Developing a Methodology for Deriving Cost Impacts to the Trucking Industry that Generate from Freight Bottlenecks

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ABSTRACT
This paper documents an approach to estimate the annual cost to the trucking industry of specific, severe freight bottlenecks. The approach cross-tabulates independent research on truck travel time measures and operational cost data; by relating decreases in speed to the actual costs experienced by the trucking industry when utilizing congested roadways, marginal truck delay costs can be generated. An initial test of the methodology indicates that a sample bottleneck location in Atlanta, Georgia that has severe congestion may cost the trucking industry $5.7 million more in operating costs annually than if trucks were able to traverse the area at a free-flow speed.

INTRODUCTION AND LITERATURE REVIEW
There are numerous data collection and analysis efforts that aim to quantify delay within the transportation system. These efforts focus primarily on performance measures such as average speeds by time of day, system reliability and estimated hours of delay experienced by system users. Beyond these basic performance measures, researchers and analysts have estimated the cost of traffic mobility deficiencies as a means of expressing the financial impact of congestion. These congestion cost measures can have utility to both system users and transportation decision-makers if they accurately reflect the tangible costs of transportation use on congested facilities.

This paper documents an approach for developing a methodology that can estimate the additional costs incurred by the trucking industry when using specific severely congested freight bottlenecks. This work builds upon a previous study, *Freight Performance Measures Analysis of 30 Freight Bottlenecks* (Short, et al, 2009), which quantifies the decreases in average speeds and travel times experienced by trucks during specific hours of the day at freight bottlenecks identified in previous research. The approach cross-tabulates independent research on truck travel time measures and operational cost data; by relating decreases in speed to the actual costs experienced by the trucking industry when utilizing congested roadways, marginal truck delay costs can be generated.

The literature on this topic includes the efforts of the Texas Transportation Institute (TTI), which produces the annual Urban Mobility Report. The TTI mobility research, which does not focus exclusively on trucks, measures the costs of congestion at both the national and the local levels. As an example, the most recent report (Schrank and Lomax, 2009) estimates that the overall cost of congestion in the United States -- based on wasted fuel and lost productivity -- was $87.2 billion in 2007, representing an annual traveler per capita cost of more than $750.

A separate congestion cost measure was developed and promulgated by the National Surface Transportation Policy and Revenue Study Commission, which estimated that the cost of congestion across all modes of transportation may be nearly three times as high as the 2006 TTI measures (nearly $200 billion per year) when productivity losses, cargo delay costs, and other economic impacts are included (Wells, 2006).
In Canada, Colledge (2007) found that congestion costs account for up to $1.5 billion (CAD) a year in lost economic opportunity for British Columbia’s Lower Mainland economy. The annual cost to trucks alone is estimated to be $500 million (CAD), up from about $110 million in a prior study.

While most congestion-related delays are viewed as enduring artifacts of stagnant infrastructure investment and population growth, Oak Ridge National Laboratory examined congestion that results from temporary capacity losses such as work zones, crashes, and adverse weather (Chin et al. 2004). The study concluded that these temporary capacity losses result in over three and a half billion vehicle-hours of delay on U.S. freeways and principal arterials in 1999. Assuming a $15/hour value-of-time constant, the study further asserts that temporary capacity losses annualize to $55 billion in lost time.

Furthermore, research has attempted to isolate and localize congestion cost measures. Weisbrod et al. 2001 proposed to measure the real monetary cost of congestion to local or regional economies, and used data from Chicago and Philadelphia to test the methodology. Among the findings of this report were that business costs associated with product and service deliveries were as high as $980 million per year in the Chicago region and $240 million per year in the Philadelphia region based on hypothetical scenarios in which there was a 2.5 percent reduction in average truck travel times. The annual savings in commuting costs ranged as high as $350 million/year in Chicago and $200 million/year in Philadelphia for the hypothetical scenario in which there is a region-wide 10 percent reduction in average commuting time and cost.

