COST OF ROAD CONGESTION IN CANADA: DATA AND METHODOLOGY ISSUES

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Introduction

Most Canadians who live in cities with strong population and economic growth have experienced congestion. It is no surprise that many urban Canadians bear the congestion costs of: trip delays; additional fuel burned; other vehicle operating and ownership costs, and the health impacts of additional vehicle emissions. It has become a source of increasing public concern and policy debate in Canada.

There has been increased attention from government, academics, and non-governmental organizations *(*NGO) to quantify the cost of congestion. Some Canadian metropolitan regions have developed their own congestion cost estimates. Transport Canada (TC) also estimated the costs of congestion as part of a larger effort to quantify the full costs of transportation in Canada.

The results of these cost estimates demonstrate that there is no single acceptable methodology to measure and quantify the negative effects of congestion. In the absence of a clear methodology, some organizations such as the Organisation for Economic Co-operation and Development (OECD), have reported multiple cost estimates that may confuse public debate on this important issue.

The purpose of this paper is to: list some of the relevant congestion concepts as they apply to congestion measurement; evaluate some of the data and underlying methodologies available for the measurement of congestion in the Canadian context; and review some of the reports on congestion costs in Canada and the world.

[1] Views expressed in this paper benefited from exchanges between the authors and colleagues from Transport Canada. The authors thank all reviewers of this article for their useful comments. However, the views expressed herein do not necessarily reflect those of Transport Canada.

1. Economic Theory Concepts and Congestion Measurement

This section presents the basic economic concepts with regards to congestion measurement. Often traffic volumes exceed road capacity leading to congestion in some sections of the road network. Congestion may follow a regular time pattern, called recurrent congestion, or it may occur unpredictably due to accidents or weather conditions, called non-recurrent congestion.

While non-recurrent and recurrent congestion costs are roughly equal, non-recurrent congestion measurement presents its own challenges. Data on incidents (weather, accidents, work zones) in combination with travel time data is difficult to obtain in a format that could be used consistently. The details behind modelling techniques that focus on the predictability of random events, and the reliability of travel are not addressed in this paper.

Economics explains congestion as the result of allowing unrestricted access at all times to a limited resource, in this case, road space. On the one hand, growing population and economic activity lead to more trips, while on the other, the supply of road space is limited by funding, physical and environmental considerations. When the demand of road users exceeds road capacity, the use of road space becomes “rival”, which means that each additional user occupies road space that would otherwise be available to existing users, thereby contributing to lower travel speed for all drivers.

Analyzing the supply and the demand sides of the road congestion issue requires appropriate and consistent measurement techniques.

Some of the important analytical decisions to make include:

- Defining congestion threshold(s);
- Accounting for off-peak delays;
- Accounting for peak to non-peak hour traveler shifts, and other costs of avoiding congestion; and,
- Assigning monetary values to congestion impacts.

Congestion Threshold

Congestion may be measured as the gap between slower observed traffic speeds with regards to the posted speed limit. However, posted speeds do not correspond to realistic service level expectations in the presence of growing population and economic activity. Alternatively as (TC 2009) employed, congestion could be measured as the gap between slower observed traffic speed with regards to a threshold that equals a percentage of the posted speed limit. A threshold lower than the posted speed limit reflects realistic service level expectations.

Off-Peak Delay

Congestion levels vary considerably by time of day and day of the week, due among other reasons, to workers commuting patterns. However, congestion is not exclusively a peak-period occurrence. Off-peak period travel accounts for a considerable amount of travel, especially on arterial roads with delays occurring during mid-day hours (Texas Transportation Institute, 2010). Ideally, off-peak delay data should be appropriately measured and accounted, for a more accurate measure of congestion, as well as for the design of congestion pricing policies that target specific trip purposes.

Diversion of Peak Hour Travel to Non-Peak Hour and Other Behavior Changes in Response to Congestion

Due to delays, wasted fuel, and other costs, many travelers avoid congestion by altering their travel behavior. In the short or long term, travelers may shift from peak to non-peak hours, change itineraries, cancel their travel plans, or even engage in some productive or additional leisure activity depending on the mode. The full impact of these changes, whether negative or positive, are difficult to measure.

