THE COST OF CONGESTION DUE TO ROAD ACCIDENTS: PEANUTS COMPARED TO THE VALUE OF LIFE?

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ABSTRACT

This paper examines the economic costs of road accidents, and the congestion costs more specifically. In order to calculate these congestion costs two important input variables, the value of travel time and the lost vehicle hours, are needed. First, the value of travel time, and some difficulties in valuating this value of time, will be discussed. Many variations occur when valuating this, amongst others because of the type of the vehicle or traveller, the occupancy of the vehicle, the region and the travel motif. Even if sufficient quality data is provided, there will still be uncertainty about the estimates for the value of travel time. Thereafter, the lost vehicle hours (VHL) are being studied in more detail. This indicator shows the delays incurred by vehicles because of congestion and delayed traffic flows. However, the calculation of the VHL itself is quite complicated: quality input data is needed, and to collect this data there is a need for reliable measurement systems. At this moment, there are no such measurement systems in Belgium or Flanders. Therefore this paper will not focus on the calculation of the lost vehicle hours, but on some different methodologies for the calculation of lost vehicle hours and the description of the data needed to perform the calculations. The next chapter will cover the costs incurred by the time lost due to congestion and traffic delays because of road accidents. By valuating these time losses, the cost of "being in a traffic jam" will be calculated. Multiplying the value of time and the lost vehicle hours, which were discussed before, results in the congestion costs. This calculation is followed by a thorough discussion in which the restrictions of the calculations and the used data are commented.

Keywords: Congestion costs, Value of travel time, lost vehicle hours

INTRODUCTION

The quantification of the costs of road accidents is a very important step in the efficient spending of resources to improve road safety. It offers an insight in the size of the problem and makes it comparable with other societal problems. Even more relevant, it reflects the magnitude of the benefits to be obtained if road accidents can be avoided (De Brabander, 2006). In other words, it is important for policy makers to take the costs resulting from road accidents into account when deciding on road safety measures.

The social costs caused by road accidents include all costs for the compensation and recovery from any injuries and damages and all costs relating to the settlement of damages caused by an accident, but also all other costs (of congestion created by an accident) and intangible suffering (SWOV, 2006). This definition proves that many different types of costs originate from road accidents. These can be divided into two groups: First there are the injury-related costs such as medical costs, production losses and intangible costs. Second, there are the accident-related costs, which are the tangible costs, handling costs and congestion costs. Especially about the congestion costs, almost no empirical data exists (De Brabander, 2006), which is why this paper is about these costs.

The total costs due to road accidents were estimated at €12.215.432.410 for Belgium in 2002 (De Brabander, 2006). This represents 4.6% of Belgium Gross Domestic Product, which is higher than the average accident costs of developed countries. According to Connelly and Suspangan (2006) the average cost of road accidents in developed countries is about 2-3% of the GDP. The biggest part of the total costs consists of the intangible costs, costs by production losses and material costs. Congestion costs were only €13.282.770 and thus represent a rather small part of the total cost in Belgium (De Brabander, 2006).

However, calculating congestion costs often results in an underestimation. Congestion costs are the costs resulting from the time lost in traffic jams caused by road accidents. To determine these costs, the total congestion costs are divided by the share of the congestion caused by road accidents. There are three types of congestion costs: costs resulting from direct travel time losses, costs resulting from the unreliability of travel times and the costs of alternative behaviour (Van Reisen, 2006). Direct travel time losses refer to the economical damage that occurs because within a certain amount of time fewer destinations can be reached and thus people cannot travel as far as they want to. Unreliable travel times arise from the fact that because of traffic jams as a result of road accidents the travel time is difficult to estimate. Arriving too early or too late because of this creates additional costs. Finally, alternative behaviour arises because people want to avoid congestion by choosing a different route, leaving sooner or later, choosing another transport mode or even completely renouncing from the journey. Usually, only the costs resulting from direct travel time losses are charged, while the costs resulting from unreliable travel times and alternative behaviour are not taken into account (Koopmans & Kroes, 2003). Besides, unreliable data for the lost vehicle hours are frequently used in the estimation of these costs. All this often results in an underestimation and therefore it seems interesting to take a closer look at the calculation of congestion costs resulting from road accidents. So, the remainder of this paper will handle about congestion costs more specifically. It will be studied whether it is true that congestion costs are systematically being underestimated, and whether they account for a larger share of the total costs incurred by road accidents than usually assumed.

In order to do so, the congestion costs due to road accidents have to be calculated first. For this calculation the value of travel time has to be multiplied with the lost vehicle hours incurred by road accidents. According to De Brabander and Vereeck (2005) about 12% of the total number of traffic jams is caused by road accidents. This, however, does not mean that also 12% of the lost vehicle hours are caused by traffic jams as a result of accidents. Indeed, traffic jam caused by accidents will, on average, last longer than ordinary structural traffic jams. Hof and Vermeulen (2001) argue that 13.5% of all lost vehicle hours are the result of congestion due to road accidents. The value of time will be discussed in the following chapter. Thereafter, the lost vehicle hours will be studied. With these two input variables, congestion costs can then be calculated. This calculation is followed by a discussion in which the restrictions of the calculations and the data are commented. Conclusion finalises the paper.

VALUE OF TRAVEL TIME

The value of travel time is a much needed input variable concerning the estimation of congestion costs, because the hours lost due to congestion have to be multiplied with this value of time in order to compute the congestion costs. It would be unrealistic to put a fixed value on the value of time, hence different values of time exist for various journey motifs. This chapter is about this variation in the value of time.