The Economic Development Research Group calculated the economic impacts of congestion in a 2005 report for the Portland, Oregon region. In addition to the direct financial impacts associated with congestion (the study predicted a cost of $844 million annually and a loss of 6,500 jobs by 2025 if infrastructure improvements are not made), several qualitative effects of congestion are discussed. For example, Sysco Foods opened a new regional distribution center in Spokane to better serve their market area because it was taking too long to serve its market from the Portland area.

In a report prepared for the Federal Highway Administration, Cambridge Systematics (2008) identified freight-specific highway bottlenecks in the U.S. and estimated the truck-delay caused by those bottlenecks. Using Highway Performance Monitoring System (HPMS), the Freight Analysis Framework (FAF2), and FHWA/ATRI’s Freight Performance Measures bottleneck analyses, the authors conducted a national scan of highway bottlenecks, and estimated congestion severity at the worst bottleneck locations. Methodology from a previous Cambridge Systematics study (1998) was then used to estimate truck delay at the bottleneck locations. Taking into account value-of-time, a trucking industry cost of $7.3 billion per year is calculated in the report for the worst 30 bottlenecks in the United States.

In 2008, the American Transportation Research Institute (ATRI), conducted a study to assess the operational costs of truck delays, defined as the full marginal cost of operating a truck for one mile or one hour in typical operating conditions (Trego, 2008). As a critical component of this work, ATRI collected and analyzed key cost center data from for-hire motor carriers representing a range of industry sectors, fleet sizes and geographic regions. Both costs per mile
(CPM) and costs per hour (CPH) were calculated to accommodate travel time and travel
speed/distance measures. Total marginal costs for the industry across all sectors, fleet sizes and
regions were $1.73 per mile and $83.68 per hour. The study found that the specialized sector had
the highest total marginal CPM, followed by the Less-than-Truckload (LTL) and Truckload (TL)
sectors.

Motor carrier incremental cost center data can be categorized into two primary groupings:
vehicle-based costs and driver-based costs.

- **Vehicle-based**
  - Fuel-Oil Costs;
  - Truck/Trailer Lease or Purchase Payments
  - Repair and Maintenance
  - Fuel Taxes
  - Truck Insurance Premiums
  - Tires
  - Licensing and Overweight-Oversize Permits
  - Tolls

- **Driver-based**
  - Driver Pay
  - Driver Benefits
  - Driver Bonus Payments

Finally, it should be noted that the aforementioned costs, and the marginal costs referred to
throughout this paper, represent long-term marginal costs (and are not short-term marginal
costs). Short-term marginal costs, which are likely limited to driver and fuel costs, are good
measures for studying decisions such as whether or not to change routes; this paper however
focuses on the societal costs of congestion, and therefore long-term marginal costs are used.

**METHODOLOGY**

In response to the growing need to understand the cost impact of highway bottlenecks to the
trucking industry, and in order to build upon the existing literature, this paper explores a logical
approach for accurately developing freight congestion measures by relating industry-generated
marginal cost data with GPS-based travel time delay metrics.

As a first step in the analysis a geographical study area was selected as a test area. The
researchers chose Interstate 285 at Interstate 85 in Atlanta, GA, which is shown in Map 1.
The geographic information shown in Map 1 is overlaid with a sample of more than 70,000 truck position records that were collected from onboard trucking communications systems over a one year time period. A component of each record is a speed at a given point within the geographic location; in Map 1, those trucks with free-flow (posted speed) or near free-flow speeds are shaded in green; those trucks that are moving less than free flow are incrementally shaded in yellow, orange and red.

The truck positions were analyzed using a suite of commercially available and customized data analysis software to produce average speeds by time of day (weekdays only) during the sample time period. As shown in Chart 1, a free-flow speed of 55 mph is achievable during off-peak times of day, but during congested peak rush hour time-periods median and mean speeds decrease considerably, thus indicating significant delay. The data shown in Chart 1 becomes the basis of the delay information used in the proposed methodology.
Next, ATRI inputted and modeled the marginal trucking cost data to produce a per mile cost for traversing the 2 mile area of the bottleneck shown in Map 1. The two mile area was selected for this particular bottleneck using the assumption that a truck moving through the study area shown in Map 1 would be required to travel 2 miles.

