Internalisation of external costs of transport in Flanders

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Abstract: *We calculated the private and marginal external costs of different transport modes. The private costs are the costs for the user. For road transport these include the vehicle purchase costs, insurances, maintenance, fuel costs, etc. For transport services (bus, train, plane) this is the ticket price. Marginal external costs are the costs the user does not take into account when deciding to make a trip. They are called marginal as we focus on the additional effect of that one trip. We considered congestion, environment (air pollution and greenhouse gasses), noise, safety, infrastructure wear & tear and health.*
The internalization of external costs determines the extent to which the user does take into account part of these external costs via taxes and levies. In the case of full internalization, the user pays for all the costs he causes via taxes and levies. Today, in most cases, the user does not pay the full costs he causes.
In this study we calculated the private costs, marginal external costs, and degree of internalization for all modes in Flanders for the period 2000-2014, with an outlook towards 2016. Based on these calculations we assessed the evolution of the degree of internalization over time. Is Flanders heading towards the "polluter pays principle"? Which steps are needed to evolve to a better pricing?

Keywords*:* external costs, internalisation, private cost, road, bike, air transport;, shipping, rail

1. <u>Introduction</u>

This article is based on Delhaye, E. et. al. (2017). It discusses the private costs, the external costs and the level of internalization of transport in Flanders for the period 2000-2014, with an outlook towards 2016. We first discuss the level of internalization, its importance and its evolution over time. Next, we describe in more detail how the external costs and private costs were calculated.

2. <u>What is internalization of marginal external costs?</u>

The transport user is not always aware of the nuisances transport causes. Think for example of air pollution, climate change, noise nuisance, accidents and – for lorries, rail, inland waterway and sea transport – damage to infrastructure. This nuisance causes *marginal external costs* of transport. These costs are called external as each of these aspects comes at a price, which is not paid directly by the polluter, but by society as a whole. They are, in other words, external to the user. The user only takes into account his private costs (for example, fuel costs and the price of a train ticket), taxes and levies (for example the annual road tax). They are called marginal as we only consider the additional external costs caused by an additional vehicle kilometre.

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Internalization of external costs deals with the question to what extent the user pays for part of these external costs via taxes and levies. Full internalization implies that the user pays for all the costs he causes via taxes and levies[5].

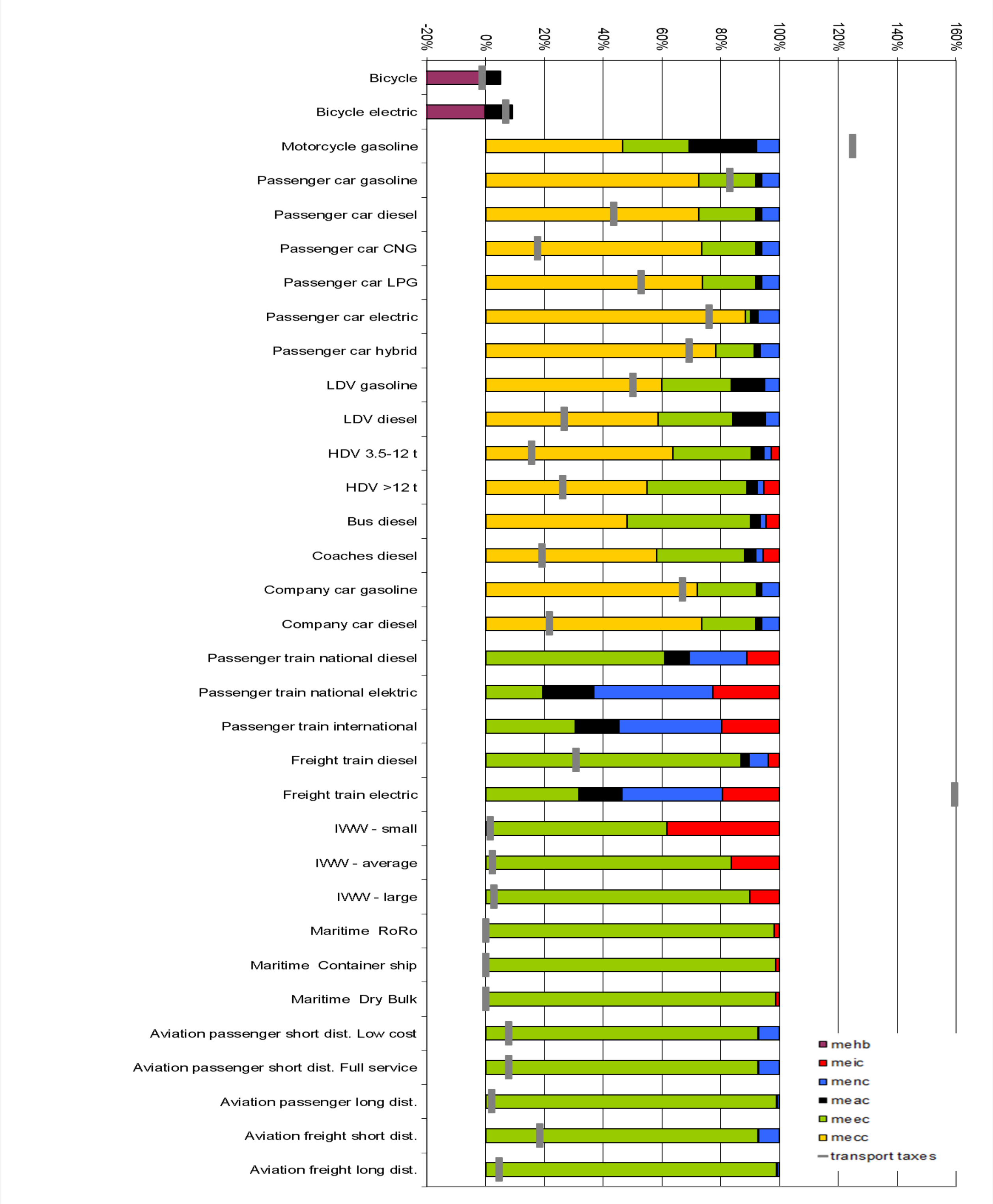
3. To what extent does the transport user internalize their external costs?