The value of travel time (VTT) refers to the cost spent for transportation, including the waiting and the actual transport itself. It consists of the personal, unpaid time lost to transportation, as well as the costs for businesses, being paid working hours that are lost while being on the road. The value of travel time savings (VTTS) consists of the benefits arising from reducing the travel time (Litman, 2009).

The costs associated with travel time can be divided into two major groups. First there are the on-the-job time losses; these include the costs to the employer who has to pay the lost hours of employees during work-related travel. Second, there are the off-the-job travel time losses. These are the trips for personal purposes and commuting, and represent the opportunity cost of time spent on journeys that could be spent on doing something else.

The total travel cost is the product of the time spent on travelling (expressed in hours) and the unity cost (expressed in euro per hour).

$$TravelCost_{total} = T_{travel} \times UnityCost$$

With $TravelCost_{total}$ = the total cost of the trip (expressed in euro)
T_{travel} = time spent on the trip (expressed in hours)
UnityCost = the cost of one hour travel = value of travel time (expressed in euro/hour)

This unity cost varies according to the purpose of the trip. For example, on-the-job trips (freight and business transport) will have a higher value of time than off-the-job trips (commuting and other transport). This is illustrated in table 1.

Table I - Value of time per motif (euro/hour)

	Freight transport	**Persons transport**		
		commuting	***business***	***other***
(1)	-	8,37	28,97	5,78
(2)	42,35	8,6	29,77	8,94
(3)	45,78	6,86	24,04	4,58
(4)	45,3	7,5	24,5	6

Sources: (1) De Nocker et al, 2006
(2) Rijkswaterstaat: Dienst Verkeer en Scheepvaart, 2006
(3) Vanhove, 2008
(4) De Brabander, 2006

A lot of other variation occurs in the valuation of travel time. This variation depends on various factors like the type of vehicle, the purpose of the trip, the occupancy of the vehicle, the traveller himself, the region, etc. The result of this variation is that, even if sufficient quality data is available, there is uncertainty about the estimates of the value of time and the congestion costs.

It should also be noted that travel time is not always lost time. Indeed, some travel can be used useful, or people may enjoy a certain amount of time in the car, train or bus. Some types of travel time have very low costs, or even positive values. This can be the case when travelling is a desired activity and people are enjoying the experience of the trip. Mostly these are recreational trips or trips for leisure, which involve e.g. riding with a new car or social activities like joyriding with friends. Travelling can also be combined with another activity. People can for example work on the train, or read a book or the newspaper. The literature however, is still often based on the rather short-sighted idea that travel time is always lost time. There is no model available yet for calculating the value of travel time that takes the fact that travel time does not necessarily have to be lost time into account (Lyons & Urry, 2004). In our case, however, it can be assumed that most travel time has a negative perception, because this paper is about the time lost due to congestion.

In the next chapter the second important variable to calculate the congestion costs, i.e. the lost vehicle hours, will be discussed. After a brief literature study, an ideal framework to compute the lost vehicle hours will be presented.

LOST VEHICLE HOURS

The indicator lost vehicle hours (VHL) shows the delays incurred by vehicles because of congestion and delayed traffic flows. In other words, lost vehicle hours draw a picture of the lost travel time of road users and thus are an important indicator for quantifying the economic effects of congestion (AVV, 2004). Congestion costs can be calculated by multiplying these lost vehicle hours with the value of time, which was discussed in the previous chapter. However, the calculation of the VHL itself is quite complicated. Quality input data is needed, and to collect this data there is a need for reliable measurement systems. At this moment, there are no such measurement systems in Belgium or Flanders. Therefore the focus in this chapter will lie on the methodology of the calculation of lost vehicle hours and the description of the data needed to perform the calculations.

Theoretical framework - methodology

In this section a brief literature review on the existing methods for computing the lost vehicle hours is presented. First the method used in the Netherlands is explained. Second, a more graphical method based on a study of Tampère et al (2007) is presented. Finally, the better known and similar method of Morales (1986) will be discussed. The last part of this chapter will present a new framework for computing the lost vehicle hours, based on the discussed literature.

1th method: The Netherlands (AVV, 2004)

In the Netherlands the former AVV (Advice on Traffic and Transport), now RWS-DVS (Rijkswaterstaat – Dienst Verkeer & Scheepvaart), is in charge of the calculation of the lost vehicle hours. The basic ingredients for the present methodology in the Netherlands are data on speeds and intensities on the highway network. For the part of the network that is equipped with signalling infrastructure, this data is used to calculate the lost vehicle hours. For the part that is not equipped with the right infrastructure, estimates of a model, called Flowsimulator, are used. This model simulates synthetic data that are similar to the data from the signalling infrastructure.
Lost vehicle hours are calculated for each quarter on each measurement site. First the actual speed and the standard speed (normally 100 km per hour) are expressed in hours per kilometer instead of kilometers per hour. By subtracting the standard speed of the actual speed the travel time losses in hours per kilometer are calculated. These travel time losses are then multiplied with the distance over which the measurement site has been declared applicable. This leads to the travel time losses expressed in hours. Finally, this number is multiplied by the number of vehicles, which is determined by multiplying the intensity (in vehicles per hour) with 0.25 hours (one quarter).
Or, expressed as an equation:

$$VHL = TTL \times d \times I \times t$$

With: *VHL = Vehicle Hours Lost*
TTL = Travel Time Loss (hours/km)
d = Distance over which the data are applicable
I = Intensity (vehicles/ hour)
t = Time over which the intensity is measured (0.25 hours)

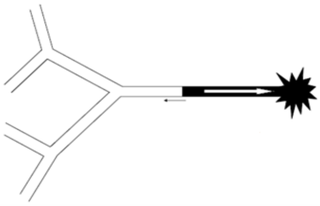
And: $$TTL = \frac{1}{V_{actual}} - \frac{1}{V_{standard}}$$

With: V_{actual} *= The actually driven speed*
$V_{standard}$ *= The standard speed or comparison speed*[1]

2nd method: Method of Tampère et al (2007)

This model is based on a study of Tampère et al (2007) who has developed a methodology for identifying vulnerable sections in a road network. In a first stage of this model they make a long list of those vulnerable network links, based on the travel time losses and the occurrence of incidents on that particular link.
For the simplicity, we consider an accident that only caused congestion on the affected network link. So there is no repercussion of the traffic jam to the upstream links, as can be seen in figure 2.

