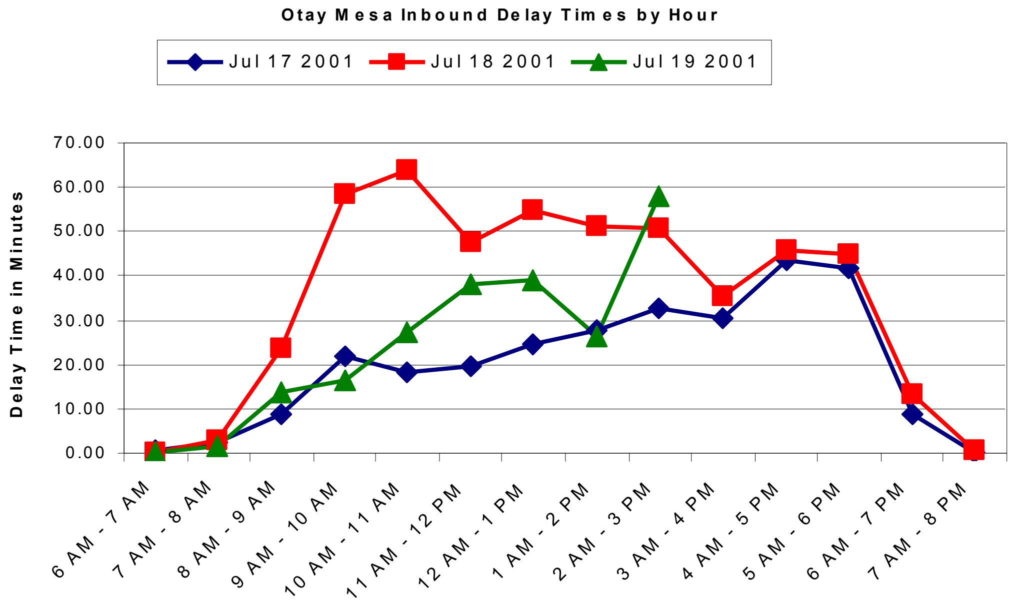

Figure E-8. Estimated Border Delay Time by Hour on Surveyed Days, Commercial Vehicles Entering the U.S. from Mexico, Otay Mesa, 2001.

Source: See source note to Figure E-6.

DELAYS AT U.S. CUSTOMS SECONDARY INSPECTION

Customs data reported by the General Accounting Office indicates that in FY 1998, 29 percent of commercial trucks entering the U.S. from Mexico underwent a secondary inspection. For the present study, we requested an update of these data from U.S. Customs, which informed us that the data are now classified as security-sensitive.

From information obtained during our field visits, our impression is that Customs processing time for secondary inspection is typically about 40 minutes (excluding the intensive manual inspections, which are nowadays infrequent). Total delay time for vehicle is often somewhat longer than Customs processing time, however, since vehicles must sometimes wait their turn for inspection.

THE COSTS OF BORDER DELAY

Border delays for commercial truck movements can impose costs on society in the following ways:

- Requirements for driver labor and other trucking inputs increase, adding to transportation cost.
- Increased time is required for delivery of cargo, interfering with just-in-time production processes and other logistic arrangements.
- Vehicles wait in line with their engines idling, spewing pollutants into the atmosphere.
- Queues of northbound commercial trucks at the U.S. border sometimes extend far enough south that they cause congestion delays for other traffic on the roads of the Mexican border cities.

This list is not exhaustive–for example, the vibrations from heavy vehicles can weaken bridges on which they are often queued at some POEs. The major costs of border delay, however, are those listed above. Of these, we omit from the following discussion the costs from spillover congestion onto the Mexican road network, estimation of which would require a detailed traffic simulation model.

Costs in Trucking Inputs

Delays at the border increase the resources required to accomplish a given cross-border freight task–resources such as driver time, fuel, or truck fleet capital. For their contribution to this binational study, Felipe Ochoa and Associates (FOA) simulated a scenario where an increase in staffing at Mexican primary inspection reduced truck delays *(2)*. To value this benefit, the researchers estimated the operating cost per hour while idling in the inspection queue, for a six-axle combination truck. Estimation was in two stages and relied on the Highway Development and Management (HDM) Model version 3.0, which the World Bank developed and which includes the full range of trucking inputs in calculating operating costs. The first stage consisted of various runs of the model to estimate the operating cost per km at alternative values for road roughness and vehicle speed. The second stage entailed econometric analysis of the first-stage results to estimate the operating cost per hour as vehicle speed approaches zero (idling). The

value thus obtained was $111.25 Mx or $11.93 at the average exchange rate during 2001 when FOA conducted its modeling. (We us the same exchange rate for other currency conversions.)

The HDM model's valuation of vehicle operating costs follows the factor-cost approach, which many other highway evaluation models have used as well. A characteristic feature of this approach is the use of an input's average unit cost to value marginal changes in input consumption. To illustrate, consider a drayage truck driver whose wage is $6 per hour and who saves 5 minutes on a particular trip. For this time saving, the HDM model would count a 50 cent saving in labor cost for the trip. A common objection to this practice, especially as applied to small time savings, is that the carrier may not be able to use the time savings productively because of the "lumpiness" of transport tasks. For example, a drayage truck driver may be carrying three shipments across the border each working day, each shipment involving 3 hours round-trip. Even if 5 minutes are trimmed from each of these trips, it may not be possible to squeeze a fourth trip into a day because of various constraints, such as those on the working hours of drivers (legal limits or worker preferences) or on the schedules of border agencies and the members of the trading community (shippers, importers, brokers, etc.). Other potential adjustments to take advantage of the time savings, such as reducing the driver hours on the job, may also run up against these constraints.

Yet it is far from certain that the factor-cost approach overstates the benefit from truck time savings, even as regards small savings. For one thing, even when small time savings may be "unproductive" in some sense, they rarely have no value. Even if they merely allow a driver to spend some time on break rather than behind the wheel, that should count for something – particularly in view of the hazards from driver fatigue. More importantly, the arguments about lumpiness of trips and other constraints can cut both ways. In some cases, a small saving in time may be just enough to overcome these obstacles–for example, just enough to reach Customs before it closes for the day. In such situations, the factor-cost approach may understate the benefit of the time savings. To make essentially the same point another way, it is consistent to claim, for example, that 5 minutes off the border-crossing trip has no value while an hour saved brings a appreciable benefit: logically, the benefit from an hour saved must equal the benefit from 20 increments of 5-minute time savings.

The bottom line is that for large reductions in trip time, the factor-cost approach gives acceptable estimates of the savings in the costs of trucking inputs, whereas for small reductions,

it is more problematic though whether it is biased in a particular direction is unclear. The adequacy of the factor cost approach also depends on the specificity of the scenario being analyzed. If the scenario involves time savings across a wide range of trucking operations, the errors entailed in the factor cost approach may tend to cancel out. On the other hand, when the context is rather specific, such as cross-border drayage operations, the canceling out is less likely.

The binational study also estimated the hourly cost of truck delay at the border and although the study report does not document the estimation method, we have learned that it was based on the factor cost approach. The estimates, which pertain to a typical five-axle combination truck undertaking cross-border trips in 1995, exceed those obtained by FOA. The mean cost was established at $17.45 per hour for delays in the Customs complexes and $21.45 per hour for delays in lines to cross the borders. (The difference between these figures reflects that vehicles in line are burning fuel.) One of the consultants from the binational study estimated for the Mexican Ministry of Transport (SCT) that idling operation of a five-axle combination truck costs $28.70 per hour. To round off our discussion of the factor-cost approach, a few other points also deserve mention:

Economic Versus Financial Costs

For various reasons, what a carrier pays for a trucking input may differ from the cost of the usage of that input to society. As the documentation for the HDM model cautions:

Unit costs are applied to the calculated physical and operational quantities to produce the cost estimates used in investment decisions and budget preparation. Unit costs should be expressed in economic terms when economic analysis is being undertaken and in financial terms for financial analysis. Financial unit costs are the market prices of resources. Economic unit costs are the real value or opportunity costs of resources, and they are found by removing distortions such as taxes, subsidies and other miscellaneous costs from the market prices *(3)*.

In the context of cross-border trucking, probably the most important source of divergence between the financial and economic costs is taxes. As explained above, tax payments represent transfers within society rather than net benefits or costs to society. And with motor fuel so highly taxed, economic evaluations of transportation arrangements often measure fuel costs net of taxes. In contrast, the FOA estimate of operating cost per hour was gross of fuel taxes. That said, fuel

tax payments are typically a modest component of truck operating cost, so netting them out would probably have had only a small effect on the FOA estimate.

Values for Unit Input Cost

For some trucking inputs, such as fuel, the unit cost is readily measured from prevailing prices and tax rates. Issues, such as depreciation, complicate measurement of costs for capital inputs, and the diversity in pay and earnings complicates measurement for costs of labor inputs. In the case of driver labor, the FOA analysis assumed an hourly labor cost of $15.25 pesos per hour, which equates to about $1.65 (U.S.). Based on the conversations and interviews conducted for the present study, we consider this value to be conservative.

Unanticipated delays

Unanticipated delay is generally more costly than the same amount of anticipated delay. In terms of trucking costs, unanticipated delays can result in cost increases because of missed connections, as when a vehicle arrives too late for a pickup, leaving the vehicle and driver with some dead time. In practice, carriers cope with the risk of unanticipated delays by building buffer time into their schedules. However, while this strategy reduces the risk of lateness, some buffer time may go wasted when delays do not materialize. Whatever the carrier's strategy, difficulty in predicting delays adds to the costs of trucking operations.

These sorts of costs are hard for researchers to measure and are not reflected in the estimated costs of delays from the FOA analysis and the binational study. In this respect, these estimates are conservative.

A first step in measuring the costs of unanticipated delay would first require quantification of the amount of unanticipated delay, which raises the question: anticipated when? As the time of planned arrival at the POE approaches, the amount of delay becomes easier to predict. For a growing number of POEs, a web site provides live views of traffic conditions and, failing access to that, truckers may hear reports over radio or through other means. Companies can sometimes make "last-minute" adjustments in light of such information, changing their schedules or, when more than one POE is nearby, rerouting a vehicle. But the "last minute" is too late for some changes to occur as when a carrier must decide today on whether to accept a particular job for tomorrow.

So a question of interest is how much of the variation in delay time can be predicted a day ahead of the planned arrival at the border? Partly as a rough start toward an answer, but more to stimulate discussion of directions for research and data collection, we conducted an econometric analysis of the U.S. Customs data on commercial vehicle wait times for primary inspection. For each of the four POEs with the longest wait times along the U.S.-Mexico border, our analysis sought to explain the daily variation in wait times over the period for which we have data (September 15, 2001 through June 12, 2002). We analyzed the wait times measured in the afternoon (4-4:30 p.m.) and, at Otay Mesa, in the morning (8-8:30 a.m.; at the other POEs, the waits recorded in the morning were too short and infrequent to warrant analysis.

The explanatory variables in the econometric analysis distinguished the day of the week and the proximity to a national holiday in the U.S. or Mexico. The holiday variables separately identified days that coincided with, immediately preceded, or immediately followed a holiday. Another explanation was the current month volume of truck traffic arriving at the POE from Mexico. We contemplated separate variables for the volumes of empty and loaded trucks, but the split of traffic between categories was fairly stable across months.

Our econometric analysis, detailed in this Appendix, succeeded in explaining only a modest amount of the variation in wait times. As was foreseeable from Table E-1, the variables for day of the week were statistically significant in many cases. So was the variable for monthly traffic volume, which had the expected positive sign. The estimated effects of proximity to holidays were significant in some cases and varied in their signs across POEs. But most of the variation in wait times was left unexplained by our regressions. The econometric analysis depicts the large variation that remains; each shows the probability distribution of wait times assumed for the explanatory variables.

Without a doubt, these distributions somewhat overstate the unpredictable variation in wait times. Predictive power would increase with data on daily traffic volumes, in the absence of which, we had to use monthly figures. Other omissions from our analysis include, for example, information on temporary conditions that affect traffic flows at the POEs, such as repairs to bridges. Equally, however, there is no doubt that delays at the POEs are hard to predict much ahead of time.

Costs in Added Time for Freight Delivery

When border delay time increases, it takes longer for cross-border shipments to get from origin to destination, and this can create various costs aside from the extra costs in trucking inputs discussed above. We term these the "costs in added time for freight delivery."

One source of these costs is the increased risk of spoilage for perishable commodities and of other time-related damage to cargo. Another source is the increased requirement for stocks of precautionary inventories, particularly when the occurrence and amount of delay are hard to predict. An example of this effect can be found in the short-term aftermath of the September 11 terrorist attacks, when tightening of security caused major delays for vehicles entering from Canada. For the U.S. motor vehicle manufacturers in the Detroit region, this seriously interfered with their just-in-time dependence on deliveries of parts and components from plants in Canada. Reportedly, GM™ and Chrysler™ initially adjusted to the delays by adding a day's worth of input requirements to their inventories. But subsequently, as crossing times returned to normal, all three major automakers have returned to the usual two days worth of inputs.

Yet another way in which added time for freight delivery can raise costs is by affecting the number and location of warehouses (depots), decisions that are often made by the areas that can be served within a day's travel from the warehouse. European investigations found the main costs of added time for freight delivery to be related to depot structure and inventory size.

From various carrier providers interviewed for this study, we heard they build sufficient buffer time into their schedules that truck shipments from Mexico seldom arrive so late that downstream logistics are seriously disrupted. When this does occur, contract carriers may be liable for substantial penalties, so they, like private carriers, build sufficient buffer time into their schedules to make this occurrence infrequent.

In addition, while auto components are a significant export from Mexico to the U.S., the sort of logistics that integrate motor vehicle plants in the U.S. and its neighbors–just-in-time production processes with very narrow delivery windows–are quite different from the logistics that characterize many other trade links between the U.S. and Mexico. For example, a shipment of clothing from Mexico may enter a warehouse in one of the U.S. border towns late in the day, where the cargo stays overnight or longer.