Currently, most users do not pay for the nuisances they cause. Figure 1 below shows the degree of internalization for the different modes examined in this study. The numbers are relative: the sum of all external costs equals 100%. The small grey bars show to what extent the taxes cover the marginal external costs. A negative tax represents a subsidy. For cyclists, the marginal benefits are larger than the marginal costs, so that the sum of external "costs" does not equal 100 %.

Figure 1 clearly shows that current taxes and levies on transport capture only a portion of the external costs. We find that, in general, the degree of internalization is the largest for road transport, and for motorcycles and passenger cars in particular. The taxes for motorcycles are higher than their external costs. Among the passenger cars, the gasoline car has the highest level of internalization (80 %). Diesel cars only internalize 42 %. Company cars (defined as cars owned by a company but also used for personal purposes) have a much lower level of internalization with only 66 % for gasoline cars and 21 % for diesel cars. Due to its high subsidization, public transport does not internalize its external cost. The subsidies are about 7 times higher than the external costs for buses and about 5 (diesel) to 11 (electric) times higher for rail (national passenger transport). Coaches only internalize 19 %. Air transport for passengers internalizes about 8% on short hauls, and only 2% on long hauls.

[5] It is also possible to internalize external costs using tradeable emission or mobility rights.

Figure 1: Internalization of external costs for all transport modes, euro per 100 vehicle kilometres (total marginal external costs = 100%), Flanders, 2014. Source: TML



The degree of internalization for the modes bus and passenger train fall outside the scale of this graph. The degree of internalization for bus is -744 %, for passenger train national diesel -540 % and for passenger train electric -1115 %.

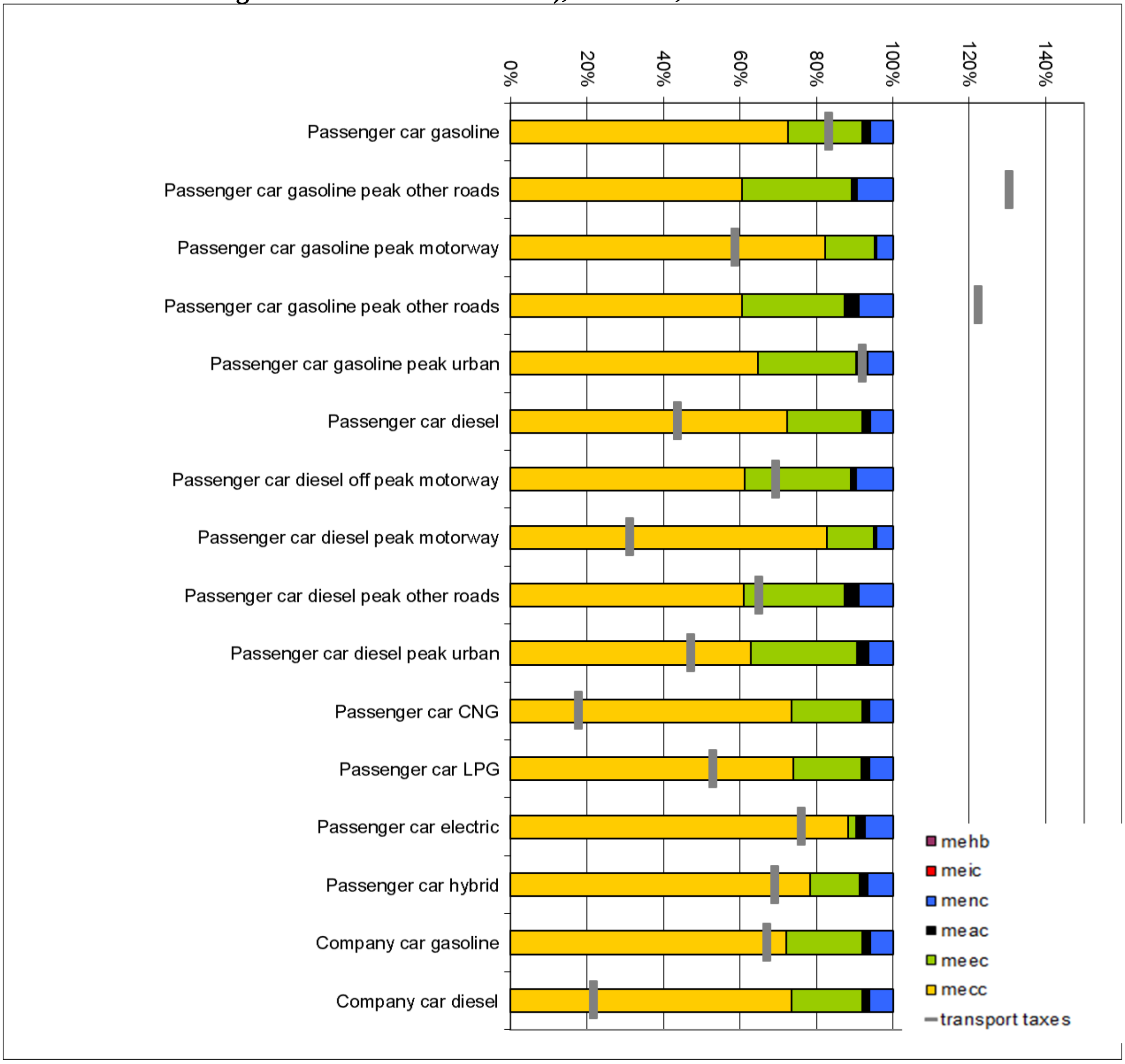
mehb = marginal external health benefit
meic = marginal external infrastructure cost
menc = marginal external noise cost
meac = marginal external accident cost
meec = marginal external environmental cost
mecc = marginal external congestion cost