As previously noted, actual motor carrier operating costs are utilized rather than subjective costs such as the “value of travel time” or societal costs. Since the impact of congestion as an externality is desired, fixed costs were excluded from the study for three reasons: fixed costs are typically independent of driver and vehicle operating costs; fixed costs fluctuate greatly between industry sectors and business models; and a carrier’s fixed cost per mile (CPM) declines as the fleet mileage increases.

Based on the cost data generated from carriers operating throughout the U.S., ATRI estimated an “average congestion impact cost per truck” for trucks that traverse the bottleneck during a 24-hour range of weekday time periods. To do so, ATRI did the following:

1) To identify the per truck cost of time delay, ATRI converted the aggregate average cost per hour (CPH) ($83.68) to a CPM by dividing the hourly cost by the industry’s average operational speed (52.05 MPH). The methodology assumes average operational speeds reflect average free-flow speeds. At this free-flow speed, ATRI calculated the cost of traversing one mile to be roughly $1.61, and the cost for two miles (which is the minimum and maximum distance traversed by a truck moving through this bottleneck) to
be $3.22. The 52.05 mph operating speed, and the associated cost of $3.22 per truck to
travel 2 miles, are herein referred to as “free-flow” speed and cost.

2) Next, ATRI calculated the additional cost -- which is the cost that exceeds free-flow costs
vis a vis operating below free-flow speed -- that was incurred by moving through the
bottleneck at specific congested hours of the day. This was produced by dividing
congested speeds by free-flow speeds over a series of 24-hour time periods. If an average
speed was 52.05 mph or above, no additional cost was incurred by the truck. If, however,
the speed fell below 52.05 mph then additional costs per truck were incurred.

The effects of delay on trucking can be demonstrated by considering an instance where
average speeds are 25 mph during a 1-hour time period. To produce a truck congestion
cost for a time period where average speed is 25 mph, the $83.68 per hour figure for
operational costs is first divided by 25 (the number of miles that a truck moving 25 mph
could move in 1 hour). This number results in a per mile cost of $3.35, which for two
miles is a total cost of approximately $6.71; the latter figure is $3.49 greater than the
“free-flow cost” of traversing this bottleneck, and is shown in 5pm-6pm period in Chart 2
below:
CHART 2 Extra Cost Per Truck to Traverse by Time of Day: I-85/285

Extra Cost Per Truck to Traverse Bottleneck by Time of Day
I-85/285, Northside

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<th>Time of Day</th>
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<th>$0.5</th>
<th>$1.0</th>
<th>$1.5</th>
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</table>

Additional Cost Per Truck

Time of Day
3) Finally, the number of vehicles that were likely affected by the per-unit congested truck costs was calculated. Both the Freight Analysis Framework (FAF) dataset and Georgia STARS figures were considered; from this information it was determined that roughly 35,000 trucks traverse the study bottleneck daily. Next, the 35,000 trucks were distributed across the 24 hour time period based on an hourly estimated distribution of truck volume. Each truck that would hypothetically be affected by delay during each hour of the day had the additional cost applied to it based on the severity of delay that the truck would experience, as shown in the Table 1 “Cost exceeding free-flow cost” column. This number was then aggregated with total truck counts to reflect total daily costs and total annual cost of the bottleneck to the trucking industry for weekday travel only.