Assigning Monetary Values to Congestion Costs

To quantify the congestion impact to society, in addition to measuring delay hours, one must determine the monetary value of: delays; additional fuel burned; other vehicle expenses; vehicle emissions; and the economic impact on commercial activities (time and resources lost by companies carrying freight and otherwise).

Time Lost to Congestion

Time lost by travelers, especially commuters represents a large share of congestion costs. The value of travel time varies according to trip purpose. For commuters, time has a value that is tied to hourly wages. For business trips, time lost is valued at the average wage rate, while trips for leisure or shopping could be valued at slightly less than half the average wage rate.

Studies disagree as to the appropriate value of time in particular for commuters, that can range from 100 percent of the average wage rate (TC 2005 and 2006) to about half of the average wage rate (TC 2008). The rationale is that commuters travel on their own unpaid time, and their travel is neither for leisure or business. This distinguishes the difference between commuting in unpaid time and actual business travel on employers paid time during working hours.

Table 1 Time Value (in 2006 $ /hour)

Location	**Business/Work**	**Commuter**	**Leisure**
Vancouver	$23.43	$11.21	$10.09
Edmonton	$23.01	$10.86	$9.77
Calgary	$25.22	$11.75	$10.58
Winnipeg	$20.03	$9.62	$8.66
Toronto	$23.61	$11.35	$10.22
Ottawa	$26.86	$12.75	$11.48
Montréal	$21.87	$10.44	$9.40

Source: Transport Canada (2008 and 2009)[2]

[2] No available data for Hamilton and Quebec City, so Toronto and Montreal values used to substitute data.

Table 1 shows the updated values of time used by TC for the full cost investigation of transportation in Canada. For Business/Work trips, the time value is related to delays on paid or business time, and represents 100 percent of the average wage rate. The time value applied to commuting and leisure time lost is also presented.

Vehicle Operating Costs

In Canada, the majority of workers use a private automobile to commute to work (Statistics Canada 2005). Private vehicle cost components could be influenced by the amount of driving (such as fuel), or be independent of it (such as registration fees). Although variable costs change by vehicle age and type, on average, fuel and other operating expenses that would be directly affected by congestion delays represent close to 40 percent of the cost of light duty vehicles in Canada (TC 2009a). In particular, fuel represents close to 30 percent of the total operating and ownership costs of vehicles. Most studies attempt to measure fuel costs as a component of the cost of congestion. Some studies also include other operating costs. Vehicle cost components that are not directly affected by congestion such as insurance or parking, are nonetheless important because they may be subject to congestion pricing schemes.

Vehicle Emissions

Vehicle emissions could be valued at the cost of greenhouse gases in the emissions markets, and by the health impact associated with criteria air contaminants to individuals. While there are methodological limitations to allocating the impact of vehicle emissions to human health due to data issues (e.g. related to separating emissions by mode), ignoring these impacts underestimates congestion costs.

Commercial Traffic

Freight carriers on roads face numerous challenges in the urban setting to overcome recurrent and non-recurrent congestion. Local companies that operate their own fleet for commercial purposes on a regular basis are known to show their creativity by working around peak hours to avoid recurrent congestion, or by trying to influence urban location to better protect themselves against unpredictable gridlocks caused by accidents or weather. The reliability of their deliveries has a cost that could be measured in fuel wasted, additional labour costs, and decreased overall efficiency. Intercity trucking also contributes to urban congestion and creates interesting policy issues for international trade, and jurisdictional taxation and responsibilities.

2. Transport Canada: Data and Methodology Evaluation

This section evaluates the data and methodology strengths and limitations of the most recent congestion study funded by TC (2009).

TC commissioned David Kriger, an iTRANS consultant, to update the congestion costs in Canada's major metropolitan regions. While the update improved the congestion cost estimates produced in 2006, this update nonetheless had several limitations:

- Not all cities had available data, therefore their updated figures are an approximation based on population growth;
- Off-peak period congestion could not be measured;
- Time lost by automobile passengers, other than drivers, and transit users, as well as commercial traffic, is not included;
- Vehicle operating costs other than fuel are not included;
- The impact of congestion on accidents or noise is not measured;
- The costs of avoiding congestion are not measured.