For freight transport, the level of internalization for light-duty vehicles varies between 27 % and 50 %, depending on the fuel type (diesel versus gasoline). Heavy-duty vehicles internalize between 15 % and 26 % of their external costs. Rail freight transport internalizes about 30 % (diesel) and even pays more than its costs when electric (159 %). For freight air transport there is a large difference between short (18 %) and long (4 %) distance. For maritime and inland waterways, the degree of internalization is low to inexistent.

4. What is the importance of differentiated taxes for road transport?

For road transport, we can make a further distinction in terms of time (peak versus off-peak hours) and place (motorways, other roads, and urban roads) of transport. On average, the gasoline car does not internalize its external costs. However, Figure 2 shows that gasoline passenger cars pay too much in some situations. This is the case for example during off-peak hours on motorways and in peak hours on “other roads”. Diesel cars, on the other hand, internalize less than gasoline cars. They never pay too much. Company cars – and certainly diesel cars – internalize much less than private owned cars. Within the group of passenger cars using alternative fuels, it is clear that CNG cars are (over)subsidized. Their marginal external costs are very similar to gasoline cars, but they pay far fewer taxes. The level of internalization for cars using alternative fuels lies between that of the diesel and the gasoline car.

Figure 2: Internalization of external costs by passenger cars, euro per 100 vehicle-km (total marginal external costs = 100 %), Flanders, 2014. Source: TML