For both of these reasons–the buffer time built into carrier schedules and the relative time-insensitivity of some of the cargo–some of the Mexican shippers with whom we spoke were not particularly concerned about their shipments getting delayed at the border for short periods of time. Indeed, when we spoke about our project at a meeting of maquiladora managers in McAllen, Texas, the border delays that most concerned the audience were those on their commutes between homes in the U.S. and their Mexican plants. One of the managers remarked that even a few hours of delay did not matter much, and that while an overnight delay was of great concern, such delays seldom occurred.

Modeling approaches

Economic evaluations of freight-related issues generally have trouble costing the time required for freight delivery. The value of a reduction in delays varies greatly among shipments, and the data from which one could calculate a "hard" estimate are commercially sensitive. Many companies base their logistics on sophisticated optimization models that could simulate the effects of a change in delay time, but economic researchers do not have access to the companies' models. Occasionally, someone from a company may report the result of some such simulation, which, to maintain commercial privacy, may pertain to some hypothetical "representative" company. But the actual realism and representativeness of the results can be hard to judge from the information provided, and strategic bias may be a problem. (Some industry representatives may be tempted to overstate the benefits from reduced delays in order to influence policy decisions.) An early example of such simulation analysis, though not with a sophisticated model, pertains to the effects of reduced delays on logistic costs for U.K. supermarket chains *(3)*.

In the absence of access to company data, researchers have taken several approaches to valuing the cost of added time for freight delivery. One of them is an extension of the factor-cost approach discussed. Some evaluations take a factor-cost approach to valuing delay-related costs of spoilage and other damage. They may also estimate an opportunity cost of cargo in transit by applying an interest rate to the value of the cargo. But this is a very partial allowance for the costs of added time for freight delivery that omits, as one study noted, "many advantages from … speedier deliveries, such as can be gained from rationalizing deliveries, storage locations, or inventory size" *(3)*. Moreover, the estimated interest cost on in-transit inventory generally turns out negligible relative to the estimated delay-induced costs in trucking resources (such as labor

and fuel). If only for this reason, many economic evaluations omit it from the estimated cost of freight delay.

The other approaches to valuing the cost of added time for freight delivery are more modeling-based: revealed preference analysis and stated preference analysis. Actually, one can bring these approaches to bear on the costs of freight delay in general, be they the costs of additional trucking inputs or the costs of added time for delivery. The data and study design determine which elements of time cost are reflected in the findings.

With both these techniques, the modeler infers the value that companies attach to freight time by examining the choices companies make among alternative logistic arrangements. Econometric analysis is usually involved, and the choices analyzed often pertain to mode of transport (e.g., rail versus road) or, more commonly, to choices of route or facility. The difference between these techniques is that revealed preference analysis looks at data on actual choices that companies make, whereas stated preference analysis takes its data from surveys in which respondents are presented with hypothetical choices.

Studies that have used these techniques to value the cost of freight time are not numerous, and they have tended, at least in recent years, to use stated preference more than revealed preference analysis *(4)*. Compared with the latter, stated preference analysis is much less data constrained because the researchers can incorporate into their hypothetical questions variation not observed in the real world. To make the questions as relevant as possible to each individual respondent's circumstances, practically all the stated preference surveys in freight transport have been carried out as computerized interviews. The interviews include questions that are customized to each respondent through a computer program that inputs the responses to the standard questions asked at the start of the interview.

Of the stated preference studies we know of, the most relevant to trucking between the U.S. and Mexico was based on a survey conducted in urbanized areas of California in November 1998 and January 1999 *(5)*. The respondents to the survey were drivers, dispatchers, fleet managers, and supervisors in companies that provided trucking for hire, or that maintained private fleets of at least 10 vehicles. The aim was to interview the decision-maker for fleet management and operations. The interview questions presented respondents with a number of hypothetical scenarios where they had to choose between tolled lanes and free lanes on a congested freeway. The scenarios involved various combinations of tolls and of time savings that

would result from using the tolled lane. The choices entailed in these scenarios, although hypothetical, would have been familiar to many of the respondents because of the value-priced toll lanes in operation on SR 91 in Orange County, CA. Because these lanes provide an option to "buy" out of the delays on the regular untolled lanes, they have been highly popular with time-pressed travelers and well received in general *(6).* To the extent that truckers in Southern California share this favorable attitude, the existence of the value-pricing scheme on SR 91 would have reduced a potential source of bias in the responses to the trucker survey. There are some indications from a European stated preference study that general resentment against expressway tolls may bias responses to questions involving payment of tolls. The responses to the study's survey indicated that the willingness of truckers to pay for time savings was only half as large when the payment involved a toll rather than an increase in money cost of unspecified form (*7)*.

The responses to the California survey yielded an estimate of $23.40 per hour for the average value to companies of savings in truck trip time. The willingness of respondents to pay this amount for time savings undoubtedly stems in large part from the time-related savings in trucking input costs (including the tax component of fuel costs, which is a private, rather than a social, cost.) The willingness of the respondents to pay for time savings may also reflect in some measure the costs of added time for freight delivery discussed above (such as the costs in increased stocks of precautionary inventory). To factor these costs into their responses, however, the interviewees would have needed knowledge of company logistics that may have lied outside their area of expertise. For example, the dispatcher for a for-hire carrier may lack much knowledge of customer needs for precautionary inventory. Even for those respondents familiar with the broader logistics beyond trucking, to factor considerations such as precautionary inventory into their responses would probably require more investigation and reflection than the survey would allow time for.[3]

In many stated preference analyses of travel decisions, the often important distinction between anticipated and unanticipated delay is either absent, as in the California study just discussed, or unclear. A well-designed stated preference survey should convey to the respondents

[3] These doubts about the extent to which respondents factor in the costs of added time for freight delivery have also been expressed elsewhere. De Jong, op. cit. writes: "The indirect reorganization benefits of transport-time savings consist of opportunities to reorganize the distribution and logistic process, opportunities that are lost at present

hypothetical choices that they will understand and be able to meaningfully evaluate without a great deal of reflection. One survey of freight shippers incorporated in the hypothetical choices a specified probability of being late, but to incorporate more detail on the probability distribution of delay might be expecting too much from some respondents *(8)*.

Additional evidence on the value of truck freight time may emerge from the freight benefit-cost analysis study being conducted for the Federal Highway Administration. A report on that study noted the potential for stated preference analysis to assist with the valuation of freight time savings and also noted some analytical improvements, such as increased sample size, that could help realize that potential *(9)*. Sample size can be a problem because of the expense of the stated preference surveys. The aforementioned report cited findings from an NCHRP study that conducted a stated preference survey of motor carriers and came up with quite large estimates for the average value of time–between $144 and $192 per hour for savings in transit time and $371 per hour for savings in unanticipated delay. The report cautions, however, that the results are only indicative "since the sample was restricted to 20 carriers, the characteristics of which were not controllable."

Costs in Air Pollution

As notorious contributors to ambient ozone[4] and fine particulate matter, heavy-duty diesel vehicles are targets for U.S. EPA emission standards that are increasingly stringent and costly. Vehicles of this type entering the U.S. from Mexico are especially bad polluters because they are relatively old and mostly domiciled in Mexico where emission standards are more lax than in the U.S. Further exacerbating the pollution from heavy trucks crossing the border are the queues in which these vehicles sometimes have to wait. While queued, the vehicles generate idling emissions and emissions associated with the short acceleration-deceleration movements (creeping motion) of vehicles as they progress forward. In this section, we restrict our focus to the idling emissions and their cost to society. By estimating the rate of emissions per vehicle-hour and then the cost per unit of emission, we are able to estimate the cost of the emissions per

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because of longer and unreliable transport times. These long-run effects will probably not be included in the trade-offs that respondents make when comparing within- or between-mode alternatives in SP experiments." (p. 562).

4 The emissions from heavy-duty diesel trucks that are of greatest concern from an air quality perspective are Nitrous Oxide (Nox) and particulates. Ground level ozone is formed by a series of reactions between NOx and VOC (Volatile Organic Compounds) in the presence of sunlight. For heavy-duty diesel vehicles, the VOC emissions are usually much lower than the prescribed standards and, hence, are less of a concern than the NOx emissions.

hour of idling operation. To help prepare these estimates, we reviewed the various studies that are summarized in Table E-3.

Table E-3. Environmental Literature Review.

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
Border Congestion, Air Quality, and Commerce	Richard W. Halvey, Western Governors' Association		The study was designed: • To examine explanations for border congestion, • To understand the relationship between various factors that contribute to border congestion and delays, and • To propose opportunities to alleviate that congestion and the resulting impacts on air quality and commerce. Four POE systems on the U.S.-Mexico border were analyzed: • Laredo, Texas–Nuevo Laredo, Tamaulipas • El Paso, Texas–Ciudad Juárez, Chihuahua • Nogales, Arizona–Nogales, Sonora • San Isidro / Otay Mesa, California–Tijuana, Baja California	Determine existing conditions: • Congestion was quantitatively measured through a study of vehicle arrival and departure rates (North Bound and South Bound). Formed basis for existing delays. Delay were estimated as follows: ➢ The time of arrival of vehicles at the back of the queue was noted. ➢ When the vehicle arrived at the primary inspection booth, the time was checked. ➢ The wait time was the difference between when the vehicle arrived at the queue and when the vehicle reached the inspector. ➢ From that point, the vehicle was monitored to determine the amount of time spent with the primary inspector. ➢ Individual wait times were then added to determine an average wait time for all vehicles. • Benefits of candidate actions and improvements (see Table E-2) aimed at reducing avoidable or correctable delays (potential changes in queues and delays) were analyzed using variations of a model developed as part of the Binational Border Transportation Planning *and Programming Study*.	• Traffic counts of commercial vehicle arrival and processing rates – U.S. Mexico Binational Border Transportation Planning and Programming Study (1998) • Additional traffic counts conducted on Fridays • Surveys of commercial vehicle processing rates • Used vehicle exhaust emission estimation model MOBILE Juarez (2000) to estimate emissions for CO, NOx, VOC associated with avoidable or correctable delay for existing conditions as well as for improved operations • EPA's PART5-TX1 model – used to model particulate matter idling emission rates.

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
				➢ The combined impact of individual delay strategies were calculated by means of an algorithm in the model ➢ Average avoidable delay in minutes/ vehicle was calculated from average wait time for all vehicles and the vehicle counts. ➢ Idling emissions in grams/ vehicle hour (for each vehicle category and a composite factor) from PART5-TX1. ➢ Generate potential emissions savings (in kilograms per day) from total avoidable delay estimate and the composite emissions factor. The combined impact of individual delay strategies were calculated by means of an algorithm in model ➢ Average avoidable delay in minutes/ vehicle was calculated from average wait time for all vehicles and the vehicle counts. ➢ Idling emissions in grams/ vehicle hour (for each vehicle category and a composite factor) from PART5-TX1. ➢ Generate potential emissions savings (in kilograms per day) from total avoidable delay estimate and the composite emissions factor.	

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
Air Polution Overview Along the United States-Mexico Border Region	Dr. Carlos A. Rincón, Environmental Defense	2000	Highlights the concerns relating to increased air pollution along the U.S.-Mexico border attributable to increased population growth and economic expansion (maquiladoras and increased trade). Conditions that affect air quality in the border region: • Climate • Land use characteristics • Percentage of unpaved streets • High concentration of old and badly-maintained vehicles • Inadequate planning and design of roadways to allow free flow and movement of traffic • Long queues at the international bridges • Industrial processes • Power plants • Open air burning (brick kilns, dumps, and home fire places • Paint body shops • Fueling		• Paso del Norte emissions inventory shows information by sources of pollutants e.g., motor vehicles, open air burning of trash, home fuel consumption fuel transport and storage; dust from highway traffic; construction materials and equipment; brick ovens and small scale industrial sources; fugitive solvents from painting, architectural coatings and manufactured processes; and heavy industry.) • La Paz Agreement Annex V seeks a better understanding of the problem through a binational inventory of emissions sources, air quality monitoring, and modeling.

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
			Highlights regulations pertaining to air quality in U.S/Mexico and steps taken to solve transboundary air pollution problems.		
Freight Activity and Air Quality Impacts in Selected NAFTA Trade Corridors	Jeffrey Ang-Olson and Bill Cowart, ICF Consulting	2002	Examines the current and future air quality impacts that occur as a result of the development of NAFTA trade and transportation corridors. The analysis focuses on five specific binational corridor segments: Vancouver-Seattle, Winnipeg-Fargo, Toronto-Detroit, San Antonio-Monterrey, and Tuscon-Hermosillo. For each segment, commodity flows and ground freight traffic volumes (truck and rail) are used to develop an estimate of current air pollution emissions associated with cross-border trade. Trade forecasts to 2020 are used to develop a sketch-level estimate of future trade-related emissions. The paper also discusses the impace of six emission mitigation strategies:	• Procedure followed: • Used commodity flow data to analyze trade and transportation in each corridor segment • Calculated the number of larger trucks (four or more axles) at each crossing to represent the number of trade-related freight trucks • Estimated average border crossing delay for each POE • Used commodity flow data and average payloads to calculate the loaded rail car volumes • Calculated air pollution by applying freight vehicle activity data to emission factors • Two truck emissions factors (1999) were developed: an on-highway emission rate based on 55 mph average speed and an idle emission rate based on certain assumptions about the age distribution of the truck fleet	• U.S. Bureau of Transportation Statistics Transborder Freight Dataset • Information on cross-border movements from U.S. Customs, Canada Customs, and private bridge and tunnel operating authorities • Heavy-duty truck emission factors for NOx, VOC, CO, and PM10 estimated from the EPA's MOBILE5 and PART5 models • Current and future locomotive emissions factors were based on the Class I line-haul emission rates used in the EPA's 1998 Regulatory Support Document.