However, this update retained some of the strengths of previous studies while incorporating several improvements. The update:

- Included recurrent and non-recurrent congestion estimates;
- Used a new methodology to estimate the value of time;
- Used three different speed thresholds to measure congestion;
- Used updated fuel prices; and,
- Revised the monetary values for greenhouse gas emissions.

Table 2 details the congestion costs in Canadian cities. Close to 80 percent is the cost of delay experienced by drivers of private vehicles, while the remainder is the cost of additional fuel burned and vehicle emissions generated.

The congestion estimates in the third column, are based on congestion measured as the gap between observed speeds and a threshold that equals 70 percent of the posted speed limit. Congestion threshold estimates in the first column are set against 50 percent of the same posted speed limit, producing the lowest congestion cost estimates.

Table 2 Congestion costs in Canadian cities
$Million (2006)

	Threshold		
City	**50%**	**60%**	**70%**
Vancouver	$518	$652	$755
Edmonton	$85	$103	$120
Calgary	$149	$171	$180
Winnipeg	$73	$100	$125
Hamilton	$13	$24	$37
Toronto	$1,298	$1,672	$2,014
Ottawa-Gatineau	$220	$304	$380
Montréal	$697	$811	$910
Québec City	$63	$89	$118
Total Congestion Cost	**$3,116**	**$3,927**	**$4,640**

Source: Transport Canada (2009)

While there may be limitations, there is however one significant improvement: updating the value of time. For example, for Toronto-Hamilton, by applying the 50 percent discount rate for commuters, the cost of congestion is reduced by half. Rather than almost $4B in congestions costs originally estimated in the (TC 2006) study, this figure is reduced to $2B in the (TC 2009) study.

3. Literature Review of Congestion Costs and Pricing Impacts

This section reviews the literature on selective congestion cost estimates in the GTHA, the United States, and in Europe.

GTHA

The OECD conducted a 2009 Territorial Review of Toronto that was published in 2010. This study included an assessment of the region's transportation shortcomings.

The annual costs of congestion documented in the OECD report for GTHA, included an estimate from TC (2005) of $1.6B and a $6B figure published by Metrolinx.[3] This section will compare and clarify these congestion cost estimates.[4]

The Metrolinx estimate originates from a 2008 HDR Corporation study."[5] The HDR $6B cost estimate is composed of two separate costs: the direct burden to commuters of time lost in traffic for all modes which is estimated to be $3.3B; and the regional economic impact to the GTHA which is estimated to be $2.7B.

Commuter Costs: $3.3B

The HDR estimate includes five individual cost elements: time cost to auto users ($2,245 million); time cost to transit users ($337 million); vehicle operating costs ($479 million); accidents ($256 million); and vehicle emissions ($29 million). The methodology used to derive these costs is similar to the (TC 2006) cost estimate, but with some minor differences.

[3] OECD, Territorial Review of Toronto, 2010, page 103.
[4] The OECD reported two Transport Canada congestion studies: $1.6 B in recurrent congestion costs (2005) and apx. $2B for recurrent and non-recurrent congestion costs (2006).
[5] HDR Corporation, Costs of Road Congestion in the Greater Toronto and Hamilton Area, Metrolinx, December 2008.

Similar to the TC estimate, HDR did not measure congestion as the difference between observed traffic flows and free traffic flows. Instead, it substituted free traffic flows for optimum traffic levels which is determined by intersecting the demand curve by the marginal social cost curve of traffic volumes. While similar in effect to the TC threshold speed which is determined using road engineering principles, the HDR Optimum Traffic Level economic approach is consistent with many congestion studies. "A study that focuses on the economic costs of total road congestion, relative to travel times under free-flow conditions, would exaggerate the congestion problem."[6]

For the entire region of GTHA, HDR calculated commuter time lost in traffic as the difference between the actual recorded speed of traffic for all combined regions at 50.6 km per hour compared to the economically optimal speed which HDR estimated to be 74.6 km per hour. The $2.2B travel time cost estimate was derived by applying a time value ($26.57 per hour) reduced by 50 percent, to the estimated 50 hours per year, or 11.5 minutes per day lost to the average auto commuter. Per capita, this cost was estimated at $370 per year.