mehb = marginal external health benefit
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meec = marginal external environmental cost
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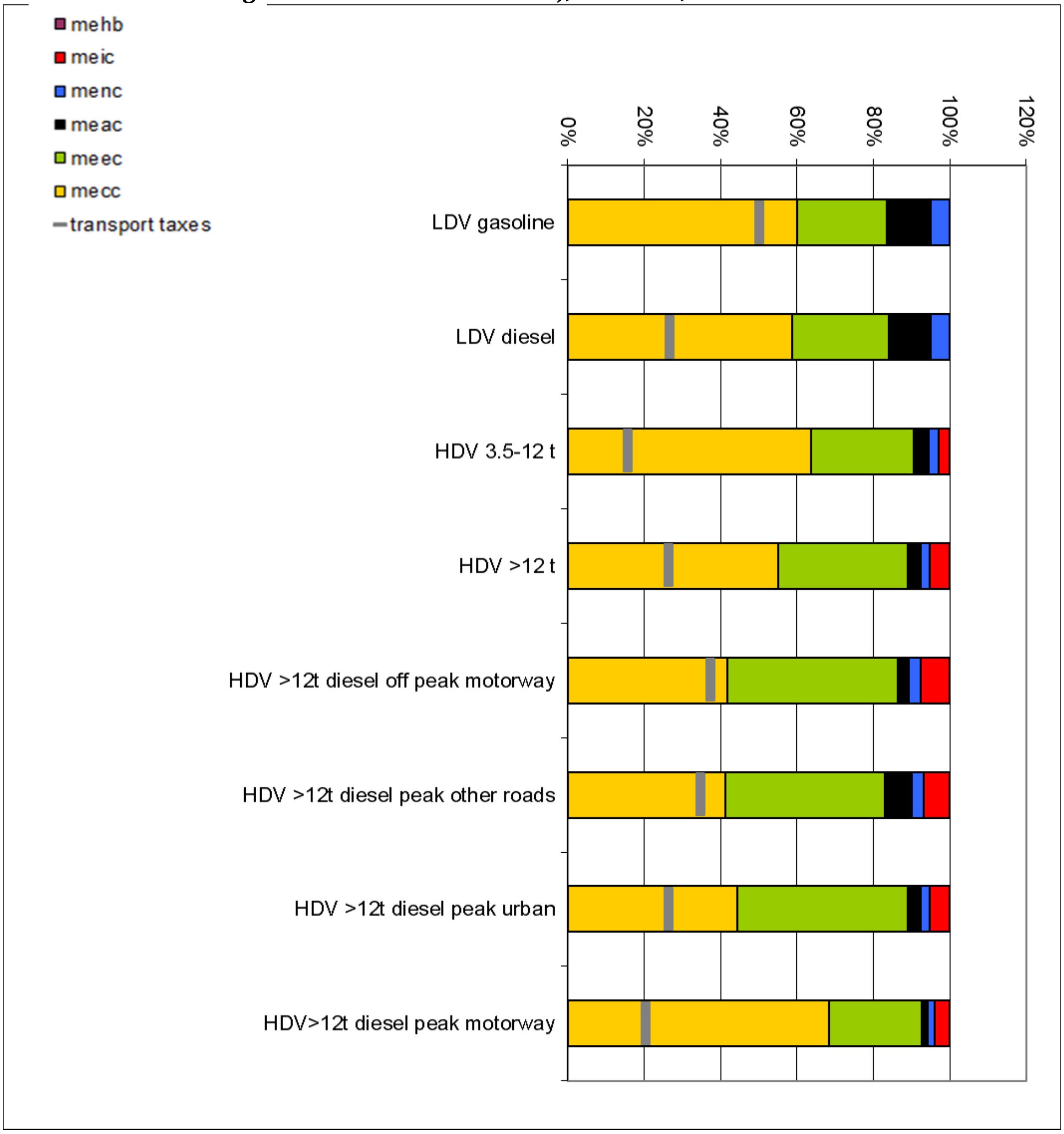
A similar picture is obtained for lorries (Figure 3). In general, they pay too little, particularly in peak hours on motorways and in urban environments.

Figure 3: Internalization of external costs of lories, euro per 100 vehicle kilometres (total marginal external costs = 100%), Flanders, 2014. Source: TML



mehb = marginal external health benefit
meic = marginal external infrastructure cost
menc = marginal external noise cost
meac = marginal external accident cost
meec = marginal external environmental cost
mecc = marginal external congestion cost

This implies that it would be economically optimal to differentiate taxes and levies in terms of fuel type, place, and time of transport[6]. Today, most taxes are dependent mainly on fuel type/environmental performance of the vehicle. In 2016, a start towards a location dependent charge was made with the introduction of the kilometre charge for heavy-duty vehicles.

[6] The calculations take account of the average environmental performance of the vehicle fleet, but do not further distinguish between Euro standards. Different Euro standards have a different impact on marginal external environmental costs. Given the importance of the congestion costs, it seems more important to differentiate with respect to time and place.

5. How did the level of internalization evolved over time?

Figure 4 shows the evolution of the level of internalization over time for road transport. For most passenger cars, the level of internalization decreases. This is more linked to the increase in external costs – congestion in particular – than to a decrease in taxes. Taxes remained relatively constant over time. Taxes on company cars did increase between 2012 and 2014 due to the reduction of the VAT deduction and the increase in "benefits in kind" for commuting (and hence a decrease of the implicit subsidy) since 2013. This led to an increase in the level of internalization. For lorries, the level of internalization is relatively constant (not yet taking into account the kilometre charge). Light-duty vehicles on diesel are the exception with an increase in their level of internalization.

Figure 4: Internalization of external costs over time (2000-2014) – road transport. Source: TML