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
			alternative fuels for heavy trucks, reducing border delay, low sulfur diesel and use of advanced emission controls for truckis in Mexico, reducing empty freight mileage, expanded use of longer combination vehicles, and use of advanced emission controls for locomotives	• Two truck emissions factors (2020) were developed based on the adoption of the stringent EPA 2007 standards by the U.S. and Canada standards by Mexico • Calculated railroad emissions based on freight tonnage and fuel consumption • Calculated rail fuel consumed (1999) by estimating an average fuel consumption rate pre revenue ton-mile. A curve was fit to historic data and projected to 2020 to estimate the future fuel consumption rate per revenue ton-mile • Calculated rail locomotive emissions by multiplying fuel consumption by relevant emissions factors	
Workzone mobile source emission prediction	Pattabiraman Seshadri, Southwest Region University Transportation Center Rob Harrison, Center for Transportation Research	1993	Developed a methodology for calculating excess emissions resulting from traffic congestion associated with freeway reconstruction and rehabilitation work within construction workzones. The methodology, presented in the form of a computer model, takes into account workzone configuration and traffic characteristics.	Case III: Vehicle stoppage near the workzone caused by queues: • Vehicles decelerate from the approach speed until they are idling at the end of the queue. • Vehicles make short acceleration-deceleration movements (creeping motion) as they progress through the queue. • Vehicles accelerate to workzone speed at beginning of workzone. • Vehicles pass through workzone at the average workzone speed	Data required: • Approach speed • Length of deceleration zone • Length of queue • Average queue speed • Length of first acceleration zone • Workzone average speed • Length of second acceleration zone • Vehicle mix

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
			Using the model, planners can compare different workzone strategies to identify the one that most effectively reduces vehicle emissions.	• Vehicles accelerate to pre-workzone speeds at the end of the workzone. Calculations performed include: • Average emissions associated with deceleration • Average emissions associated with creeping • Average emissions associated with lower-speed travel • Average emissions associated with acceleration Excess emissions were defined as the difference between the total emissions produced at and near the workzone minus those that would have been produced had the same number of vehicles cruised unhindered through the workzone. The approach was to determine the time spent by each vehicle in each mode of operation (accel, decel, cruise, and queue) so that the average emission rates for each mode can be multiplied with the time spent in that mode to obtain the emission values. These emission values, when multiplied by the total number of vehicles in the analysis period, will give the total mass of pollutants.	• Vehicle acceleration-deceleration characteristics • Traffic data • Workzone parameters • Average vehicle emission rates

Table E-3. Environmental Literature Review. (Continued)

Publication Title	Author	Year	Study Purpose	Quantification Approach	Data Sources
U.S. Mexico Border: Despite Some Progress, Environmental Infrastructure Challenges Remain	United States General Accounting Office: Report to Congressional Requesters	2000	This report analyzes: • The nature and extent of environmental infrastructure problems along border • The programs/funding levels in place to address problems, and • The impediments to improving environmental infrastructure. The report focused on three areas: water, wastewater, and solid waste. Detailed analysis was conducted at five cities: San Diego-Tijuana, El Paso-Ciudad Juarez, Brownsville-Matamoros, Calexico-Mexicali and Douglas-Agua Prieta.		

Idling Emissions Factors

For a given pollutant, the amount of emissions per hour ("emissions factor") from an idling truck depends partly on ambient temperature. Other influences are vehicle characteristics including:

- type of fuel consumed,
- age and condition,
- truck model year,
- weight (heavy-versus light-duty),
- whether trailer or container is refrigerated ,
- technologies, and
- any tampering with emissions technologies.

For the present analysis, we have taken idling emissions factors from a study undertaken by ICF Consulting for the North American Commission for Environmental Cooperation (*10*). The study found that:

- NAFTA trade contributes significantly to air pollution on the San Antonio to Monterrey corridor, particularly the emissions of NoX and PM-10, that is, nitrogen oxides and fine particulate matter (less than 10 microns in diameter);
- Most of the NoX and PM-10 emissions stems from trucks since they transport most of the freight in the corridor; and
- Truck idling due to border crossing delays contributes significantly to carbon monoxide (CO) emissions.

ICF estimated emission factors for cross-border drayage trucks assumed to be Mexican-domiciled vehicles with four or more axles (Table E-4, first row). Diesel fuels in Mexico were assumed to be the same as the U.S., with 500 parts per million (PPM) sulfur. Compared with U.S. line haul fleets, the ICF assumptions for vehicle age were that the Mexican trucks average 5 years older but have the same dispersion around the average. The estimation of emission factors took account of vehicle age and of the Mexican emission standards for the model year. Based on the assumptions about age, ICF estimated that 90 percent of the Mexican drayage fleet was manufactured before 1993 when Mexico first introduced emission standards. The emissions factors for VOC, CO, and NOx were estimated using the U.S. EPA's MOBILE 5 model. PM-10 emissions factors were estimated using EPA's PART 5 model.

Table E-4. Estimation of Cost of Emissions per Hour of Idling Operation, Drayage Trucks Entering the U.S. from Mexico.

Estimates of	Units	VOC	CO	NoX	PM-10
Emission factors	grams/hour	23.4	146.4	103.2	4.92
Cost per unit emission:					
Damage cost	1989 $/ton	2,420	N/A	4,820	6,507
Control Cost	1989 $/ton	9,944	2,714	10,634	3,687
Emission cost per vehicle-hour:					
Damage cost	1989 $/hour	0.06	N/A	0.50	0.03
Control cost	1989 $/hour	0.23	0.40	1.10	0.02
Emission cost per vehicle-hour:					
Damage cost	2001 $/hour[a]	0.10	N/A	0.91	0.06
Control cost	2001 $/hour[b]	0.33	0.57	1.57	0.03

a The estimates of damage cost were updated from 1989 to 2001 using the medical care component of the BLS consumer price index. This component covers medical care commodities, professional medical services, and hospital and related services. Medical care commodities comprise of prescription drugs and nonprescription medical equipment and supplies.
b The estimates of control costs were updated from 1989 to 2001 using the consumer price index for all items.

Sources: 12, 13, 19, 20

Costs Per Unit of Emissions

Estimation of the cost per unit of emissions has generally taken either of two methods, the difference being in the measure of cost. The damage cost method measures the cost in damage to human health and, theoretically but rarely in practice, to property, animal welfare, visual amenity, etc. Costs of damage to human health can relate to medical expenses, loss of work, shortened lifetimes, and reduced quality of life. The method normally involves seven steps:

1. Identify the emission sources.
2. Estimate the quantities of emissions.
3. Simulate air pollutant concentrations in the atmosphere.
4. Estimate exposure of humans and other objects to air pollutant concentrations.
5. Identify and estimate physical effects of air pollutant concentrations on humans, using dose-response relationships from epidemiological studies.
6. Value the physical effects on humans.
7. Calculate emission values in dollars per ton.

Most of these steps are fraught with uncertainties, making the results rather speculative. Researchers differ in the assumptions and simplifications they adopt to deal with the uncertainty, which often leads to a wide range of estimates. Using the damage cost approach, one study estimated that the health costs of anthropogenic air pollution ranged from a low $55 to a high $670 billion (1991 dollars) in the U.S. in 1990 (McCubbin, Murphy, and McCubbin; 2001).

An alternative to the damage cost method is to measure the costs of emissions as the costs of actions to curb them. Examples of such actions are planting trees, improving the catalytic converters on vehicles, raising fuel taxes, and installing scrubbers in coal-powered plants. The idea behind the control cost method is to estimate the cost of the most economical means of controlling a pollutant. Calculating control costs require information on costs and emission reductions associated with the control measure over its entire life, including initial capital cost, operation cost, maintenance cost, and the emission control deterioration rate over the lifetime of the equipment. In addition, if the control measure reduces emissions for a number of pollutants, the cost of the measure needs to be allocated among the pollutants reduced. The control cost method requires fewer steps than the damage cost method and is,

thus, generally regarded easier to undertake. That said, estimating emission values by using either method remains time-consuming and resource-intensive.

The values we use in this report are drawn from a summary by Litman, who, in turn, extracted them from the econometric analysis of Wang and Santini *(11)*. The econometric analysis used as data inputs previous studies' estimates of the cost to society per unit of emission. The variation in these estimates across U.S. urban areas was modeled as a function of air pollutant concentrations and population exposed. Wang and Santini modeled this variation separately by type of emission and by method of estimation–damage versus control–used in the source studies. They then extrapolated the results of the modeling to nine major urban areas in the U.S. that were not represented among the source studies. Table E-3 gives the average values of the extrapolated costs per unit of emission both at the 1989 prices used in the study and at 2001 prices. A damage cost value for CO was not available, which is why we have chosen to use the control cost values in this report's analysis. The control cost values indicate that for each hour a commercial truck waits in the primary inspection queue, it generates emissions that impose a cost on society of $2.50.

Total Cost per Hour of Border Delay

For a commercial truck in the primary inspection queue at U.S. Customs, we assume for our calculations a total cost to society of $31.20 per hour of delay. Of this assumed amount, $28.70 per hour consists of trucking costs–the estimate prepared last year for the Mexican SCT–and the reminder consists of costs from air pollution (the $2.50 estimate derived above). That the trucking cost component far exceeds the allowance for pollution agrees not only with the evidence we have reviewed but also with what we know of benefit-cost analyses of highway-related projects. Typically, when such analyses have attempted to measure pollution costs, the benefits from reduced congestion still consist overwhelmingly of the more traditionally- measured logistic benefits.

With more complete data on the occurrence of delays at the border, we could combine those data with our assumed cost per hour to get a rough estimate of the total annual cost of current delays. Even with the data available, however, we can get a crude order of magnitude for delays at U.S. primary inspection. From Tables E-1 and E-2, we infer that among commercial vehicle entries from Mexico, the average wait time at U.S. primary inspection does

not exceed 30 minutes. Given that some 4.3 million commercial trucks entered from Mexico in FY 2001, the total cost of delays at U.S. primary inspection in that year was probably not more than about $60 million – provided that our assumed cost of delay per hour does not underestimate by much.

VALUE PRICING

To begin with, what is “value pricing”? A recent exchange in a transportation journal offered two competing definitions. The broader definition comes from the manager of the FHWA Value Pricing Pilot Program:

The term was proposed by the U.S. DOT to Congress during the development of the Transportation Equity Act for the 21st Century (TEA-21) legislation in response to calls from state and local pricing project partners (under the predecessor Intermodal Surface Transportation Efficiency Act program) to come up with a new name for the Congestion Pricing Pilot Program. The desire was to have a name that would convey the position benefits (value) of using pricing to reduce congestion *(12)*.

Although “value pricing” may thus have emerged as a euphemism for “congestion pricing”, a more specific meaning has attached to the term. As often used nowadays, “value pricing” refers to an arrangement in which motorists have the option to choose between regular facilities (lanes or roads) and facilities that provide a premium level of service for an extra payment:

Known as value pricing, the concept was first introduced by the operators of a privately funded toll facility, the SR 91 Express Lanes, built in the median of an existing freeway in Orange County, CA. The facility was marketed to the public as offering extra value in the form of providing a faster, safer, and more reliable trip in return for a fee (hence, “value pricing”) *(15)*.

In this report, we use “value pricing” in the sense of payment for premium service. Although value pricing is usually proposed in connection with the construction of new infrastructure (lanes, etc), the main economic rationale is its potential to improve the utilization of infrastructure. Our discussion of value pricing, therefore, takes infrastructure as given so that its adoption entails the tolling of an existing facility that would otherwise be unpriced. From

this perspective, dedicating an expressway lane for value pricing means one less lane for regular use.

Value pricing is sometimes viewed as a special case of congestion pricing, one that is politically more acceptable. Several analyses show that peak-period congestion fees on all lanes of an expressway to be economically more efficient than imposing them only on special value-priced lanes. It may well be, however, that leaving some lanes free of the congestion fee will be more acceptable to the public.

The functional similarity between value pricing and congestion pricing is emphasized in much of the research literature. Indeed some benefit-cost analyses of value pricing limit their modeling of benefits to a reduction in the overall level of congestion (Box 1).[5] The other benefit from value pricing – more efficient management of delay – is absent from these analyses because they ignore the variation among vehicles in the per hour cost of delay. Precisely because of this variation, value pricing yields benefits even in the hypothetical event of no impact on the overall amount of congestion. These benefits arise from a more efficient distribution of the burden of delay, shifting it from relatively time-sensitive traffic to traffic that can bear delays at lower cost. The more time-sensitive traffic opts for the fast lane and experience shorter delays than it would in the absence of value pricing, while traffic that sticks with the untolled lanes experiences longer delays. In what follows, we consider only the benefit from this redistribution of delay since the pricing policies to reduce POE congestion are considered elsewhere in this report.

Value Pricing at the Border Crossings

Many of the recent plans and proposals to deal with compliance issues at our land border POEs - especially the threat to national security – feature fast lanes for traffic precertified as low risk. Already, fast lanes for low-risk passengers exist under the SENTRI program at crossings in San Diego and El Paso and under the NEXUS program at some

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[5] One of these analyses is by the aforementioned FHWA manager: DeCorla-Souza, P. "The Long-Term Value of Value-Pricing in Metropolitan Areas", *Transportation Quarterly*, vol. 56, no. 3 (summer), 2002, pp. 19-31.

Another analysis that abstracted from heterogeneity among vehicles is Liu, L. N. and McDonald, J.F., "Efficient congestion tolls in the presence of unpriced congestion: a peak and off-peak simulation model", *Journal of Urban Economics*, vol. 44, no. 3 (November), 1998, pp. 352-366.