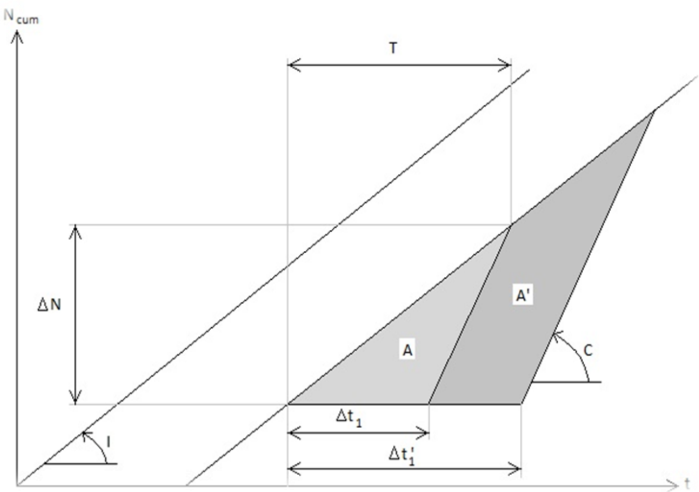
Figure 1 - Accident with no repercussion to the upstream network links



Source: Tampère et al (2007)

The model is based on the following figure:

Figure 2 - Calculation of the lost vehicle hours due to an incident



Source: Tampère et al (2007)

[1] The comparison speed is set at 100 kilometers per hour. If the actual speed exceeds this comparison speed, 'profit hours' are not taken into account.

The line under slope I from the origin in figure 3 shows the inflow in a certain road network link. The line under the same slope, but shifted along the time axis, represents the outflow on that particular network link. An incident reduces the outflow to zero. If, after a certain amount of time Δt the capacity has fully recovered, the traffic jam will resolve at a getaway flow C. This continues until after a period T all the accumulated traffic at the road network link is dissolved. From that moment, the outflow is back at its original level (slope I). The gray area A represents the total vehicle hours that are lost due to the accident. For A we find the following expression (Tampère et al, 2007):

$$A = \frac{\Delta t_1^2 I}{2\left(1 - {}^{I}/_{C}\right)}$$

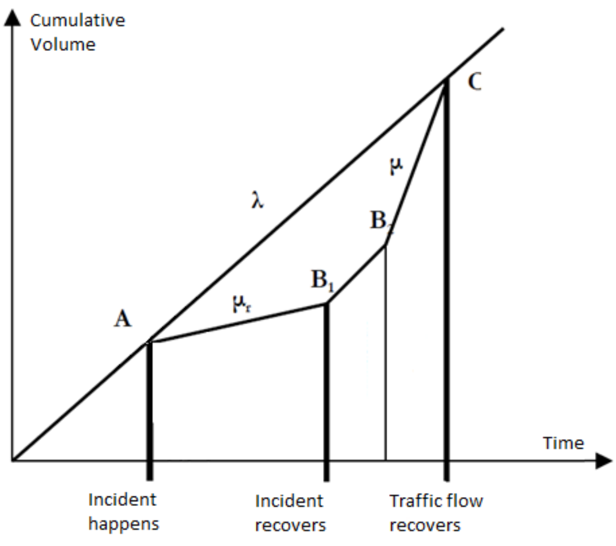
The formula shows (and this is also illustrated in figure 2) that the effect of an incident measured in lost vehicle hours is proportional to the square of the incident duration. Namely, if Δt_1 increases to Δt_1', the amount of vehicle hours lost will increase from A to A+A'.

3th method: Method of Morales (1986)

The premise of this theory is that an incident affects the road capacity. An incident reduces the capacity of the part of the road where it occurs. Congestion will arise when the incident reduces the capacity in that extent that the intensity exceeds the reduced road capacity. If the intensity already exceeds the road capacity before an accident happens, then congestion will increase due to that incident (De Ceuster, 2003).
For any road, delays due to incidents depend on the following data:

- Demand (λ: the number of arrivals per hour) at the time of the incident
- The reduced capacity (μ_r) of the road after the incident
- The total incident duration
- The capacity after the incident (μ: drive off capacity or getaway flow)

Figure 3 - Method of Morales



Source: De Ceuster, 2003

Figure 3 can be used to calculate the incident delay (the area AB_1B_2C). The horizontal axis represents time, the vertical axis the cumulative traffic flow. The demand, in vehicles per minute, is shown by the line segment AC. If an incident takes place, the traffic flow gets stopped because capacity reduces (line segment AB_1). At that moment, demand (λ) is greater than supply (reduced capacity μ_r). The reduction of the capacity gets smaller when the vehicles that were involved in the accident are cleared (line segment B_1B_2). After the complete recovery of the incident, traffic can continue its path (line segment B_2C). At that moment, full capacity is restored, but it will still take some time for the congestion to be resolved. It is thus possible to determine the total incident duration on the basis of this theory.
In figure 4 the cumulative volume (expressed in number of vehicles) is again plotted against time. λ indicates the arrival intensity (vehicles per unit of time) and μ indicates the departure capacity. The reduced capacity (μ_{R1} and μ_{R2}) can still vary throughout the incident. Once μ falls below λ congestion is created. Total delay is then equal to the polygon $AB_1C_1D_1$ (expressed in lost vehicle hours).
The length of the traffic jam (t_Q) is a function of the incident duration (t_R), λ, μ and μ_R:

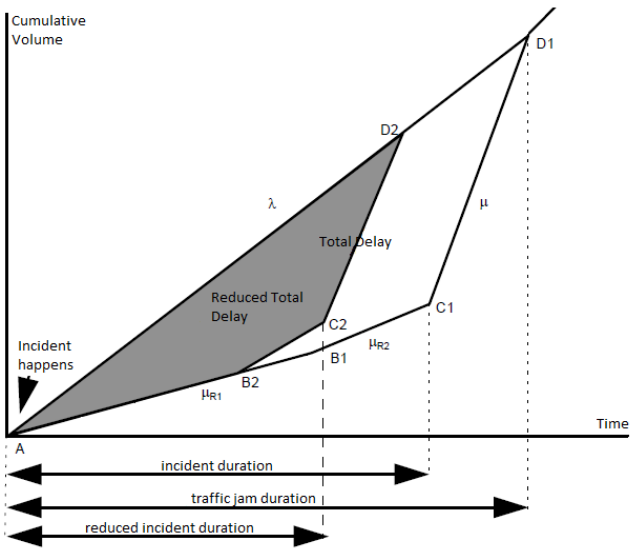
$$t_Q = \frac{t_R(\mu - \mu_R)}{\mu - \lambda}$$

The total delay (TD) caused by an incident is equal to:

$$TD = \frac{t_R t_Q(\lambda - \mu_R)}{2}$$

These equations show, like in the previous method, that the total delay increases in proportional fashion with the square of the incident duration. If the duration of the incident can be decreased, then the total delay will be reduced (as can be seen in figure 4).

Figure 4 - Incident duration and delay

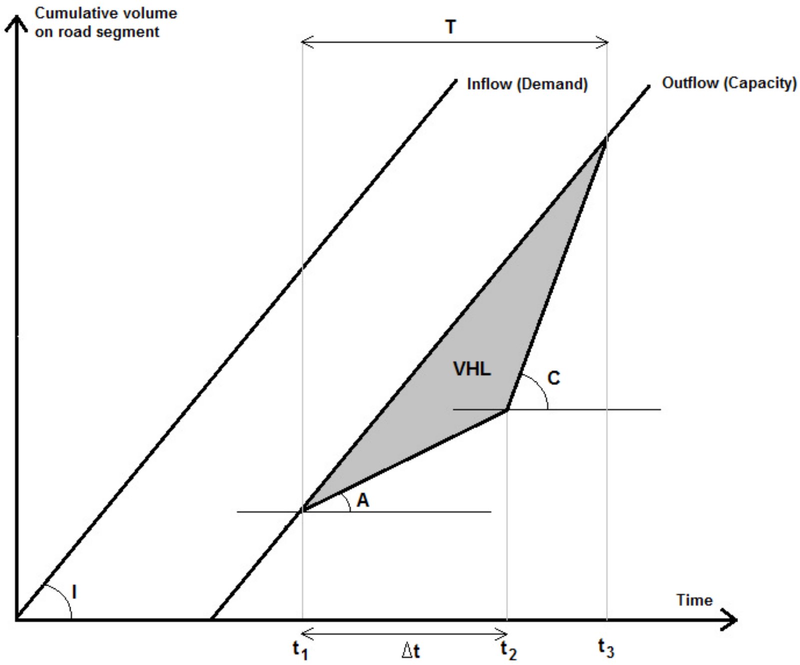


Source: De Ceuster, 2003

New Framework

Each of the previous methods has some strengths and weaknesses. Therefore an ideal framework, which combines the strengths of the previous methods, is presented in figure 5. This model is applicable on a given road segment, for which accurate and reliable measurement systems (i.e. double loops) are available to measure the in- and outflow on that given segment. If an incident happens, the outflow (or capacity) reduces, but in contrary to the method of Tampère, it does not reduce to zero. Namely, an incident does not always block the entire road, so that a reduced outflow is still possible. This reduced outflow is shown by the slope A in the figure. The inflow is given by slope I. After a while the capacity will regain its normal value (this can also happen in different steps if different driving lanes have to be cleared), and the congested traffic will get away at a getaway flow with slope C. Like in the two methods discussed above, the problem arises when, because of the accident, the capacity can no longer fulfil the demand. Because of this, the inflow and outflow curve are not parallel anymore, which results in lost vehicle hours. These lost vehicle hours are presented as the shaded area in figure 5.

Figure 5 – Own Framework



Source: Own setup

Because in this model inflow, outflow, reduced capacity and getaway flow are all linear functions, it is known that:

Outflow (Capacity): $D(t) = It + K_1$
Reduced capacity: $\mu_r(t) = At + K_2$
Getaway flow: $G(t) = Ct + K_3$

With K_1, K_2 and K_3 being constants.

The lost vehicle hours can then also be calculated using integrals:

$$VHL = \left(\int_{t_1}^{t_2} D(t)dt - \int_{t_1}^{t_2} \mu_r(t)dt \right) + \left(\int_{t_2}^{t_3} D(t)dt - \int_{t_2}^{t_3} G(t)dt \right)$$

This formula can be easily expanded if the recovery of the road capacity takes place in various stages. If the accident would reduce the outflow to zero, the formula proposed in the method of Tampère can be used (only if capacity recovers in just one step).