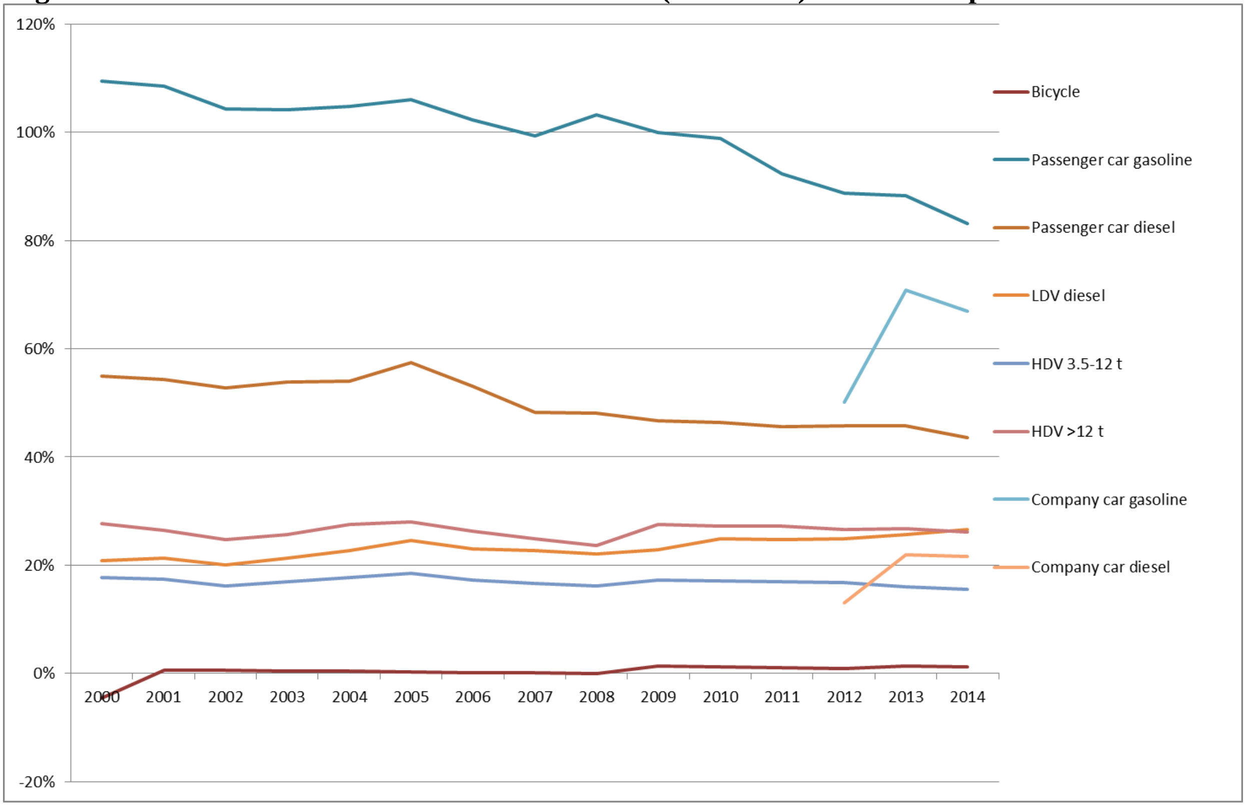
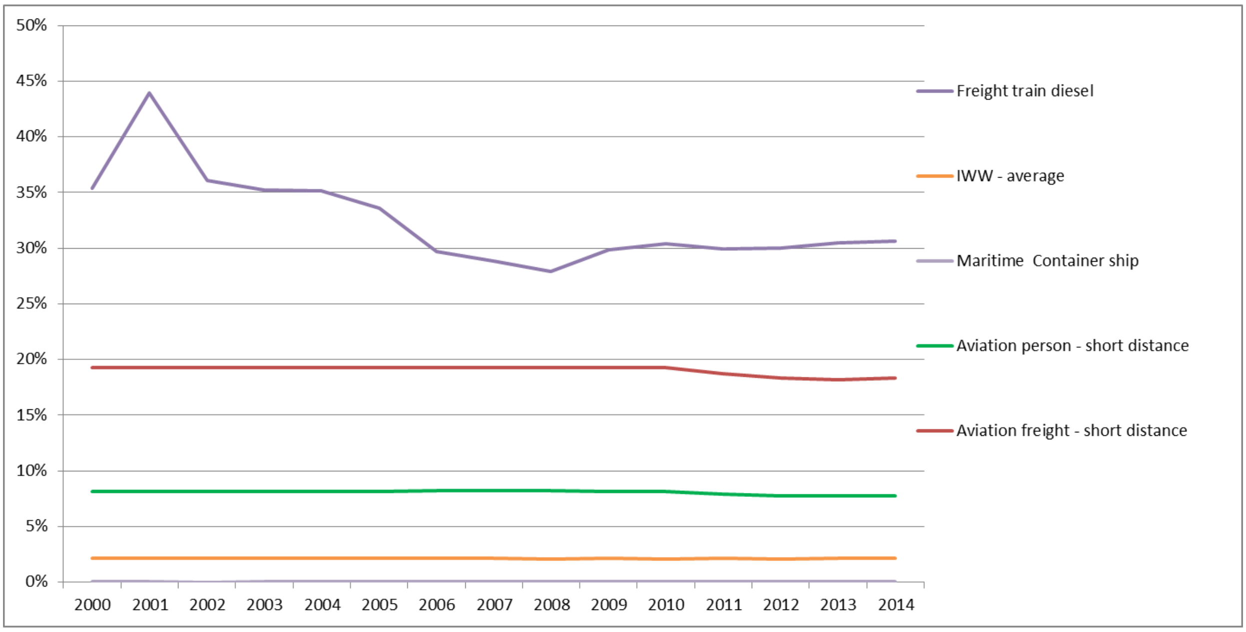


Figure 5 shows the level of internalization for non-road transport. For diesel freight trains, the level of internalization decreased. For electric freight trains and international passenger transport (not shown on Figure 5), the level of internalization remains rather constant. National passenger rail transport is more and more subsidized and hence the level of internalization decreases. For shipping, the level of internalization remains relatively constant for inland waterways, whereas it remains virtually zero for maritime shipping. For air transport, the level of internalization also remains relatively constant – although this is partly caused by the lack of differentiated time series for many elements.