BOX 1: BENEFIT-COST ANALYSES OF HIGHWAY VALUE PRICING

A recent analysis by De Corla-Souza evaluated various tolling options to accompany the addition of two lanes to a prototypical six-lane urban expressway segment. The value pricing options involved peak-period tolls on dedicated fast lanes consisting of the new lanes, and in one scenario, two existing lanes as well. An important simplification of the analysis was the assumed homogeneity among vehicles on the prototypical expressway: traffic consisted of identical passenger vehicles for which the cost of time was $12 per vehicle-hour. The tolls were set high enough to ensure that the satisfaction of two equilibrium conditions:

(1) Traffic flows freely on the fast lanes (no congestion delays)
(2) The total private cost of a trip in time and money (including tolls) - is the same on the fast lanes as on the untolled lanes.

Condition 2 means that in equilibrium, travelers are indifferent between going on the regular lane or going on the fast lane (and paying the toll). The division of traffic between these lanes emerges from Condition 1, which sets the traffic volume at the maximum possible without congestion.

Compared with the base case equilibrium where all eight lanes are free of tolls, the value-pricing equilibrium features less congestion on the tolled lanes. But it also features additional congestion on the remaining untolled lanes, so that the total cost of a trip during the peak period increases on these lanes and, by Condition 2, on the tolled lanes as well. Because of this cost increase, value pricing reduces demand for peak-period travel from a level that would otherwise produce excessive congestion.

For the prototypical expressway segment, DeCorla-Souza measured the net benefit from value pricing as the net benefit from the reduction in peak-period demand, minus the capital and operating costs for toll operation. The estimate of net benefit was then annualized and extrapolated to all 2,780 miles of severely congested urban freeways nationwide. The final estimates indicated annual net benefits of between $3 billion and $5.3 billion, depending on the value-pricing strategy. The magnitudes of these estimates are dependent on the responsiveness of peak-period travel demand to changes in travel cost. De Corla-Souza assumed an elasticity of unity (-1.0); other analyses that (like De Corla-Souza) treated vehicles as homogenous, but which assumed demand to be less responsive, obtained results less supportive of value pricing.

Small and Yan reworked the analysis Liu and McDonald and extended it to account for heterogeneity: Small, K. and Yan, J., "The Value of 'Value Pricing' of Roads: Second-Best Pricing and Product Differentiation", Department of Economics, University of California-Irvine, Irvine Economic Papers, November 1999.

crossings along the Canadian border. Current plans are being developed to expand such precertification programs, for commercial as well as passenger traffic, and to provide fast lanes for vehicles thus identified as low-risk. As we discuss in a following section with respect to commercial vehicles, the provision of these fast lanes would have as one of their likely benefits the an efficient redistribution of wait time at primary inspection. As long as participation in the precertification programs remains voluntary, companies will not participate unless the costs they incur in the certification process and in other ways (e.g., the implementation of transponder technology, security equipment and infrastructure, and more tightly controlled operations and procedures) are less than the benefits they accrue. Since the primary benefit to the participants is the saving in border-crossing time, companies that decide to participate will naturally tend to have more time-sensitive shipments than have the non-participants. So the dedication of fast lanes for commercial traffic precertified as low risk should partly fulfill one of the objectives of value pricing.

Even so, the introduction of value pricing arrangements at the border could further improve the allocation of delay time among commercial vehicles. Inevitably, the eligibility criteria for the precertification programs will exclude some legitimate traffic that is at least sometimes hard pressed for time. For example, a carrier may be ineligible to participate because it lacks a sufficient history of border crossings for its risk of noncompliance to be assessed. In other cases, the shipper may not export the required volume of merchandise to qualify for existing U.S. pre-clearance programs (e.g., a minimum of 50 trailer loads per year are necessary to enroll in the Border Release and Advanced Screening and Selectivity Program.) Among eligible companies too, participation will be less than universal because of the costs involved, which may include costs for inspections, record-keeping and other administrative tasks, special equipment or infrastructure, and other expenses. For some companies that cannot participate in the precertification programs or do not receive significant time savings through participation, having an option to pay for fast-lane access would be beneficial.

One possibility is fast-lane access that is free to traffic precertified as low risk and tolled for other traffic, analogous to high occupancy toll (HOT) lanes on expressways, where high occupancy vehicles (HOVs) travel for free and other vehicles have to pay. In this scenario, traffic that pays for access to the fast lane will, unlike the traffic precertified as low risk, be

subject to the normal inspection requirements; by paying, these vehicles simply get inspected sooner. Given that the wait times for primary inspection are hard to predict, the toll for using the express lane would have to vary as a function of real-time traffic information.

Benefits from More Efficient Allocation of Wait Time: Evidence

However it comes about–whether through value pricing or through dedicated lanes for precertified traffic or some other means–a reallocation of border wait time from time-sensitive traffic to other traffic will reduce the cost to society of a given amount of border delay. In this section, we present some evidence on the size of this cost saving under alternative scenarios for reallocation of wait time, and focusing on commercial traffic.

As discussed previously, estimates of the hourly value of commercial truck time are usually based on either the stated preference approach or the factor-cost approach. Both approaches permit the estimation of a distribution of time values among trips rather than merely an average or typical value. With the factor-cost approach, one could, for example, attach higher time values to more expensive trucks or perhaps to trucks operated by better-than-average paid drivers. We do not know, however, of any such application of the factor-cost approach that would shed light on the distribution of the value of time among commercial trucks crossing the border.

The only evidence we have encountered that would serve our purpose is from stated preference studies, of which the most relevant is Kawamura's study of California truckers *(13)*. The distributions of truck time values estimated in that study show the variation among companies. They do not capture, however, any of the intra-company variation. The study's survey asked truckers to focus on their situation at 10 a.m. on a typical weekday, when stating the choices they would make among the hypothetical alternatives presented. Thus, the study did not capture the variation across alternative situations within a company in the value attached to truck time. In this respect, the time value distributions estimated in the study understate the true variation. It should also be noted that these distributions are among companies, without any weighting for the size of a company's fleet. Weighted distributions would be more informative, but it is unclear what difference weighting would make.

For all truckers within the survey universe, the estimated distribution of per hour values of time had a mean value of $23.40, a median of $13.90, and a standard deviation of $32.

Figure E-9 graphs this distribution for all truckers combined as well as separately for private fleets versus for-hire carriers. The distributions are lognormal. So in contrast with the normal distribution, which is symmetric around the median/mean, the distribution has a long tail to the right, and the mean exceeds the median. For private carriers, the mean value of an hour ($17.60) was substantially lower than for carriers for-hire ($28.80).

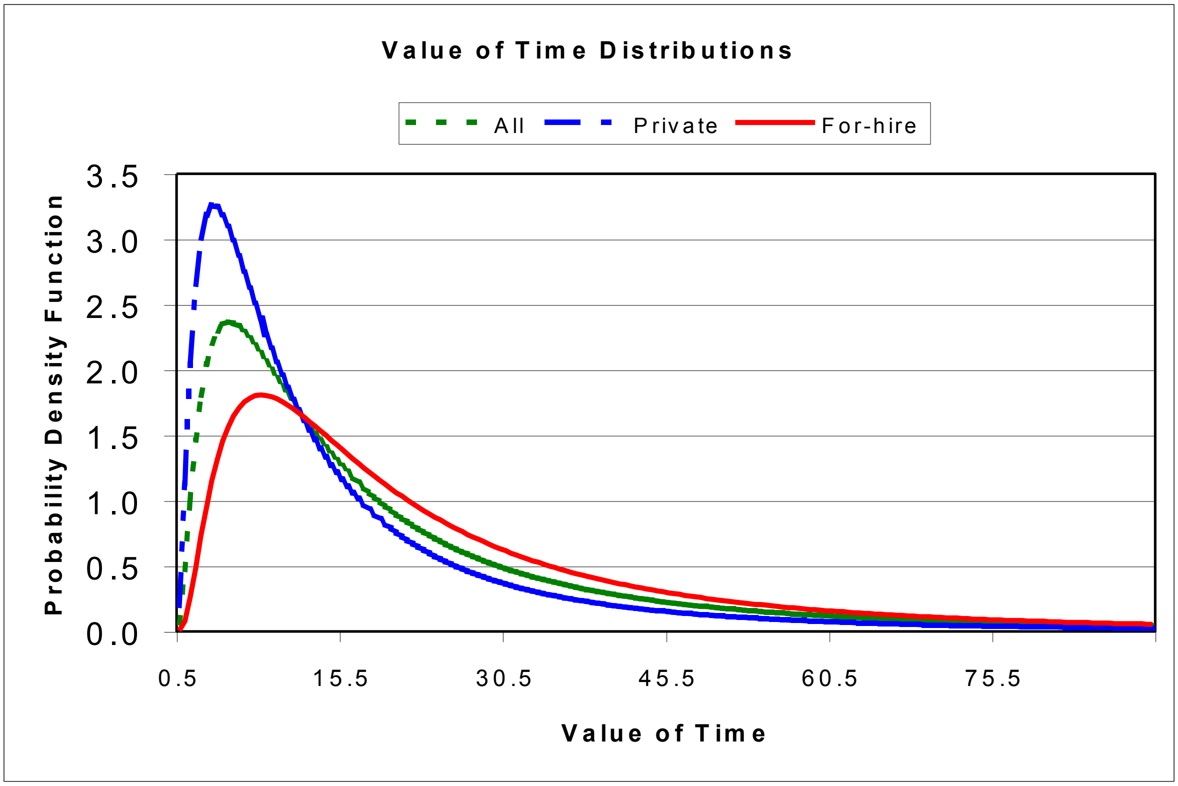

Figure E-9. Estimated Distribution of Values of Time for Commercial Trucks Operated by California-Based Motor Carriers, 1998.

Sources: 7, 21

Table E-5 provides another view of the study's estimated distribution of time values among California truckers (private and for-hire combined). To interpret the numbers, consider the entries in the row that has the value 25 in the first column (heading, "Lowest X Percent"). The numbers in this row indicate that the average value of time is $4.12 (second column) among truckers whose value of time is in the lowest quartile (25 percent), and $28.36 among truckers whose average value of time is in the highest quartile (last column).

Table E-5. Average Value of Time by Percentile Group in the Distribution of Value of Time among Commercial Trucks Operated by California-Based Motor Carriers, 1998.

Lowest X percent	Average Value	Highest Y Percent	Average Value
X=		Y= 100-X =	
10	$2.43	90	$24.54
15	$3.02	85	$25.73
20	$3.57	80	$27.00
25	$4.12	75	$28.36
30	$4.67	70	$29.83
35	$5.24	65	$31.43
40	$5.82	60	$33.18
45	$6.43	55	$35.12
50	$7.08	50	$37.28
55	$7.77	45	$39.72
60	$8.52	40	$42.50
65	$9.33	35	$45.73
(2/3)*100 ≈66.7	$9.62	(1/3)*100 ≈33.3	$50.96
70	$10.23	30	$54.12
75	$11.25	25	$59.84
80	$12.43	20	$67.29
85	$13.82	15	$77.67
90	$15.57	10	$93.87
100	$23.40	—	—

Sources: 7, 21

Table E-6 contains a worked example of the benefits of reallocating border wait time from time-sensitive traffic to traffic with a lower value of time. For simplicity, the table heading attributes these benefits to value pricing although other measures, such as dedicated fast lanes for traffic precertified as low risk, could achieve at least a portion of these same benefits. The estimated values of time in this table are taken from Table E-5. The assumed peak-hour wait time for primary inspection, 60 minutes, is worse than the late afternoon average at the busier POEs but not extraordinary. The number of lanes leading to primary inspection is set at two–as at Nogales–one of which forms the express lane under the value

pricing scenarios, though what matters for our calculations is simply that half the lanes, however many, become express lanes. Likewise, based loosely on data for Nogales on a day when the afternoon wait time was 60 minutes, the number of commercial trucks waiting during the peak hour is set at 120. The choices of traffic volume and the base case wait time (60 minutes) affect our estimates of the benefits of value pricing as measured by the dollar savings in delay costs. They do not, however, affect the estimated benefits as measured by percent savings in delay costs, and these are the bottom-line numbers in Table E-6 that warrant the most attention (bottom right).

Table E-6. The Value of Value-Pricing for Entry to U.S. Customs, Worked Example for Peak Hour

Assumptions

# lanes	**2**
Traffic volume (# commercial trucks)	**120**
Average wait per vehicle (minutes)	**60**
Average cost of delay per vehicle-hour	**$23.40**

Base Case: No Value-Pricing

Total daily cost of peak hour wait time	**$2,808**

Value Pricing Scenarios:

(one fast lane, one slow lane)

	Traffic Spilt		Wait / Vehicle		Average Cost of Delay/ Veh.-Hr.		Daily Cost of Delay Peak Hour		
Scenario	Fast lane	Slow lane	Fast Lane	Slow Lane	Fast Lane	Slow Lane	Total	Savings from Base Case	
								$	*%*
A	**1/3**	**2/3**	**40**	**70**	**$50.96**	**$9.62**	**$2,257**	**$ 551**	**19.6**
B	**1/3**	**2/3**	**20**	**80**	**$50.96**	**$9.62**	**$1,706**	**$1,102**	**39.3**
C	**1/3**	**2/3**	**10**	**85**	**$50.96**	**$9.62**	**$1,430**	**$1,378**	**49.1**
D	**1/4**	**¾**	**30**	**70**	**$59.84**	**$11.25**	$ 2,079	**$ 729**	**26.0**
E	**1/4**	**¾**	**15**	**75**	**$59.84**	**$11.25**	$1,715	**$1,093**	**38.9**
F	**1/4**	**¾**	**12**	**76**	**$59.84**	**$11.25**	$ 1,642	**$1,166**	**41.5**

The six value pricing scenarios in Table E-6 differ in the traffic split between the express lane and the untolled ("slow") lane and in the time savings that truckers gain from choosing the express lane, which ranges from 30 minutes in Scenario A to 75 minutes in Scenario C. Value pricing is estimated to reduce the total cost of the wait at primary inspection by between 19 percent and 50 percent, depending on the specific scenario. Not represented in the table are scenarios that might be possible at large POEs, in which lanes are "express" to varying degrees, much like parcel delivery services offer a menu of fast-delivery services, in which the price increases with speed. Offering such a menu would permit a still more efficient allocation of wait time than the simple fast-slow choice considered here.