The statistics that resulted from this three-step methodology indicate that congestion delays generate roughly $22,000 in daily industry costs and $5.7 million in annual industry costs for trucks that traverse this bottleneck location when average speeds drop below the free-flow of 52.05 mph (see Table 1).
## TABLE 1

<table>
<thead>
<tr>
<th>Time of Day</th>
<th>Cost Per Truck Per 2 Miles (hourly)</th>
<th>Cost Above &quot;Free Flow Cost&quot;</th>
<th>Estimated Hourly Dist. of Truck Volume</th>
<th>Hourly Dist. of AADTT Figure</th>
<th>Daily Bottleneck Cost (For Travel Below Free-Flow)</th>
<th>Annual Bottleneck Cost (For Travel Below Free-Flow)</th>
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<td>00:00-01:00</td>
<td>$3.22</td>
<td>$-</td>
<td>2.31%</td>
<td>807</td>
<td>$-</td>
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</tr>
<tr>
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<td>$-</td>
<td>2.17%</td>
<td>761</td>
<td>$-</td>
<td>$-</td>
</tr>
<tr>
<td>02:00-03:00</td>
<td>$3.22</td>
<td>$-</td>
<td>2.21%</td>
<td>772</td>
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<td>$-</td>
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<td>$-</td>
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<td>$1,483.26</td>
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<td>$0.59</td>
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<td>6.94%</td>
<td>2,428</td>
<td>$5,749.47</td>
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<tr>
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<td>6.65%</td>
<td>2,329</td>
<td>$8,117.24</td>
<td>$2,110,483.05</td>
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<td>$-</td>
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<td>$-</td>
<td>2.17%</td>
<td>761</td>
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<table>
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<tr>
<th>Daily Delay Cost</th>
<th>Annual Delay Cost</th>
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<tbody>
<tr>
<td>$21,934.09</td>
<td>$5,702,862.54</td>
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CONCLUSIONS AND FUTURE RESEARCH

Using this cost calculation exercise, it can be shown that truck bottleneck cost measures can be derived by applying industry operating cost data to empirical truck speed/time data. Further aggregation results in a daily and annual cost to the trucking industry of an interstate bottleneck. Thus, this approach represents an initial design for determining the end-cost to the trucking industry from mobility-constraining congestion and chokepoints.

The next step in this research will be to further explore the relationship of costs and delay. For instance, there is an imperfect, generalized correlation between many of the operational costs and the delay information utilized in this study. For instance, different driver compensation models (per mile, per load, per hour) will likely generate different labor cost metrics in a more granular or sector-targeted analysis.

Therefore, future truck congestion cost research must focus on unique or targeted trucking costs, or marginal costs that are unique to a region or commodity. Additionally, the precise impact of decreases in travel rate on the following costs will have to be decoupled from the industry averages and measured:

- Fuel and Oil Costs: Sudden decreases in travel rates on interstates and the resultant “stop and go” traffic can have an impact on fuel consumption and use of oil.
- Vehicle Costs: As with fuel and oil costs, sudden decreases in travel rates on interstates, and the resultant “stop and go” traffic, can also have an impact on vehicles which can lead to increased maintenance needs and vehicle depreciation.
- Opportunity Costs: Delay can equate to lost opportunities or the inefficient use of equipment, dock workers or back-office personnel. If a driver and truck are delayed by congestion, then output is cut for current and future tasks. Thus, business is lost or additional revenue opportunities may be forfeited. This is further complicated by federal Hours of Service regulations.
- Driver Turnover Costs: There is anecdotal evidence that frequent travel in congested conditions may attribute to increased driver turnover rates, especially for drivers typically involved in urban travel (for example, LTL pickup and delivery drivers). Frequently replacing these drivers causes carriers to incur additional administrative costs as well as fees for background checks and pre-employment drug screens.
- Driver Pay/Benefit Costs: Truck drivers are typically paid by the hour, load or mile. Delay for drivers paid by the hour causes the motor carrier to incur additional cost, which contributes to the overall inflationary impact of congestion. Delay for drivers paid by the mile reduce driver wages, likely contributing to the industry’s historic high rate of driver turnover.
- Shipper/Consignee Penalties: Due to the fiercely competitive nature of the industry and strict shipper/customer requirements, decreases in travel rates can cause carriers to miss pickup or delivery windows. Missed appointments may result in a carrier losing business, or in some cases, monetary penalties for service failures.
REFERENCES