Figure 5: Internalization of external costs over time (2000-2014) – non-road transport. Source: TML



In 2016, several measures were taken which affect the level of internalization to a greater or lesser extent. The kilometre charge for heavy-duty vehicles increased (when keeping all other private and external costs fixed at the level of 2014) the level of internalization for heavy-duty vehicles 3.5-12t from 15 % to 34 % and from 26 % to 45 % for heavy-duty vehicles of more than 12t. The change in the car registration tax and yearly road tax also increased the level of internalization – although to a lesser extent. When all other private and external costs are fixed at the level of 2014, the level of internalization increases from 83 % to 86 % for gasoline cars and from 44 % to 46 % for diesel cars.

6. <u>Does this means that Flanders is on the right track?</u>

Not really….

Over the years, changes in the level of internalization are mainly driven by developments in external costs (improvements in environmental performance, increasing congestion) rather than by a targeted adjustment of taxes. Overall, we observe a declining trend in the level of internalization. Over the last years, there have been some changes. For company cars, we see a marked increase in the degree of internalization, mainly due the change in "benefits in kinds" in 2013. However, the difference with "ordinary" cars remains high. The introduction of the kilometre charge for heavy-duty vehicles was a first step in the right direction. The changes to the car registration tax (BIV) and the yearly road tax for cars in 2016 also had a slightly positive effect.

If we look at the degree of internalization, we see large differences between the different modes. Road transport internalizes relatively much of its external costs, but inland waterways and maritime shipping do not. Freight rail is at the same level as road freight transport (for diesel traction) or pays more than its costs (for electric traction). For aviation, the level of internalization is relatively low. Moreover, there are also major differences within road transport itself. For example, the taxes levied on CNG cars are much lower than for gasoline cars – although the differences in external costs are small.

There are also large subsidies for public transport (bus and rail). The question can be asked whether the difference with the other modes is not too large? On the other hand, subsidies can be used to stimulate modes with lower external costs, and there are also other – social - issues.

This can be further illustrated using Figure 6 below. The knowledge of external costs and whether they are included in the user price, is an input into policy decisions.

Figure 6: Illustration of the use of external costs, Flanders 2014. Euro per 100 passenger-km. Source: TML

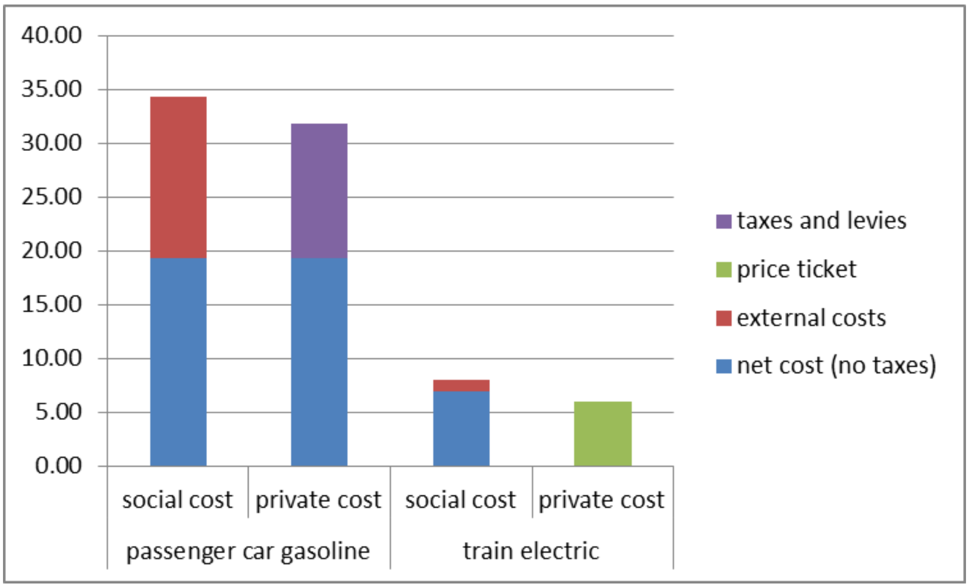


Figure 6 shows the marginal social costs (sum of the net private costs and the external costs) and the private costs (net + taxes and levies) of a gasoline car on the left-hand side. In this case, the private costs are too low and the use of the car is too high – from a social perspective. The level of internalization is lower than 100 %. If a higher tax is imposed, the private costs increase and the level of internalization rises. A congestion charge or a charge depending on environmental performance has such an effect.