The estimates in Table E-6 are largely illustrative, if only because they are based on evidence from a stated preference study of California truckers, rather than of truckers carrying shipments from Mexico into the U.S. It should be borne in mind that the values of time estimated in that study were invariant with respect to the amount of time savings, so that 40 minutes have a value 10 times greater than four minutes. Further research would be needed to more precisely estimate the benefits from value pricing at the entry lanes to U.S Customs. In addition to the valuation of time savings, an important task in such research would be the costing of systems for toll collection.

LEVELING THE FLOW OF TRAFFIC

One of the coordination problems identified in this report is the mismatch between the schedules of trading community and the schedules and processing capacity of the POE inspection agencies. The schedules of the trading community create peaks in the demand across the day, usually in the afternoons. The processing capacities of the inspection agencies are more stable because of constraints on infrastructure and staffing. As a result, the processing capacity at many POEs is not able to accommodate the daily peaks in demand and queues form.

In this section, we estimate the benefit to society from a marginal reduction in peak-period congestion. More precisely, we estimate the benefit that would result from one vehicle shifting from the peak to an uncongested off-peak hour. We then extend the discussion to consider non-marginal reductions in congestion, which reduce both the mean and variability of border-crossing time.

Benefit from Marginal Reduction in Peak-period Congestion

Rescheduling a truck's arrival at a POE from the peak to the off-peak has several benefits for society:

Reduction in primary inspection wait

For illustration, we assume a current 30-minute wait at a primary inspection during peak, similar to recent late afternoon wait times at Otay Mesa from Monday through Friday. In this case, removal of a single vehicle from a queue during the peak period would reduce the combined wait time for vehicles behind it by 30 minutes. Recalling our estimate that each hour of truck wait time in the primary inspection queue has a cost to society of $32.20, the removal of a single vehicle from the peak-period queue would yield a benefit to society of $16.10. The main component of this benefit estimate is the saving in freight costs; reduction in noxious vehicle emissions is credited with only $1.25.

Reduction in congestion within Customs' compound

When traffic peaks, the areas inside the POEs can become congested, with increased delays due to traffic conflicts and to waits for secondary inspections. We lack the data to estimate the reduction in these delays that results from one less vehicle in the congested peak.

Given such an estimate, one could value the benefit of time saved inside the POE, though presumably at a lower rate than for time saved in the primary inspection queue. Vehicles awaiting secondary inspection do not necessarily have their engines running, unlike the vehicles awaiting primary inspection, which burn fuel in idling operation.

Reduction in congestion on roads leading to the border

More speculatively, a shift in POE arrivals away from the peak periods might reduce congestion on roads leading to and from the border. At some POEs, the congestion peak overlaps to a large extent with the afternoon rush hour on local roads.

At Otay-Mesa, for example, a significant amount of the northbound traffic travels on congested Southern California freeways, heading toward the port of Long Beach, rail terminals, or other destinations in the Greater Los Angeles region, such as produce markets. The additional congestion resulting from this traffic has significant costs. Although we could not find estimates specific to Southern California, an FHWA study at the national level estimated for various types of vehicles the marginal congestion cost per mile traveled on urban interstate highways. For five-axle combination trucks, the estimate was 20.6 cents at a weight of 80,000 lb. For a truck that travels the approximately 270 round-trip miles from Otay Mesa to Los Angeles, that would equate to a total congestion cost of $55.60.

To properly analyze how a shift in POE arrival times would affect congestion on roads leading to the border would require an investigation beyond this study's scope. We suspect, however, that at many POEs, a shift away from the afternoon peak at the POE would reduce congestion.

Benefits and Costs of Non-Marginal Reductions in Peak-period Congestion

When we turn to a non-marginal reduction in peak-period traffic, estimation of the benefits becomes harder and costs also enter the picture.

On the benefit side, there is, so to speak, a law of diminishing returns. The benefit from, for example, 10 vehicles transferred from the peak to the off-peak will be less than 10 times the benefit from one vehicle transferred. As additional vehicles are removed from the peak-period queue, the size of the queue shrinks and, hence, so does the reduction in waiting time from the

removal of yet another vehicle. To estimate the reduction in congestion from such changes, we would want a full-fledged simulation model of traffic patterns, including queues, at the POEs.

As well, to induce a non-marginal shift in traffic away from the peak will entail costs in inconvenience. The schedules on which the maquiladora factories operate, for example, do not dovetail with off-peak deliveries to the U.S.. To avoid the afternoon peak at the border would require adjustments to these schedules, and these adjustments have costs, such as the premium pay that might be needed to operate a night shift.

Returning to the benefit side of the equation, recall that congestion at the POE makes the border crossing time not only longer on average but also unpredictable. A switch in traffic arrivals toward the off-peak would improve the border crossing process both by reducing the variability in crossing time and also the average.

Congestion Pricing

Congestion pricing is among the potential strategies for reducing congestion of commercial vehicle traffic at the border POEs. In its basic form, congestion pricing would involve the collection of a toll from vehicles entering the POE during periods of peak delay. Although currently there is a charge of $9.75 for commercial vehicles to enter a POE, the charge does not vary between peaks and off-peaks, and vehicle owners have the alternative of buying an annual decal for $190. Since the large majority of commercial vehicles entering the U.S. have the decal, few pay a charge per entry into the POE compound, much less a charge that varies with the time of entry.

To devise and evaluate a regime of congestion pricing would call for more data than were obtainable for this study. To make a start, one would want a clear and complete picture on when delays occur and on their length. Available data, however, are basically limited to the delays through primary inspection. In addition, the data on wait times collected by Customs pertain to only two times of the day, 8-8:30 a.m. and 4-4:30 p.m., while the data collected by TTI-Battelle indicate delay times over the course of only two or three particular days in 2001. Underscoring the need for additional data is the pattern in the TTI-Batttelle data, where the delays can peak at quite different times on successive days.

Although congestion pricing at the POEs is an option that deserves further consideration, it must be recognized that the irregular occurrence of delays could limit both its

effectiveness and political palatability. For illustration, consider the Customs observations on wait times at the Laredo World Trade Bridge POE, taken at some point between 4 and 4:30 in the afternoon. From Monday to Friday, the recorded wait time averaged 24 minutes (Table E-1), but on about 20 percent of the days, no wait was observed. Now suppose that a congestion charge has been introduced for late afternoon arrivals, and a vehicle arrives at the POE, pays the charge, and observes no congestion. One can imagine that the drivers and others involved with the shipment feeling more than the usual annoyance about having to pay a toll. Likewise, parties that inconvenienced themselves by going earlier in the day to avoid the late afternoon toll may feel annoyed when they find out that the congestion in the late afternoon did not materialize. This would not be a mere nuisance; altering the schedule of shipments to avoid the expected peak does entail costs.

Basing congestion charges on near real-time traffic information could eliminate some of these counter-productive shifts in arrival time, but only to a limited extent. The technical feasibility of such an approach is demonstrated by the value-pricing regime for California's SR 91. As of November 2001, the tolls on the express lanes varied between $1 and $4.75 according to the level of congestion delay avoided in the adjacent non-tolled freeway lanes. *14* But such variation in an express lane toll is much more likely to influence decisions than similar variation in a congestion charge. The choice between a tolled express lane and an untolled regular lane can be deferred until entering the expressway and can be influenced by a sudden change in the toll. The scheduling of shipments, in contrast, is much less flexible; as was observed above, the "last minute" is too late for many changes to occur.

In passing, we note the availability of modeling frameworks for estimating the net benefits of traffic congestion pricing. The simplest, and perhaps most often applied, distinguish only between a peak period with a fully predictable level of congestion and an uncongested off-peak period. These frameworks feature marginal and average cost curves, which reflect the relationship between congestion delay and the volume of peak-period traffic. Another element is a demand curve that reflects the degree of sensitivity of demand for peak-period trips to changes in their cost. With these elements, the modeler can estimate through subtle economic inference the net benefits of congestion pricing, apart from the costs of toll collection and administration, which can be estimated independently. In the border POE context, implementing this sort of framework would require a POE traffic simulation model and

knowledge of the demand curve for peak-period crossings. Unfortunately, neither of these elements was obtainable within the time frame and resources for the present study.[6]

Leaving aside what we cannot quantify and ignoring the day-to-day variation in congestion, the quantification performed above provides a rough indication of the magnitude of the charge that would be appropriate were congestion pricing introduced at the busier POEs. If the congestion-induced delay at primary inspection is 30 minutes at peak, a vehicle entering the POE at peak should pay about $16.10 more than a vehicle entering at a totally uncongested time. Congestion delays at secondary inspection and elsewhere inside the POE compound could justify a higher differential. All this assumes that the currently observed congestion at the POEs is “natural,” rather than a consequence of poor staffing or investment decisions by Customs or other inspection agencies. Any congestion that results from understaffing at peak periods or underinvestment would need to be considered in conjunction with pricing solutions.

INCREASED INCENTIVES FOR PARTICIPATION IN PRECLEARNCE PROGRAMS

U.S. Customs has programs that expedite border processing for shipments precertified as low-risk for noncompliance. These programs are rapidly evolving with an increased focus on national security. The U.S. and Canada are close to launching the Free and Secure Trade (FAST) program, a public-private partnership to improve security measures throughout the supply chain. In return for adopting the tighter measures, participating companies will see their trucks cross the border with less delay.

The following analysis pertains to a particular preclearance program, the Border Release Advanced Selectivity and Screening system, which was previously known as Line Release. However, the points that are made are applicable to other preclearance programs as well.

The BRASS Program – Basic Features

The BRASS system allows Customs to expedite the release of high-volume and highly compliant cargo shipments. Certain categories of cargo are ineligible: absolute quota

[6] Lack of information about the sensitivity of peak-period demand to changes in cost is a general problem in studies of congestion pricing. Fairly often, studies simply assume a certain degree of sensitivity, as expressed by an elasticity. We had considered doing likewise in the present study, when congestion pricing was being mooted as an alternative. But given our lack of access to a POE traffic simulation model, we would also have had to contrive the marginal and average cost curves, making the whole modeling exercise too speculative for our comfort.

merchandise, merchandise deemed "trade sensitive," and merchandise requiring inspection by other government agencies.

Approval to participate is granted to a combination of product and of parties involved in moving that product across the border: the shipper/manufacturer, carrier, importer, and entry filer/broker. For approval, Customs must have sufficient experience in dealing with these elements in combination to assess the level of compliance. On the southern border, this requires that the ACS cargo selectivity system has processed the combination at least 50 times in the past year. Applicants must satisfy the compliance assessment standards and show proof of an active business relationship. No application fee is required.

When a BRASS shipment arrives at Customs, the truck driver presents an invoice with a barcode label that identifies the shipper, importer, filer, and product. An inspector scans the barcode and the relevant BRASS information appears on the inspector's computer screen. Customs normally approves and releases the truck and its cargo within minutes but may order additional checks and inspections either for cause or on a random basis.

The participation rate is lower on the southern border (9 percent of entries) than on northern border partly because of the additional requirement that carriers participate in Land Border Carrier Initiative Program (LBCIP). Carriers participating in the program must be prescreened by Customs through background checks and site visits and approved as low-risk for drug smuggling. When the program went into effect in FY 1997, participation in Line Release on the southern border dropped significantly. Officials at Nogales and Laredo told the General Accounting Office that:

"companies did not want to participate in the program either because they already had contracts with non-program carriers or because they did not want to tie themselves to carrier initiative- approved carriers, many of whom were located near the border and not the Mexican interior, where many of the commodities were produced" *(17).*

Benefits for BRASS Participants

By participating in BRASS, companies reap several benefits for themselves, or "internal" benefits, for which estimates are presented below.

Reduction in delays at the border

Primary Inspection

At primary inspection, entry of information using the barcode labels saves a small amount of time relative to normal procedure. We lack current data on the time required for primary inspection, but from our discussions with Customs staff on the border, we believe that 60 seconds for BRASS traffic and 90 seconds for other trucks would be fairly realistic averages. Our assumption, then, is that BRASS participation reduces delay at primary inspection by 30 seconds per loaded truck crossing.

Secondary Inspection

More importantly, participation in BRASS reduces the probability of secondary inspection. In the absence of current data, we have assumed for our calculations that 35 percent of loaded trucks undergo secondary inspections. We have chosen a value higher than the 29 percent reported for all trucks in FY 1998 because the secondary inspection rate is higher for loaded trucks than for empties. Consistent with information we obtained from Customs, we assume that a secondary inspection rate of only 5 percent of the trucks with BRASS shipments.

Another assumption adopted here is that on average, a secondary inspection requires 2.25 inspectors to each devote 12 minutes of their time.

Reductions in paperwork

Participation in BRASS reduces the paperwork required of companies for clearing their shipments through Customs. U.S. Customs estimates that brokers save 5-15 minutes processing time per transaction, which reduces paperwork by 25 to 50 percent. For shippers, estimated reduction in paperwork is 50 to 80 percent; for importers, 25 to 50 percent.

External benefits from BRASS participation

By participating in BRASS, companies not only derive benefits for themselves but also generate benefits for the rest of society.

Reductions in time spent in inspection queues

If being in the BRASS program reduces the time required for a truck's primary inspection, that means that each vehicle behind the truck in the queue also saves half a minute.