CONGESTION COSTS

This part will cover costs incurred by the time lost due to congestion and traffic delays because of road accidents. By valuating these time losses, the cost of "being in a traffic jam" will be calculated. As mentioned before, multiplying the value of time and the lost vehicle hours, which have been discussed in the previous chapters, results in the costs incurred by congestion. It should be noted that not all congestion costs are being discussed here, but only those resulting from an accident. Structural, daily traffic jams caused by the overload of the road network or traffic jams caused by roadwork are not included.

First, incidental congestion in general will be briefly discussed. Afterwards this incidental congestion will be limited to congestion caused by road accidents. In a third paragraph, the various costs associated with these traffic jams resulting from road accidents are commented and the costs incurred by direct travel time losses are calculated, followed by a critical discussion of the limitations of this calculation.

Incidental traffic jams

According to Van Reisen (2006) incidental traffic jams, in the broadest form, can be defined as all traffic jams that are not situated at the everyday bottlenecks. In other words, incidental traffic jams are traffic jams that differ in cause, location, time, length and duration from the congestion at the fixed structural bottlenecks. These include both incidental congestion caused by problems in the capacity supply, such as congestion as a result of weather conditions, accidents and road works, as incidental congestion caused by problems in transport demand such as congestion due to seasonality and special events. Hereby, it has to be noted that most of the incidental traffic jams are caused by the first group of reasons, i.e. problems in capacity supply.

Congestion due to road accidents

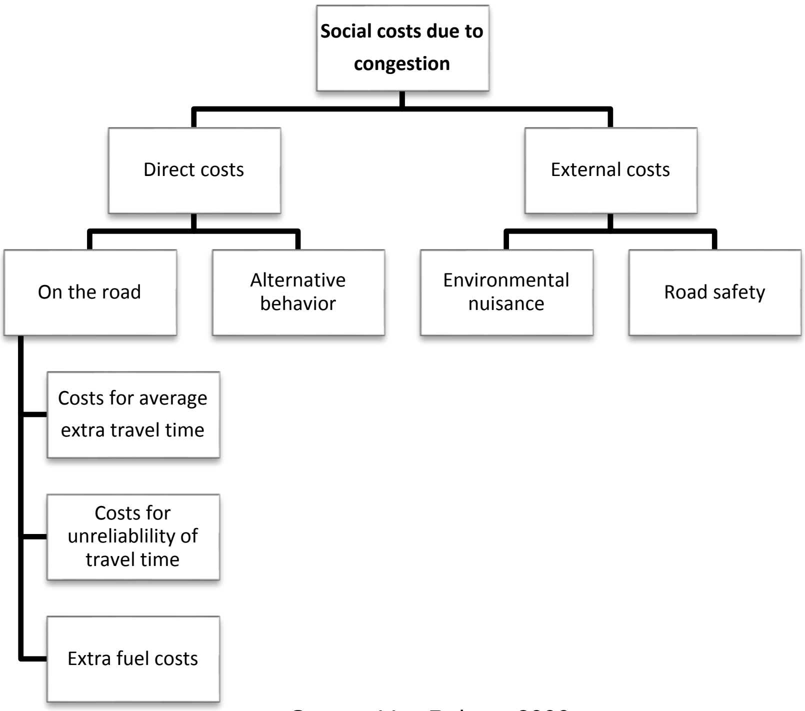
This type of congestion falls under the category of incidental traffic jams. If it is known that congestion due to road accidents represents 60% of the incidental traffic jams, and the incidental traffic jams account for 20% of the total number of congestion, it can be stated that the number of traffic jams caused by an accident is about 12% of all congestion (De Brabander & Vereeck, 2005). This does not mean that also 12% of lost vehicle hours are caused by traffic jams as a result of accidents. Indeed, traffic jams caused by accidents will, on average, last longer than ordinary structural traffic jams. According to Wismans and Knibbe (2007) in The Netherlands approximately 20% of the number of lost vehicle hours is caused by incident congestion. Hof and Vermeulen (2001) argue that 13.5% of all vehicle lost hours are the result of congestion due to road accidents.

Congestion caused by accidents, along with congestion caused by weather conditions, are the least predictable types of traffic jams. These traffic jams are therefore often very unexpected, hence the cost of unreliability will also play an important role in the calculation of the cost of this type of congestion.

Costs of congestion

As can be seen in Figure 6, there are different types of congestion costs. First of all they are divided into direct and external costs. These external costs include environmental nuisance (emissions, noise …) and road safety. The direct costs can in turn also be separated into two parts. On the one hand there are the welfare losses caused by alternative driver behaviour. Alternative behaviour covers detours, leaving earlier or later to avoid traffic jams, using a different transport mode or completely renouncing from the journey. It should be noted that alternative behaviour will occur less frequently in the case of traffic jams resulting from accidents, because these are more difficult to anticipate due to their incidental nature. On the other hand there are the congestion costs on the road itself, or observed congestion costs. These are then further divided into the costs for the average extra travel time, costs for the unreliability of travel time and extra fuel costs. The costs for the average extra travel time, which are calculated later in this paper, correspond to the average delay or cost for travel time losses and are expressed in Euros per hour travel time. The costs of unreliability of travel time are equal to the dispersion around the mean delay and are expressed in Euros per minute standard deviation of travel time. These latter costs also play an important role in congestion due to road accidents, because these traffic jams are very unpredictable, and therefore the travel time losses are difficult to estimate. Finally, there are the additional fuel costs, which will also play a role while being in a traffic jam (Van Reisen, 2006).