Time lost to transit users, which represents almost 10% of the HDR estimated annual commuter costs, was not included in the TC estimate because of methodological and data issues. The HDR study corrected this shortcoming but the methodology used to quantify this loss is unclear.

The HDR and TC (2009) estimates are similar. This is largely due to the decision by HDR to set the Optimum Traffic Level for highways at nearly 70 km per hour which is similar to the TC 70 percent threshold for the 100 km per hour posted speed for the highway network. Comparing similar cost elements for delays, fuel, and emissions, the HDR cost of $2.7B for the GTHA compares reasonably well to the TC cost of $2B for the same area. The variance may be explained by the difference in total annual delay hours, with

[6] HDR Corporation, Costs of Road Congestion in the Greater Toronto and Hamilton Area, Metrolinx, December 2008.

HDR hours estimated at 93 million while TC hours are estimated at 77 million.

Regional Economic Costs: $2.7B

As stated previously, the (TC 2009) congestion cost estimates did not investigate nor quantify regional Gross Domestic Product (GDP) costs attributed to congestion and this exclusion is the major difference with the HDR study which included this cost. HDR quantified the following regional costs attributed to congestion: reduction in demand for labour and employment; increase in industry operating costs; decrease in industry revenues; and the overall reduction in regional economic output. The elements that comprise the $2.7B cost were not identified in the HDR study.

Conceptually, the above mentioned costs merit inclusion in a congestion cost study. However, when TC considered evaluating some of these costs, such as increased operating costs for freight carriers, serious data gap issues prevented their inclusion. HDR admitted similar data shortcomings and substituted reasonable methodology to arrive at such estimates. For example in estimating lost employment, HDR estimated that congestion costs deprive the regional economy of 25,962 jobs as a result of increased salary expenditures to compensate employees' travel times lost in transit.

HDR interpreted this $2.7B regional cost as "lost opportunities for economic expansion".[7] It would be inaccurate to categorize this as a national cost if the expansion cost is diverted outside the GTHA region but remains in Canada. Indeed, as a result of increasing congestion, some urban researchers question whether some large metropolitan regions have reached their economic and environmental size limit. As a result, lost economic expansion may not be an unwelcome outcome for some. However, it is a reasonable assumption to consider the broader economic costs to the regional economy that likely are the result of increased inefficiencies of firms located in the region. Additional research in this area would further

[7] Ibid, page 1.

improve and substantiate the economic costs incurred in the regional economy attributed to rising road congestion levels.

Comparison of Per Capita Congestion Costs

HDR also conducted other congestion cost studies for the New York City Region and the Chicago Metropolitan Area. The following table compares these costs to the GTHA estimates and includes the (TC 2009) cost estimate. The costs are consistent for all three metropolitan regions, although GTHA bears the greatest congestion cost per capita. However, because the TC estimate does not include the economic costs to the regional economy, it is not consistent.

Table 3 Estimated Annual Congestion Costs, (2006)

Region	**Commuters**	**Regional Economy**	**Total Cost**	**Per Capita**
	$ (millions)			**$**
New York (US$)	$7,000	$4,000	$11,000	$917
Chicago (US$)	NA	NA	$7,300	$912
Toronto-Hamilton (HDR, CAD$)	$3,300	$2,700	$6,000	$1,000
Toronto-Hamilton (TC 2009*, CAD$)	$2,014	NA	$2,014	$335

Source: HDR Corporation, 2008, page A7-1.
* Congestion measured at 70% Speed Threshold

United States: Measuring Congestion

The Texas Transportation Institute (TTI) publishes an annual comprehensive report on road congestion in the United States. In its most recent update for 2010, congestion estimates are reported for 439 urban areas. These estimates are based on speed and traffic volume data.