For illustration, let us assume a 30-minute per vehicle wait for primary inspection, as in the above calculation for peak/off-peak diversion. In that case, a truck that carries a BRASS shipment will delay vehicles queued behind it by about 8.5 fewer minutes than a truck that does not carry a BRASS shipment. Using the above estimate of $32.10 for the hourly cost of delay, that amounts to a savings of $4.07. Included in this estimate is the benefit from reduced emissions when trucks spend less time queued. The estimate does not reflect, however, the benefits from possible reductions in time that vehicles spend waiting for secondary inspection. Because participation in BRASS reduces the rate of secondary inspections, it may shorten the time that vehicles have to wait for these inspections.

Savings in costs of Customs' Operations

Based on conversations with Customs, a reasonable value for the cost of inspector labor is about $31 per hour. This can be combined with the above assumptions about the inspector labor input per primary inspection and about the differences between BRASS and non-BRASS trucks in the processing time for primary inspection and in the rates of secondary inspection. In combination, these elements imply the following savings in inspector labor when a truck enters the POE under the BRASS program: 23 cents at primary inspection and $4.26 at secondary inspection, for a total of $4.49.

Total estimated external benefits per vehicle

Comparing vehicles that enter the POE, one under the BRASS program and the other outside it, the total estimated external benefit from BRASS participation is $8.56, the sum of the $4.07 saving in vehicle delay costs at primary inspection, and the $4.49 saving in inspector labor cost.

Increased Levels of Compliance

Increased participation in the BRASS program may enable inspection agencies to free resources to concentrate on the relatively high-risk shipments that are not in the program. This would reduce the flow of contraband and improve national security, but it is not possible to quantify these potentially important benefits.

Need for Additional Incentives to Participate in BRASS

In deciding whether to participate, companies will normally consider only their self-interest, so they will ignore the external benefits that their participation would produce for the rest of society. So without the provision of special incentives to participate, the rate of participation will be suboptimal.

What form should the incentive take?

Dedicated fast lanes

One form of incentive that has been advocated is the provision of fast lanes for BRASS traffic. U.S. Customs does not currently dedicate any of the lanes at POEs exclusively to BRASS traffic, which mingles with other traffic in sometimes-congested lanes. In a recent report on the border, Senator Shapleigh of Texas called for dedicated fast lanes for vehicles participating in BRASS, BASC, and LBCIP as an incentive to participate. Dedicated lanes to provide participation incentive will also be part of the FAST program on the U.S.-Canada border.

Dedicated fast lanes could have another rationale apart from inducing participation in BRASS since they can also reduce traffic conflicts.

Money incentives

Money incentives would have some advantages over the fast-lane incentive since they allow that the amount of incentives can be fine-tuned. Money incentives, unlike fast lane, would have incentive value for vehicles crossing at off-peak when there are no queues at primary inspection. The possibility of money incentives could be examined along with the reconsideration of Customs' user fees when COBRA expires at end of FY 2003.

How large should the incentive be?

The incentive should equal the amount of external benefit per shipment, which we estimated at $8.56 excluding the benefits in increased compliance. If the incentive takes the form of a fast lane, it is possible to translate the time saving offered by access to the fast lane into money equivalent, and conversely. Previously, the assumed cost to truckers of delay in the inspection queue was $28.70 per hour. So an incentive of $8.56 to participate in BRASS would

be equivalent to an incentive of about 17 minutes in time savings. In other words, one could economically justify a fast lane that saves BRASS traffic at least 17 minutes wait at primary inspection.

What would be the effect of an incentive on BRASS participation?

In the absence of evidence on the effectiveness of additional incentives to participate in BRASS, one can assume, for illustration, a 30-percent increase in the BRASS participation rate on the southern border, from the current 9 percent of entries to 39 percent. An entry refers here to the entry of a shipment into the Customs database. On the crude assumption that one loaded truck equals one entry, and using FY 2000 data on loaded trucks entering the U.S., a 30-percent increase in the BRASS participation rate translates to 696,000 additional BRASS entries per year. As a very rough estimate, that increase in number of BRASS entries would generate external benefits of nearly $6 million per year (= $8.56*696,000). Several caveats attach to this calculation:

- It omits the potential benefits from increased compliance with drug laws and improved national security. In this respect, the above calculation is too low.
- It omits the internal benefits that would result from the increase in BRASS participation. The reason is that the internal benefits are presumably more than offset by internal costs of BRASS participation such as the costs of applying and the loss of flexibility from having to rely on LBCIP carriers. In this respect, the above calculation of benefit may be too high.
- It does not recognize the "law of diminishing returns" in queuing: As additional vehicles are removed from the queue, the size of the queue shrinks and, hence, so does the reduction in waiting time from the removal of yet another vehicle. In this respect, the above calculation of benefit may be too high.

TECHNICAL ANNEX: ECONOMETRIC ANALYSIS OF US CUSTOMS DATA ON COMMERCIAL VEHICLE WAIT TIMES

Appendix E ("Quantification of Impacts of Alternatives") described the data that U.S. Customs collects on wait times for inbound commercial vehicles. The appendix also briefly described the study team's econometric analysis of a subset of these data. Details of this analysis are provided below.

DATA ON WAIT TIMES

The study team obtained an archive of the daily data on wait times from September 15, 2001 (when data collection began) through June 12, 2002. The data are estimates of wait times at two times of day: morning (generally between 8 and 8:30 am) and afternoon (generally between 4 and 4:40 pm).

The subset used for the econometric analysis was limited to the data for the four largest POEs on the southern border: the Laredo World Trade Bridge, the El Paso Ysleta Bridge, Nogales, and Otay Mesa. The subset included data for all weekday afternoons. For weekends and mornings, the subset included data only for Saturday afternoons at Nogales and for weekday mornings at Otay Mesa; with these exceptions, the Customs data indicated virtually no delays at the times on weekends or in the morning.

MODEL SPECIFICATION

Even after the omission of weekend or morning observations, the data for each POE include many observations with "no delay" recorded. The dependent variable in the team's econometric model – the wait time in minutes – was therefore a limited dependent variable, bounded below by zero.

Since the modeling of limited dependent variables is a complex and evolving area of econometrics, the study team sought advice from a colleague with expertise in this area, Professor Chandra Bhat of Civil Engineering Department at the University of Texas-Austin.

The team had originally contemplated using a single-equation Tobit specification, but Professor Bhat recommended a specification with two equations. One of these equations is a Logit model of the probability that a delay will occur on a given day; the other equation is a

model of the duration of delay on days when delays occur. This two-equation model is theoretically less restrictive than the Tobit model.

The study team accepted Professor Bhat's recommendations, which led to the specification of equations (A1) and ((A2). The log-linear specification of equation (A2) was adopted to preclude negative predicted values of wait times.

$$\text{(A1)}\quad \ln\left(\frac{P_i}{(1 - P_i)}\right) = \alpha + \sum_{j=1}^{k} \beta_j X_{ij}$$

$$\text{(A2)}\quad \ln Y_i = \gamma + \sum_{m=1}^{n} \delta_j X_{im} + v_i$$

where:

k is the number of explanatory variables, and j and m index these variables
i indexes the observation period (date, morning or afternoon)

P_i is the probability that a delay will be recorded for observation period i

Y_i is the duration of the wait (in minutes) for observation period m for which a non-zero wait is recorded

X_{ij}, X_{im} are the values of the explanatory variables

v_i is a stochastic disturbance term that is normally distributed with mean zero.

<u>Stochastic Restrictions</u>

The Logit model, of which equation (A1) is an example, rests on the assumption of independently and identically Gumbel-distributed disturbance terms. The independence means that serial correlation is absent, an assumption also adopted here for the disturbance term v_i in equation (A2). Although the assumption of no serial correlation is clearly restrictive, it avoids the need for estimation procedures that would be unduly complicated for the illustrative analysis

being undertaken.[7] Certainly, the treatment of serial correlation should be a priority for any future research that builds on the present analysis.

Based on Professor Bhat's advice, another assumption adopted was that of independence between the disturbance terms underlying Equation (A1) and the disturbance term in equation (A2). Professor Bhat considered that for a preliminary, largely illustrative, analysis of the type the study team was planning, the specification error from imposing this restriction would be small relative to the saving in modeling effort.

Explanatory Variables

The explanatory variables, defined in Table E-7, include variables for day-of-the-week effects. For other explanatory variables, the rationales for their inclusion or exclusion were the following:

Monthly traffic volume was hypothesized to have positive effects on both probability and duration of delay. The data on traffic volume distinguish empty from loaded trucks, and since empties take less time to process, an increase in their share of the total truck traffic could be expected to reduce delays. Since this share was fairly stable over the sample period, however, it was not included as an explanatory variable. The researchers could not obtain from U.S. Customs data on each day's traffic volume, and these would have enhanced the analysis considerably.

Figures E 10-14 show the total truck traffic volumes by month; the figures for the last two months are extrapolated from past trends because the actual figures were unavailable at the time the analysis was performed.

A variable for linear *trend was included* to allow for influences that that were not otherwise modeled and that follow a long-term trend. An example could be a secular trend toward increased productivity of U.S. Customs.

[7] Adjustments for serial correlation would be complicated because of the exclusion of one or more weekend days from the sample, and because of the two-equation framework for dealing with the limited dependent variable.

The inclusion of variables for *Mexican and U.S. holidays*, and for the days immediately before and after, was based on statements from carriers. One informant said that at Laredo World Trade Bridge, the day before a Mexican holiday tends to be relatively busy, with carriers trying to beat the holiday stoppage of production in Mexico.

ESTIMATION RESULTS

Tables E-8 – E-11 and E-12 – E-16 present, respectively, estimates of equations (A1) and (A2); the estimation methods were maximum likelihood Logit regression for equation (A1) and OLS regression for equation (A2).

As hypothesized, the estimated coefficients on "traffic volume" are positive – i.e., more traffic produces more delay – and most are statistically significant.
The estimated coefficients of linear trend varied in sign and significance. The trends were toward less delay at Otay Mesa and Nogales, and more delay at El Paso-Ysleta. The estimates of day-of-the-week effects were consistent with what the raw data showed, sometimes statistically significant, and varied by POE. The regression results also indicate that delays are generally shorter on U.S. holidays, and at Nogales, on the day after as well.

Although the regressions explain some of the variation in wait times, they leave a great deal of the variation unexplained. This is illustrated in Figures E-14 – E-18, which show two distributions of minutes of delay. One distribution shows the variation among days in the delays recorded by U.S. Customs over the analysis period (September 15, 2001 through June 12, 2003). The other distribution is a conditional probability distribution that was derived from the regression results for our two-equation model. Since it is conditional on specified values for the explanatory variables, it does not include the variation in delay that results from the real-world variation in these variables. But even with this variation in delay statistically removed, the dispersion in the probability distribution is considerable. For example, according to the model for Laredo, the median delay is about 15 minutes, but there is a 14.5 percent probability of no delay, and about a 12 percent probability of a delay of at least 30 minutes.

Table E-7. Explanatory Variables in Econometric Analysis of Per Vehicle Wait Times for U.S. Customs Primary Inspection: Commercial Vehicles Entering from Mexico

Variable Name	Definition	Data source	Remarks
Monday	**Dummy variable* for Mondays**		**Included only in the equation for Nogales**
Tuesday	**Dummy variable* for Tuesdays**		
Wednesday	**Dummy variable* for Wednesdays**		
Thursday	**Dummy variable* for Thursdays**		
Friday	**Dummy variable* for Fridays**		
Traffic Volume	**Current month's volume of truck traffic (000's) entering U.S. through the POE**	**U.S. Customs**	**Extrapolated for May and June.**
Trend	**Number of "months" since the start of the sample period (Sept. 15, 2001)**		**"Month"=30 day period. Variable has fractional values, e.g. 1.5 months.**
U.S. Holiday (-1)	**Dummy variable*for day before a U.S. national holiday**		
U.S. Holiday	**Dummy variable* for U.S. national holiday**		
U.S. Holiday (+1)	**Dummy variable* for day after a U.S. national holiday**		
Mexican Holiday(-1)	**Dummy variable* for day before a Mexican national holiday**		
Mexican Holiday	**Dummy variable* for Mexican national holiday**		
Mexican Holiday (+1)	**Dummy variable* for day after a Mexican national holiday**		

- **Note -** A dummy variable is dichotomous. It distinguishes whether or not an observation has a particular characteristic. The variable equals 1 for observations with the characteristic and 0 for all other observations. For example, the variable "Tuesday" equals 1 for all observations that are Tuesdays and 0 for all other observations.

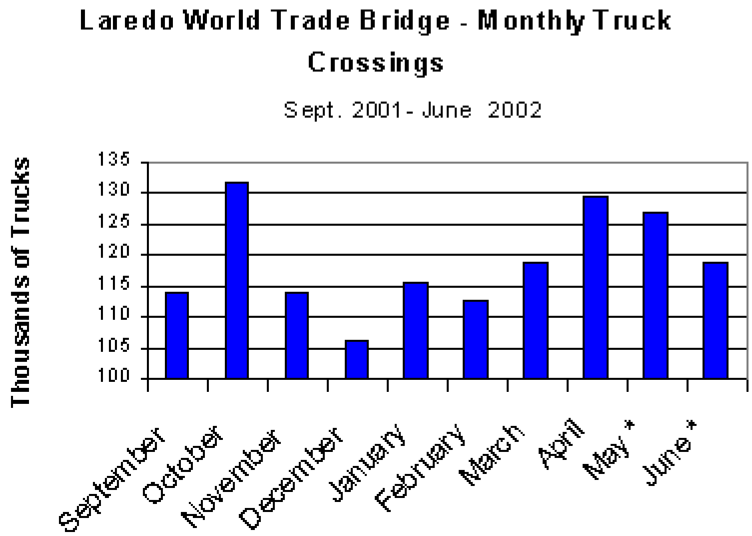

Figure E-10. Monthly Truck Crossings, Laredo World Trade Bridge

Note: May and June 2002 were calculated with the average change rate between 2001 and 2002 monthly crossings

Source: U.S. DOT, BTS based on data from US Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database.