The marginal social costs and the private costs for the user (net costs minus subsidies) for rail are shown on the right-hand side. The private costs for the user are lower than the net costs. Hence, the external costs are not included. The level of internalization is even negative. This could be a "second best" policy if this lower price for rail in peak hours would effectively decrease the use of other transport modes with higher external costs (the car for example).

From an economic theory perspective, users have to pay the right price. This means that users pay the full marginal costs – for all modes. When we set the taxes and levies equal to the external costs, the modes with the lowest social costs (= net private costs and external costs) are bicycles, rail-electric, buses and aviation. The most important reason for the low social cost for aviation is the high occupancy rate. Also in freight transport, the alternative modes such as rail and water remain considerably cheaper (per tonne-km). It is not because road transport has the largest level of internalization today that a further internalization for the other modes will lead to large changes in their relative prices.

Finally, today taxes are mostly differentiated with respect to the environmental performance of the vehicles – if they are differentiated. Given that external costs also depend on the time and place, it would be better to differentiate them further. This has started for road freight with the introduction of the kilometre charge with a differentiation in terms of place, but this could be extended to time and/or passenger cars.

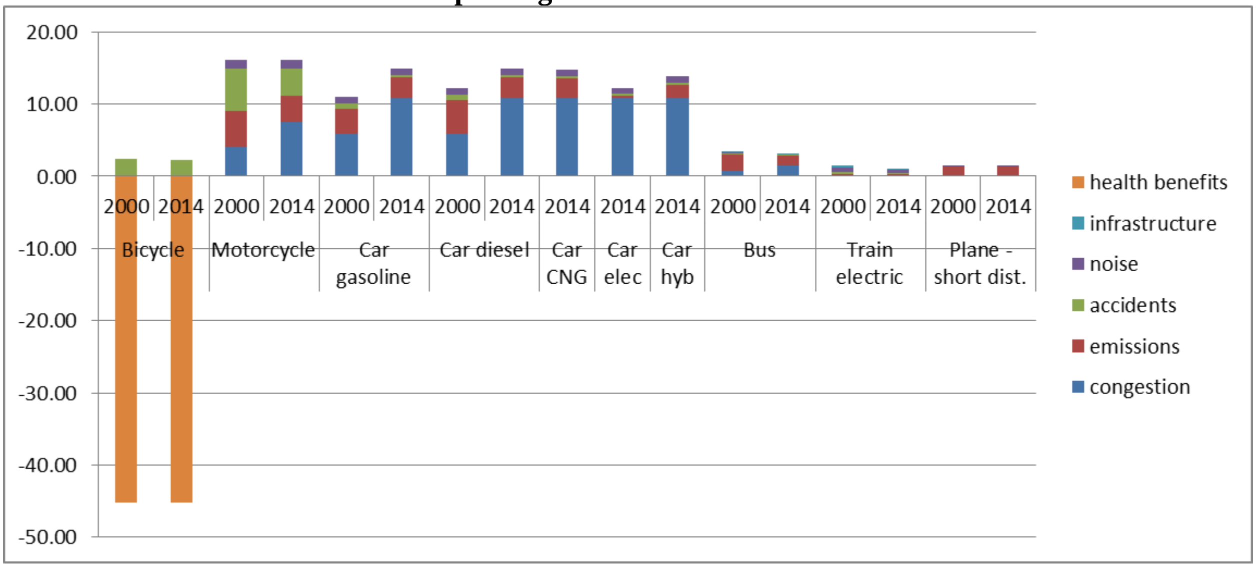
In summary, information on external costs and the degree of internalization is an important input for policy, but other aspects also have to be taken into consideration in policy decisions.

7. Which external costs are considered?

In this study, we consider the following external costs: costs caused by noise, congestion, accidents, damage to infrastructure, and environmental costs. In some cases, there are also external benefits such as the health benefits of cycling. Figures 7, 8, 9 and 10 show the different marginal external costs for different modes and fuel types per 100 passenger-km for passenger transport and per 100 tonne-km for freight transport. Each time we show the full picture and then zoom in.

The *marginal external congestion costs* are the time costs[7] caused by a road user to other road users by driving an additional vehicle kilometre. The user's own time costs are not part of the marginal external congestion costs. These external costs are particularly high during peak hours and in urban areas. The congestion costs in the figures are averaged over peak and off-peak and over all road types. The figures also clearly show that the congestion costs account for the major share of the external costs for passenger cars and lorries.

Figure 7: Marginal external costs of passenger transport (Flanders, 2000 and 2014), euro per 100 passenger-km. Source: TML



[7] Values of time uses are based on KIM (2013) and Federaal Planbureau (2015). The congestion curve was estimated using real travel time data in Delhaye et. al (2017).