Figure 6 - Overview of the social costs due to congestion



Source: Van Reisen, 2006

Calculation of the costs due to direct travel time losses

The cost due to direct travel time losses are all time losses incurred by the road users on the main and secondary roads summed over a certain time horizon, expressed in money. These costs only represent the waste of time while underway. So they do not cover the total economic impact of congestion and delays, nor the maximal benefits to be obtained by solving a traffic jam (Van Reisen, 2006).
To calculate these costs different data are needed. The number of lost vehicle hours due to traffic jams by accidents for both the main roads and the secondary roads are necessary. For further specification of these data there should be known which part of lost vehicle hours is undergone by trucks and which part by passenger cars, what the travel motif of the traveller is and what the occupancy and value of time for the different motifs are. With all these data it will then be possible to calculate the overall costs of extra travel time by congestion due to road accidents. Below, the costs for extra travel time are calculated in six steps, based on Van Reisen (2006) and Maerivoet and Yperman (2008).

1. First of all, the lost time has to be calculated. These time losses (V) can be defined as the difference between the average travel time (T) and the travel time in an unloaded network with free flowing traffic (T_{ff}). This free flow traffic is usually taken at 90% of the permitted speed on that part of the road network. The time losses show how much time an average vehicle loses per kilometer on an average hour in a given period and can be calculated by using the following formula (Maerivoet & Yperman, 2008):

$$V = T - T_{ff}$$

If the average travel time is less than T_{ff}, then the loss of time will be equal to zero. This may occur in time periods characterized by very low travel times, e.g. during the night.

2. In the second step the total number of lost vehicle hours is specified. Lost vehicle hours are defined as the product of the traffic and the lost time. They show how much lost time is incurred by all vehicles on an average hour in a given period. The formula to calculate the lost vehicle hours is the following[2] (Maerivoet & Yperman, 2008):

$$VHL = \frac{(q \times V)}{3600}$$

With VHL = Vehicle hours lost
V = Time losses
q = Traffic volume

Note that the first two steps are similar to the first method used to calculate the lost vehicle hours (i.e. the method used in the Netherlands). If another method is applied, the obtained VHL from this method can be used directly in the following step, and the time losses do not need to be calculated separately.

3. In a third step the proportion of the traffic jams due to accidents in the total number of lost vehicle hours will be determined. The part of traffic jams by an accident is, as earlier stated, about 13.5% of the total amount of lost vehicle hours (Hof & Vermeulen, 2001). Travel motifs are not yet taken into account in this step.

The annually reported figures for the lost vehicle hours in Flanders are shown in the following table. These figures, however, have to contend with some serious limitations. These restrictions are thoroughly discussed further in this paper.

Table II – Lost Vehicle Hours in Flanders

Year	VHL	VHL incurred by accidents
2004	4.533.239	611.987
2005	4.282.549	578.144
2006	4.528.245	611.313
2007	5.409.571	730.292
2008	4.489.330	606.060

Source: Flemish Government, MOW, Traffic Centre

[2] The division by 3600 is done to convert the lost vehicle hours from seconds to hours.

4. In the fourth step the division per motif is applied to the lost vehicle hours. For each travel motif, the lost vehicle hours are multiplied with the share of the relevant motif.

Table III – Travel Motif Distributions

	Persons transport			**Freight**
	Commuting	***Business***	***other***	**transport**
De Brabander (Flanders)	23,15%	4,24%	57,25%	14,52%
OVG (Flanders)	23,41%	3,78%	56,63%	16,11%
Van Reisen (NL)	29%	22%	41,50%	7,50%
SWOV (NL)	39%	28%	25%	8%

Source: Own setup

As can be seen in the table above, a lot of variation in motif distribution exists. The Netherlands traditionally have a higher proportion of business transport, which is partly compensated with less freight transport. In the calculation presented here, each of the previous scenarios will be examined.
The lost vehicle hours due to road accidents per travel motif for each scenario are given in the next table:

Table IV – VHL per travel motif

		Persons transport			**Freight**
		commuting	***business***	***other***	**transport**
De Brabander	2004	141.675,05	25.948,26	350.362,71	88.860,55
	2005	133.840,36	24.513,31	330.987,51	83.946,53
	2006	141.518,98	25.919,67	349.976,74	88.762,66
	2007	169.062,62	30.964,38	418.092,22	106.038,41
	2008	140.302,79	25.696,92	346.969,09	87.999,85
OVG	2004	143.238,50	23.102,98	346.544,76	98.587,61
	2005	135.317,35	21.825,38	327.380,69	93.135,68
	2006	143.080,71	23.077,53	346.163,00	98.479,01
	2007	170.928,30	27.569,08	413.536,22	117.645,84
	2008	141.851,09	22.879,21	343.188,13	97.632,69
van Reisen	2004	177.476,31	134.637,20	253.974,71	45.899,04
	2005	167.661,79	127.191,71	239.929,81	43.360,81
	2006	177.280,79	134.488,88	253.694,93	45.848,48
	2007	211.784,70	160.664,26	303.071,22	54.771,91
	2008	175.757,27	133.333,10	251.514,71	45.454,47
SWOV	2004	238.675,03	171.356,43	152.996,82	48.958,98
	2005	225.476,20	161.880,35	144.536,03	46.251,53
	2006	238.412,10	171.167,66	152.828,27	48.905,05
	2007	284.813,91	204.481,78	182.573,02	58.423,37
	2008	236.363,22	169.696,67	151.514,89	48.484,76

Source: Own setup

5. Thereafter, the next formula (van Reisen, 2006) has to be applied for the different travel motifs to determine the costs for travel time losses per motif.

$$Cost_{ExtraTravelTime} = VHL_{accidents} \times occupancy \times VoT$$

With $Cost_{ExtraTravelTime}$ = Cost for the average extra travel time
$VHL_{accidents}$ = Lost vehicle hours due to congestion by accidents
VoT = Value of Time

As can be seen in the table below, not only the value of time differs according to the motif, but also the average occupancy of the vehicles will be different for each motif. This is an important difference between the indicator 'congestion costs' and the lost vehicle hours. Namely, with the lost vehicle hours the distinction in travel motif is not made, so the economic impact of congestion will be underestimated (Vanhove, 2008).