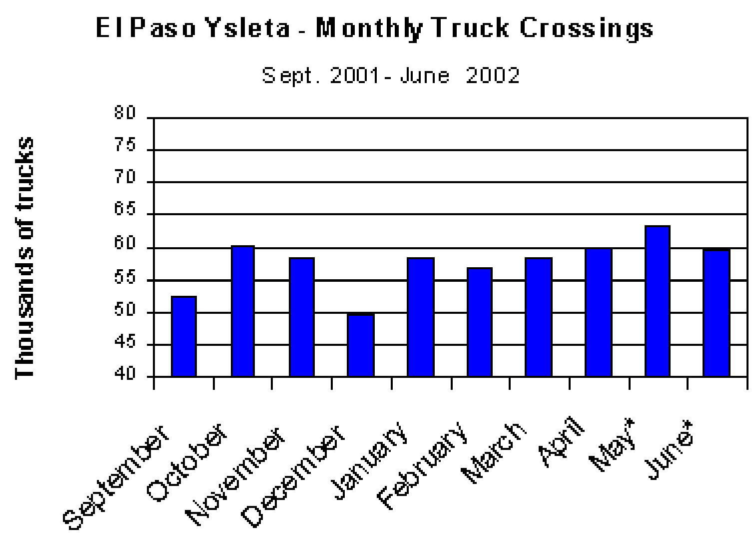

Figure E-11. Monthly Truck Crossings, El Paso Ysleta

Note: May and June 2002 were calculated with the average change rate between 2001 and 2002 monthly crossings

Source: U.S. DOT, BTS based on data from US Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database.

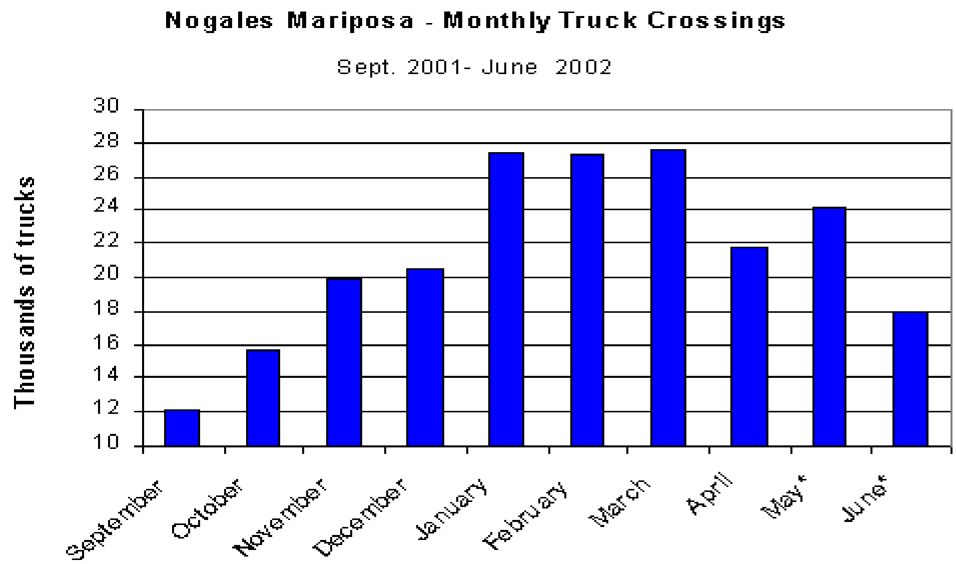

Figure E-12. Monthly Truck Crossings, Nogales Mariposa

Note: May and June 2002 were calculated with the average change rate between 2001 and 2002 monthly crossings

Source: U.S. DOT, BTS based on data from US Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database.

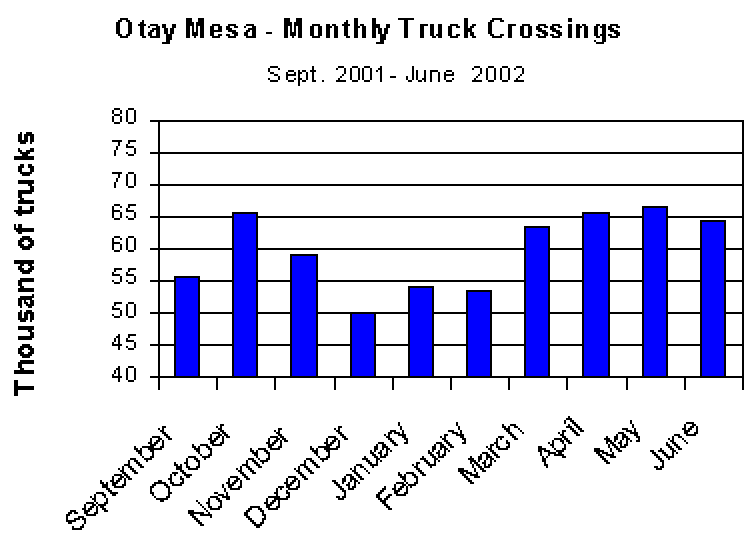

Figure E-13. Monthly Truck Crossings, Otay Mesa

Note: May and June 2002 were calculated with the average change rate between 2001 and 2002 monthly crossings

Source: U.S. DOT, BTS based on data from US Customs Service, Mission Support Services, Office of Field Operations, Operations Management Database.

Table E-8. Results from the Logit model regression: Laredo World Trade Bridge, Afternoons

GENERAL STATISTICS FOR THE MODEL				
Number of Observations				192
Number of Observations with Wait Time for Inspection				153
Number of Observations with no Wait Time				39
-2 log likelihood ratio for the model Intercept only				193.81
-2 log likelihood ratio for the model Intercept and Variables				131.46
Likelihood Ratio				62.35
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept *	-15.152	4.488	11.398	0.001
Tuesday	1.198	0.858	1.953	0.162
Wednesday	-0.097	0.675	0.021	0.885
Thursday	0.334	0.695	0.231	0.631
Friday	0.437	0.714	0.375	0.540
Traffic Volume *	0.142	0.040	12.491	0.000
Trend	0.001	0.004	0.126	0.722
U.S. Holiday (-1)	-2.449	1.769	1.916	0.166
U.S. Holiday	-2.823	1.383	4.163	0.059
U.S. Holiday (+1)	-1.173	1.229	0.912	0.309
Mexican Holiday(-1)	1.921	1.591	1.457	0.227
Mexican Holiday *	-4.087	1.002	16.638	0.000
Mexican Holiday (+1)	-0.240	1.059	0.051	0.821

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-9. Results from the Logit model regression: El Paso Ysleta, Afternoons

GENERAL STATISTICS FOR THE MODEL				
Number of Observations				193
Number of Observations with Wait Time for Inspection				151
Number of Observations with no Wait Time				42
-2 log likelihood ratio for the model Intercept only				202.22
-2 log likelihood ratio for the model Intercept and Variables				189.77
Likelihood Ratio				12.45
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept	-0.280	3.039	0.009	0.926
Tuesday	0.427	0.574	0.553	0.457
Wednesday	0.969	0.618	2.460	0.117
Thursday	0.206	0.543	0.144	0.704
Friday	0.332	0.564	0.346	0.556
Traffic Volume	.018	.055	0.103	0.748
Trend	0.002	0.003	0.706	0.401
U.S. Holiday (-1)	-1.458	1.268	1.322	0.250
U.S. Holiday*	-2.291	1.038	4.870	0.027
U.S. Holiday (+1)	-0.179	1.184	0.023	0.880
Mexican Holiday(-1)	0.165	0.905	0.033	0.855
Mexican Holiday	0.636	0.930	0.468	0.494
Mexican Holiday (+1)	-0.171	0.799	0.046	0.831

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-10. Results from the Logit model regression: Nogales Mariposa, Afternoons

GENERAL STATISTICS FOR THE MODEL				
Number of Observations				230
Number of Observations with Wait Time for Inspection				167
Number of Observations with no Wait Time				63
-2 log likelihood ratio for the model Intercept only				270.07
-2 log likelihood ratio for the model Intercept and Variables				235.36
Likelihood Ratio				34.71
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept *	-2.153	0.874	6.063	0.014
Monday **	1.043	0.583	3.196	0.074
Tuesday	0.714	0.560	1.625	0.202
Wednesday	-0.011	0.508	0.001	0.982
Thursday	0.665	0.567	1.375	0.241
Friday	0.456	0.546	0.696	0.404
Traffic Volume *	0.167	0.046	13.408	<0.001
Trend *	-0.005	0.002	4.542	0.033
U.S. Holiday (-1)	-1.371	1.159	1.398	0.237
U.S. Holiday *	-3.568	1.219	8.563	0.003
U.S. Holiday (+1) *	-2.216	0.989	5.018	0.025
Mexican Holiday(-1)	-0.246	0.675	0.133	0.715
Mexican Holiday	-0.201	0.819	0.060	0.806
Mexican Holiday (+1)	-0.041	0.702	0.003	0.954

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-11. Results from the Logit model regression: Otay Mesa, Mornings

GENERAL STATISTICS FOR THE MODEL				
Number of Observations				192
Number of Observations with Wait Time for Inspection				149
Number of Observations with no Wait Time				43
-2 log likelihood ratio for the model Intercept only				204.24
-2 log likelihood ratio for the model Intercept and Variables				176.18
Likelihood Ratio				28.06
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept *	-6.511	2.164	9.052	0.003
Tuesday **	1.055	0.608	3.008	0.083
Wednesday **	0.990	0.575	2.961	0.085
Thursday	0.944	0.579	2.661	0.103
Friday **	1.026	0.586	3.066	0.080
Traffic Volume *	0.151	0.043	12.607	<0.001
Trend *	-0.012	0.004	9.719	0.002
U.S. Holiday (-1)	-0.714	1.331	0.288	0.592
U.S. Holiday	-0.565	1.089	0.269	0.604
U.S. Holiday (+1)	0.198	0.993	0.040	0.842
Mexican Holiday(-1)	-0.488	0.772	0.400	0.527
Mexican Holiday	-0.954	0.747	1.632	0.201
Mexican Holiday (+1)	- 0.350	0.608	3.008	0.083

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-12. Results from the Logit model regression: Otay Mesa, Afternoons

GENERAL STATISTICS FOR THE MODEL				
Number of Observations				267
Number of Observations with Wait Time for Inspection				163
Number of Observations with no Wait Time				29
-2 log likelihood ratio for the model Intercept only				163.01
-2 log likelihood ratio for the model Intercept and Variables				133.61
Likelihood Ratio				29.40
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept	-3.277	2.397	1.869	0.172
Tuesday *	2.241	0.840	7.121	0.008
Wednesday *	1.490	0.681	4.792	0.029
Thursday *	1.310	0.654	4.012	0.045
Friday *	1.991	0.752	7.011	0.008
Traffic Volume **	0.073	0.043	2.938	0.087
Trend	-0.001	0.003	0.116	0.734
U.S. Holiday (-1)	-1.961	1.501	1.707	0.191
U.S. Holiday (+1) **	-2.062	1.110	3.450	0.063
Mexican Holiday(-1)	1.867	1.473	1.607	0.205
Mexican Holiday *	-2.933	0.769	14.547	<0.001
Mexican Holiday (+1)	-0.199	0.821	0.059	0.809

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-13. Results from the Log-linear model regression: Laredo World Trade Bridge, Afternoons

GENERAL STATISTICS FOR THE MODEL				
F Value				7.79
R square				34.3%
Adjusted R square				29.9%
Residual Mean Square				1.487
Regression Mean Square				11.591
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**T-stat**	**Pr > t-stat**
Intercept *	-4.422	1.336	-3.309	0.001
Tuesday *	0.821	0.286	2.868	0.005
Wednesday	0.187	0.281	0.667	0.505
Thursday	0.113	0.284	0.397	0.691
Friday	0.206	0.287	0.718	0.474
Traffic Volume *	0.054	0.011	4.785	0.000
Trend *	0.003	0.001	2.438	0.016
U.S. Holiday (-1)	-0.624	0.700	-0.891	0.374
U.S. Holiday *	-1.091	0.545	-2.001	0.047
U.S. Holiday (+1)	-0.595	0.583	-1.021	0.309
Mexican Holiday(-1)	-0.204	0.411	0.496	0.620
Mexican Holiday *	-1.776	0.402	-4.414	0.000
Mexican Holiday (+1)	-0.419	0.430	-0.976	0.331

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-14. Results from the Log-linear model regression: El Paso Ysleta, Afternoons

GENERAL STATISTICS FOR THE MODEL				
F Value				2.697
R square				15.2%
Adjusted R square				9.6%
Residual Mean Square				1.901
Regression Mean Square				5.129
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**t-stat**	**Pr > t stat**
Intercept	-0.779	1.756	-0.443	0.658
Tuesday	0.335	0.325	1.031	0.304
Wednesday *	0.771	0.317	2.432	0.016
Thursday	0.151	0.319	0.472	0.637
Friday **	0.555	0.325	1.709	0.089
Traffic Volume	0.039	0.032	1.247	0.214
Trend *	0.003	0.001	1.985	0.049
U.S. Holiday (-1)	-0.641	0.793	-0.808	0.420
U.S. Holiday	-1.865	0.615	-3.032	0.003
U.S. Holiday (+1)	0.098	0.655	-0.150	0.881
Mexican Holiday(-1)	0.063	0.464	-0.135	0.893
Mexican Holiday **	0.864	0.456	1.895	0.060
Mexican Holiday (+1)	-0.234	0.461	-0.507	0.612

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-15. Results from the Log-linear model regression: Nogales Mariposa, Afternoons