The report highlights congestion measurement for the cost of fuel, total cost to commuters, as well as the concept of average peak delay for the average commuter. TTI discusses some of the measurement issues: 1) congestion threshold; 2) off-peak delay data; 3) the costs of avoiding congestion; and 4) monetary values to measure congestion.

The basic cost elements included are the delay costs and wasted fuel. To estimate delays, a threshold is required to measure congestion as the difference between observed speeds and the threshold. Their congestion threshold is the speed observed in low-volume traffic conditions (from 10 p.m. to 5 a.m.). This speed is relatively high, but varies according to the type of road. An upper limit was established on highway observations to avoid unreasonably high estimates.

Off-peak delay data receives considerable attention. One of the new measurements is the *delay per non-peak traveller*, which is the delay experienced by those traveling midday, overnight or on weekends.

One of the congestion measurements is the planning time index, which indicates the travel time needed to arrive on time, 19 days out of 20. The evolution of this indicator measures the reliability of travel times. In addition to increasing mobility, it is a useful benchmark to measure travel reliability.

The value of time used in the study to estimate the cost of delay for passengers is US $16.01 per hour[8]. This is based on the value of time rather than the average wage rate. The study uses a separate estimate of US$ 105.67 per hour for truck travel delay.

European Case Study: London

In 2009, the Ministère de l'écologie, de l'énergie, du développement durable et de la mer (PREDIT) in France, commissioned a report by the Labouratoire d'Economie des Transports, to examine various congestion pricing benefit-cost studies (BCA) in London, (U.K.),

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[8] The values of $16.01 and $105.67 in 2010 US$ are equivalent to $16.80 and $110.8 in 2006 Canadian dollars respectively.

Stockholm (Sweden) and Oslo (Norway). The report illustrated the importance of applying consistent methods to measure and quantify the costs of congestion. While the official BCA findings indicated a healthy positive return, some economic researchers such as Rémy Prud'homme and Juan Pablo Bocarejo questioned the official findings, especially with regards to the value of time and the method used to measure congestion.

This paper does not judge the merits of the arguments posed by Prud'homme and Bocarejo. Using the central London congestion charge as a case study, the arguments are merely presented herein to demonstrate the importance of using commonly accepted values of time and congestion measurement metrics.

Value of Time

Based on a cordon based toll of £8, Transport for London (TfL) estimated an annual time savings value of £263 million: £163 million for business travelers; £65 million for non-business; and £35 million for non-business bus travelers. These savings represented the lion's share of the annual benefits. However Prud'homme and Bocarejo claimed that TfL used inflated values of time. Where TfL estimated an average value of time at €37 an hour, Prud'homme and Bocarejo argue that an average hourly rate of €15.6 would be more reasonable. Using a lower value of time would certainly impact the outcome of a benefit-cost analysis.

Congestion Measurement

While TC and HDR conducted congestion studies that do not measure congestion as the difference between current traffic flow and free flow conditions, TfL did measure and quantify congestion costs in this manner, according to Prud'homme and Bocarejo. As a result, they claim that the benefits of improved travel time-savings are exaggerated.

It should be noted that PREDIT was unable to obtain available data from TfL. As a result, we should treat their findings with caution. However, the findings illustrate that comparative analyses conducted consistently require a shared understanding of economic theory, agreement on congestion measuring methodologies and economic values, and access to good data, especially traffic data for all modes.

Conclusion

The intent of this paper is simply to shed light on some of the major methodological issues that tend to cloud the debate on road congestion costs. Further, the authors admit that the approach taken by the TC team to measure the costs of congestion can be improved.

The major areas of improvement could include the following:

- Cost of congestion to the local economy, excluding diverted economic activity that remains in Canada;
- Impact of congestion on non-peak hours; and
- Impact on trucking operations within metropolitan regions.

This paper also reminds researchers that considerable caution is required when comparing the results of congestion cost studies. Often results quoted by the media may be based on research methodologies that are not consistent with evolving methodological approaches.

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