Table V – Occupancy and VoT per motif

		personenvervoer			goederen
		woon-werk	zakelijk	overig	
Occupancy	2004	1,16	1,12	1,54	1
	2005	1,16	1,12	1,54	1
	2006	1,14	1,11	1,5	1
	2007	1,14	1,11	1,5	1
	2008	1,14	1,11	1,5	1
Value of Time	2004	8,37	28,97	5,78	40,93
	2005	8,34	28,9	5,76	40,83
	2006	8,41	29,14	5,81	41,17
	2007	8,48	29,39	5,86	42,94
	2008	8,55	29,63	5,91	42,94

Source: Own setup based on Van Reisen (2006) & RWS-DVS (2006)

In the case of freight transport it is assumed that the occupancy is always equal to 1, so it is not necessary to multiply with the occupancy for this motif. This is not because of the fact that there is only one driver, but because the freight is important, and not the occupants. Time losses are thus not inflicted to the occupants, but to the freight (De Ceuster & De Schrijver, 2002).

6. If the costs of the travel time losses are calculated for all motifs, these costs per motif need to be summed to obtain the total costs for travel time losses for a given period. If the calculations for the main roads and the secondary roads are conducted separately, they should obviously also be added together. The table below shows the results of the calculation for the main roads in Flanders for each scenario in motif distribution.

Table VI – Costs of direct travel time losses due to road accidents for Flanders

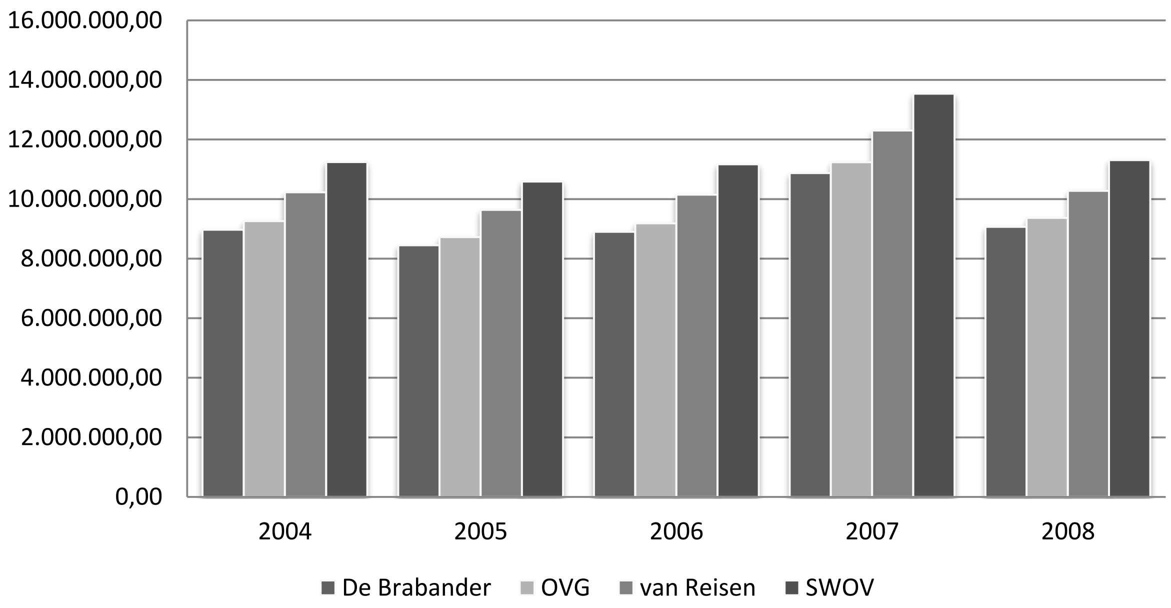
		Persons transport			**Freight**	
		commuting	***business***	***other***	**transport**	**TOTAAL**
De Brabander	2004	1.375.551,41	841.927,62	3.118.648,55	3.637.062,35	**8.973.189,93**
	2005	1.294.825,20	793.446,83	2.935.991,57	3.427.536,64	**8.451.800,25**
	2006	1.356.799,04	838.382,24	3.050.047,25	3.654.358,65	**8.899.587,17**
	2007	1.634.362,14	1.010.148,02	3.675.030,60	4.553.289,36	**10.872.830,11**
	2008	1.367.531,25	845.153,87	3.075.881,00	3.778.713,42	**9.067.279,55**
OVG	2004	1.390.731,27	749.608,67	3.084.664,26	4.035.191,05	**9.260.195,24**
	2005	1.309.114,21	706.443,89	2.903.997,72	3.802.729,74	**8.722.285,55**
	2006	1.371.771,95	746.452,04	3.016.810,52	4.054.380,68	**9.189.415,19**
	2007	1.652.398,09	899.383,38	3.634.983,35	5.051.712,26	**11.238.477,08**
	2008	1.382.622,60	752.481,15	3.042.362,76	4.192.347,86	**9.369.814,37**
van Reisen	2004	1.723.152,96	4.368.492,39	2.260.679,73	1.878.647,91	**10.230.972,99**
	2005	1.622.027,25	4.116.941,12	2.128.273,37	1.770.421,82	**9.637.663,55**
	2006	1.699.661,86	4.350.096,51	2.210.951,28	1.887.581,95	**10.148.291,60**
	2007	2.047.365,10	5.241.334,05	2.663.995,98	2.351.905,66	**12.304.600,78**
	2008	1.713.106,11	4.385.232,36	2.229.677,93	1.951.814,78	**10.279.831,18**
SWOV	2004	2.317.343,63	5.559.899,41	1.361.855,26	2.003.891,10	**11.242.989,40**
	2005	2.181.347,00	5.239.743,24	1.282.092,39	1.888.449,94	**10.591.632,56**
	2006	2.285.752,16	5.536.486,46	1.331.898,36	2.013.420,74	**11.167.557,73**
	2007	2.753.353,06	6.670.788,78	1.604.816,86	2.508.699,37	**13.537.658,07**
	2008	2.303.832,35	5.581.204,82	1.343.179,48	2.081.935,77	**11.310.152,41**