GENERAL STATISTICS FOR THE MODEL				
F Value				6.04
R square				25.9%
Adjusted R square				21.5%
Residual Mean Square				0.811
Regression Mean Square				2.806
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**t-stat**	**Pr > t-stat**
Intercept *	-1.397	0.479	-2.919	0.004
Monday *	0.895	0.306	2.922	0.004
Tuesday	0.338	0.310	1.090	0.277
Wednesday	0.057	0.303	0.187	0.852
Thursday	0.360	0.310	1.162	0.247
Friday	0.385	0.308	1.249	0.213
Traffic Volume *	0.168	0.023	7.247	<0.001
Trend *	-0.0038	0.001	-2.725	0.007
U.S. Holiday (-1)	-0.600	0.731	-0.820	0.413
U.S. Holiday *	-1.658	0.592	-2.800	0.006
U.S. Holiday (+1) **	-1.038	0.585	-1.775	0.077
Mexican Holiday(-1)	-0.115	0.390	-0.296	0.768
Mexican Holiday	-0.297	0.448	-0.663	0.508
Mexican Holiday (+1)	-0.267	0.387	-0.690	0.491

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-16. Results for the Log-linear model regression results – Otay Mesa Morning Times

GENERAL STATISTICS FOR THE MODEL				
F Value				4.783
R square				22.6%
Adjusted R square				17.9%
Residual Mean Square				1.546
Regression Mean Square				7.393
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**t-stat**	**Pr > t-stat**
Intercept	-0.849	0.963	-0.882	0.379
Tuesday **	0.549	0.293	1.875	0.062
Wednesday *	0.732	0.284	2.578	0.011
Thursday *	0.669	0.289	2.317	0.022
Friday *	0.973	0.291	3.343	0.001
Traffic Volume *	0.059	0.017	3.539	0.001
Trend *	-0.0073	0.001	-5.837	<0.001
U.S. Holiday (-1)	-0.507	0.709	-0.715	0.475
U.S. Holiday (+1)	-0.041	0.592	-0.070	0.944
Mexican Holiday(-1)	0.400	0.419	0.956	0.340
Mexican Holiday	-0.404	0.387	-1.043	0.298
Mexican Holiday (+1)	-0.382	0.415	-0.918	0.360

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

Table E-17. Results for the Log- linear model regression results – Otay Mesa Afternoon Times

GENERAL STATISTICS FOR THE MODEL				
F Value				4.35
R square				21.0%
Adjusted R square				16.2%
Residual Mean Square				1.599
Regression Mean Square				6.957
ANALYSIS OF THE PARAMETERS				
Variable Name	**Estimate**	**Standard Error**	**Wald Chi-Square**	**Pr > Chi Sqr**
Intercept	0.801	0.980	0.817	0.415
Tuesday *	1.181	0.298	3.969	<0.001
Wednesday *	1.070	0.289	3.704	<0.001
Thursday *	1.035	0.294	3.524	0.001
Friday *	1.232	0.296	4.160	<0.001
Traffic Volume	0.027	0.017	1.605	0.110
Trend **	-0.0023	0.001	-1.774	0.078
U.S. Holiday (-1)	-0.973	0.721	-1.349	0.179
U.S. Holiday (+1)	-0.602	0.602	-0.999	0.319
Mexican Holiday(-1)	0.540	0.426	1.269	0.206
Mexican Holiday *	-1.456	0.394	-3.695	<0.001
Mexican Holiday (+1)	-0.547	0.423	-1.294	0.197

Note * denotes statistically significant at the 95 percent level.
** denotes statistically significant at the 90 percent level.

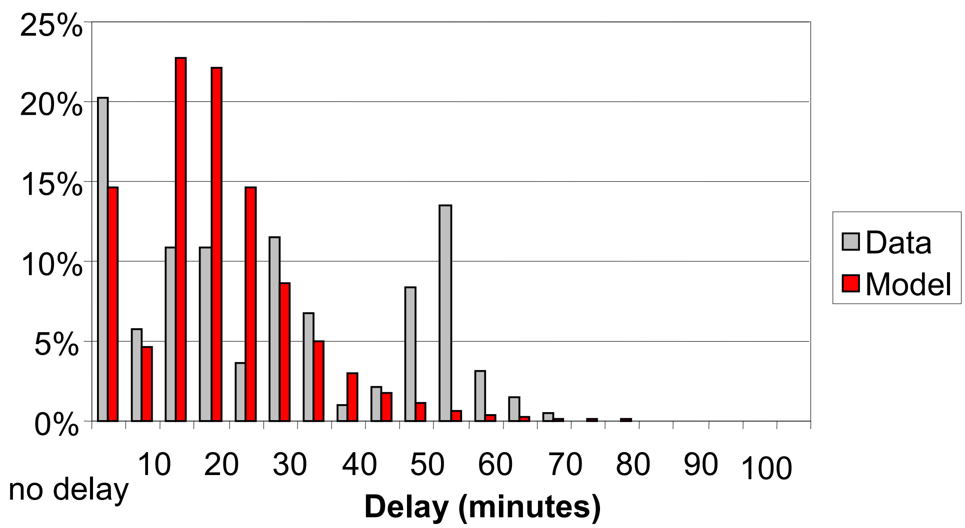

Figure E-14. Commercial Vehicle Wait Times for U.S. Customs Primary Inspection at Laredo World Trade Bridge, Afternoons: Model-Based Conditional Probability Distribution compared to Distribution of Data.

Notes:

Distribution of the data shows the distribution across days from September 15, 2001 through June 12, 2003, excluding weekend days.

The model-based probability distribution is conditional on values of the explanatory variables that describe a hypothetical Wednesday that occurs in month with an average traffic volume, that neither coincides with or comes immediately before or after a holiday.

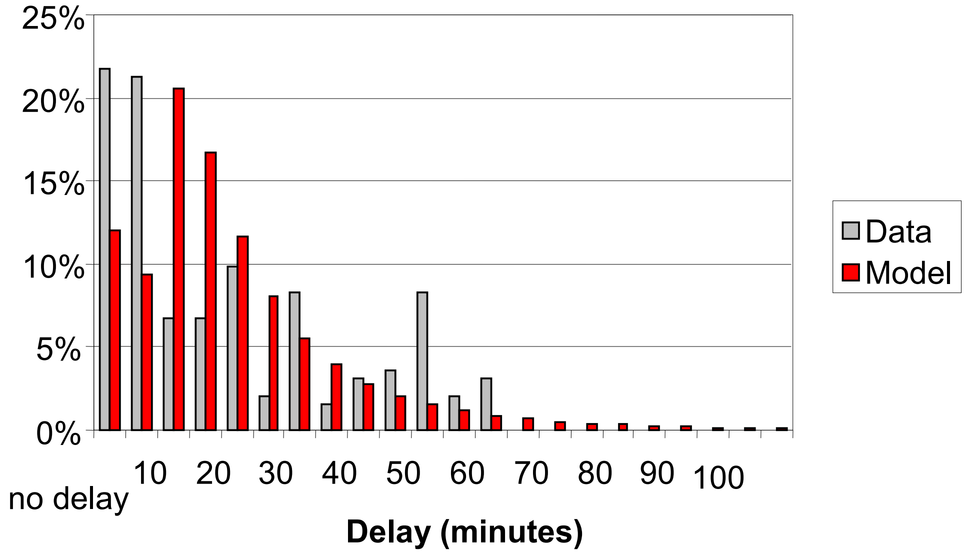

Figure E-15. Commercial Vehicle Wait Times for U.S. Customs Primary Inspection at El Paso-Ysleta POE, Afternoons: Model-Based Conditional Probability Distribution compared to Distribution of Data.

Notes: See notes to Figure E-14.

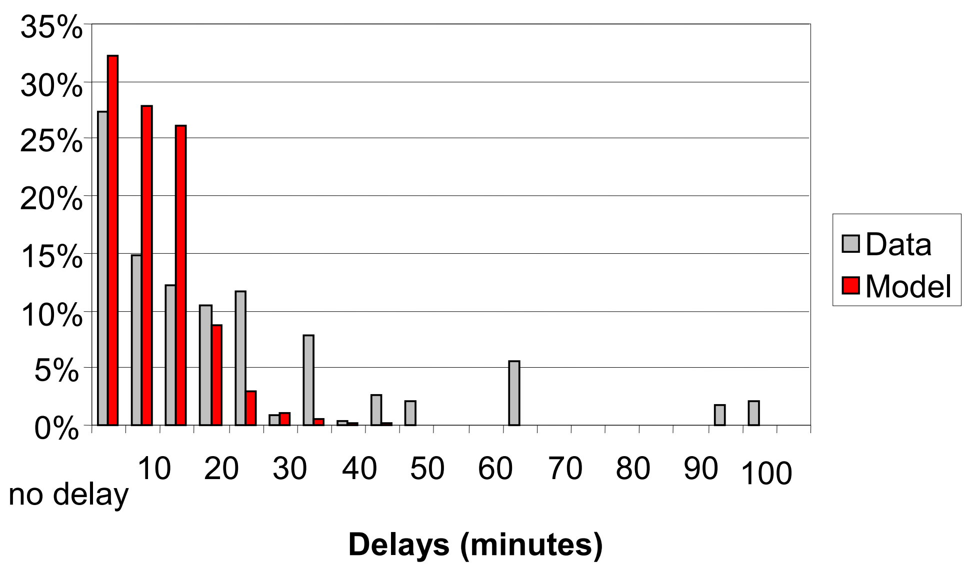

Figure E-16. Commercial Vehicle Wait Times for U.S. Customs Primary Inspection at Nogales-Mariposa POE, Afternoons: Model-Based Conditional Probability Distribution compared to Distribution of Data.

Notes: See notes to Figure E-14.

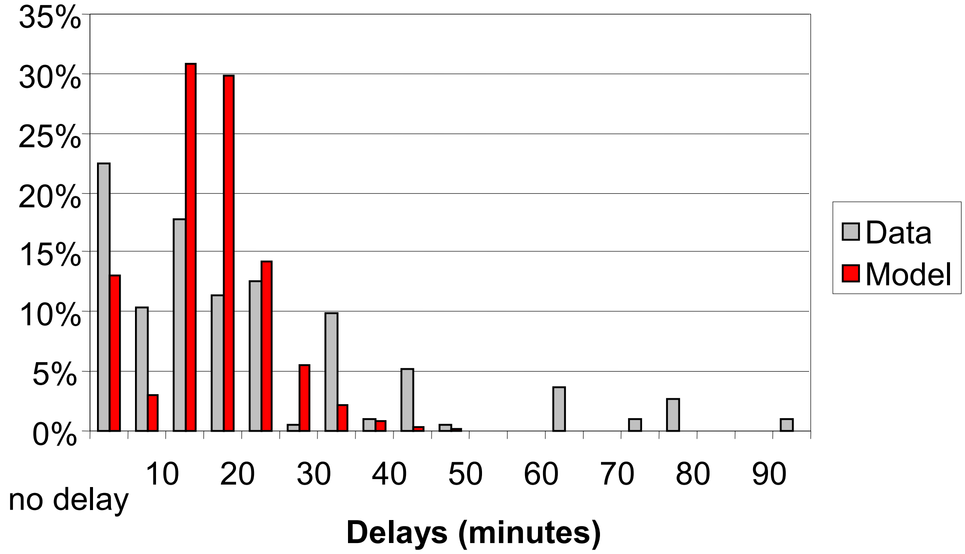

Figure E-17. Commercial Vehicle Wait Times for U.S. Customs Primary Inspection at Otay Mesa, Mornings: Model-Based Conditional Probability Distribution compared to Distribution of Data.

Notes: See notes to Figure E-14.

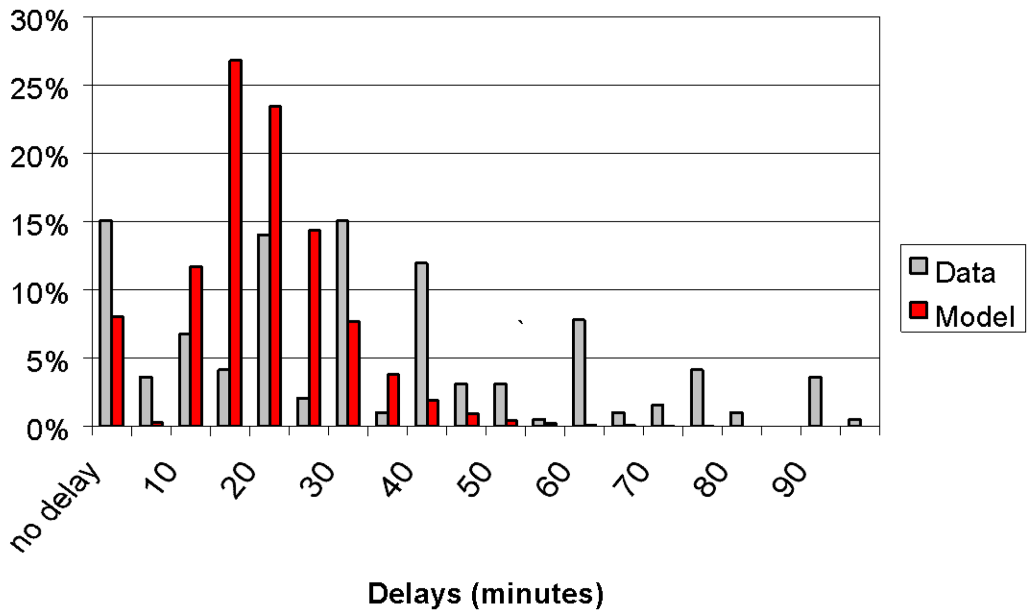

Figure E-18. Commercial Vehicle Wait Times for U.S. Customs Primary Inspection at Otay Mesa, Afternoons: Model-Based Conditional Probability Distribution compared to Distribution of Data.

Notes: See notes to Figure E-14.

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