Source: Own setup

DISCUSSION

As can be seen in table VI and in the figure below, the congestion costs in 2007 were significantly higher in comparison with the other years. According to the Mobility Report for Flanders the reason for this peak is unknown (MORA, 2009). Another notable finding from the figure is that the Dutch motif distributions (Van Reisen and SWOV) result in higher congestion costs compared with the Flemish distributions. The reason for this difference is the higher proportion of business traffic in the Dutch motif distributions. For the Dutch scenarios this business traffic is also the most important cost, while for the Flemish scenarios freight transport and other traffic account for the biggest part of the congestion costs. A third remark in relation with the results is that if another source for the occupancies would be used (e.g. Zwerts and Nuyts, 2004) the congestion costs would rise. However, these data were not used because they do not contain a specific value for the occupancy of business traffic and the occupancies are assumed to be constant over time.

Figure 7 – Costs of direct travel time losses due to road accidents for Flanders



Source: Own setup

Overall, these figures seem quite low compared with the figures from De Brabander in the introduction. This is because De Brabander calculated the congestion costs for the whole of Belgium, while these results are based on the lost vehicle hours reported for Flanders only. Moreover, the lost vehicle hours incurred on the Ring around Antwerp are not included in these figures, which can cause a significant underestimation. If it is known that the costs of alternative behaviour and unreliability of travel times still need to be added, it seems clear that the congestion costs of accidents are a lot higher than generally assumed. Furthermore, in these calculations, only the traffic jams on the main road network are charged. The lost hours on the local road network are not taken into account in this calculation due to the absence of the necessary data.

As already mentioned, the reported lost vehicle hours for Flanders and the current methodology for their calculation have some important restrictions to deal with. The traffic measurement systems on the main road network in Flanders have not yet developed sufficiently to visualize the lost vehicle hours in an accurate way. Moreover, the traffic jams on the R1 around Antwerp (which surely is a significant source of congestion in Flanders) is not included in these figures. The necessary measurement systems on the R1 were removed and replaced by double loops during road works, while the calculations are still done by the old measurement network with single loops, which are not ideal for calculating speeds. Nonetheless, this old monitoring systems has to estimate the speeds, because no reliable methodology for the new system exists yet, causing uncertainty in the figures.

Because of these limitations, the reliability of the data should be put in perspective and they should therefore only be considered as a general indication of the congestion problem.

Nevertheless it seemed interesting to estimate the congestion costs for Flanders, to obtain a general view on the economic burden of congestion.

CONCLUSION

This paper examined congestion costs due to road accidents in Flanders and studies whether it is true that congestion costs are being systematically underestimated. To valuate these costs, different input data are needed: most importantly the value of travel time and the lost vehicle hours. Concerning the value of travel time, the problem is that even if sufficient quality data exists, the estimations will still be subject to a lot of variation. This variation depends on various factors such as the type of vehicle, the purpose of the journey, the occupancy of the vehicle, the traveller himself, the region, etc. As for the lost vehicle hours, there is an even bigger problem: no reliable methodology for the calculation of this indicator exists in Flanders or Belgium. Therefore the focus in this paper was on the methodology of the calculation of lost vehicle hours and the description of the data needed to perform the calculations. After a brief literature study, a new framework was proposed in which the different advantages of the various methods that have been discussed were implemented. This framework however, could not yet be used for the calculations in this paper because Flanders is not equipped with the appropriate infrastructure: in Flanders, single loops are used to measure speeds and derive lost vehicle hours, while for a reliable estimation of the lost vehicle hours double loops (in a closed network) are needed. Currently, these are only present on the Ring around Antwerp and the E313. The reported lost vehicle hours for Flanders, calculated with single loops and Antwerp not included, should therefore be viewed at with the necessary criticism. Nonetheless it seemed interesting to calculate the congestion costs based on these figures, to give a general indication about the congestion problem in Flanders.

What can be concluded from these calculations is that congestion costs were significantly higher in 2007, although no specific reason can be given for this. Also notable is that the scenarios with the Dutch motif distributions result in higher congestion costs in comparison with the Belgian scenarios. The figures from table 6 also seem much lower than the figures of De Brabander, but this is because the calculations by De Brabander were executed for the whole of Belgium, while in this paper only Flanders was considered. In addition, the R1 around Antwerp, a major source of congestion, was not included in these figures due to the obsolete measurement network. Also, only the main road network is taken into account, while ideally the congestion on the local roads should also be charged. Finally, the costs of the unreliability of travel times and these of alternative behaviour should also be added. So, it can be concluded that congestion due to road accidents is indeed often underestimated and that it is an even bigger problem economically than generally assumed. How big this underestimation really is, is difficult to assess because the methodology and measurement systems for calculating the lost vehicle hours are outdated and not reliable. In addition, for a perfect estimate of the congestion costs, data of the delays on the local road network are still missing.

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