Figure 8: Marginal external costs of passenger transport (Flanders, 2000 and 2014) – zoom, euro per 100 passenger-km. Source: TML

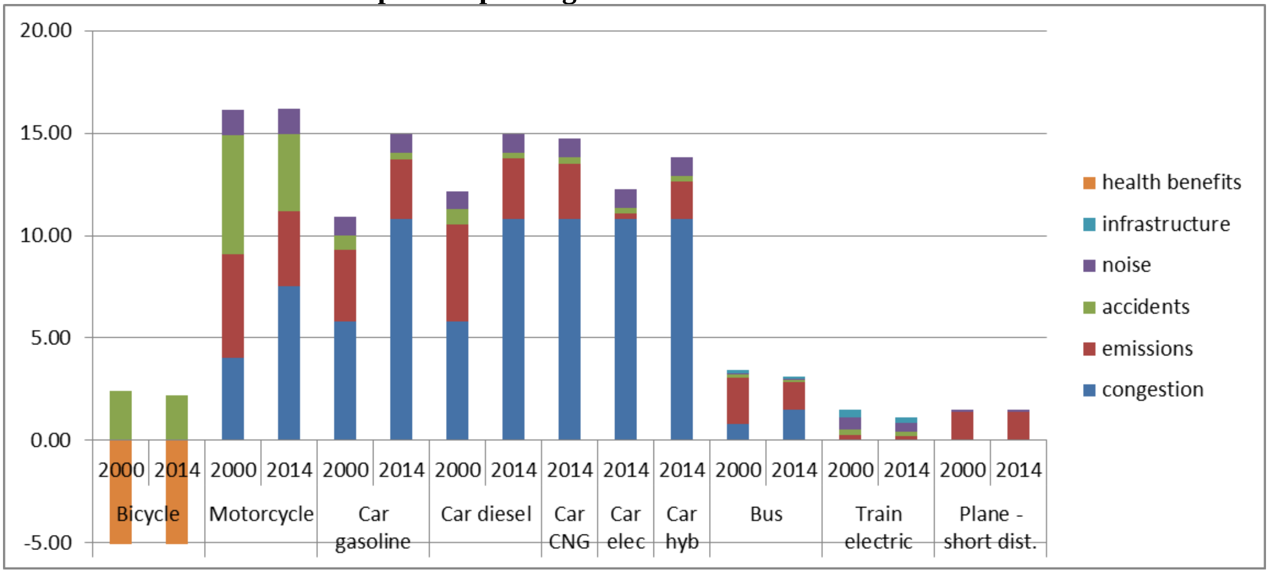
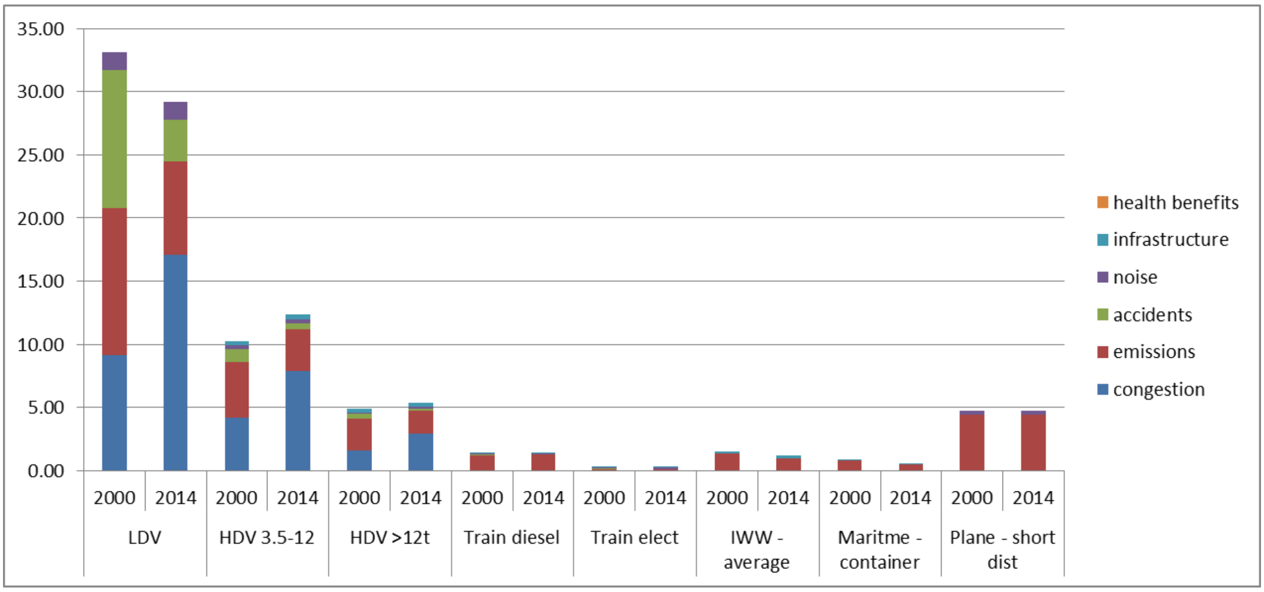
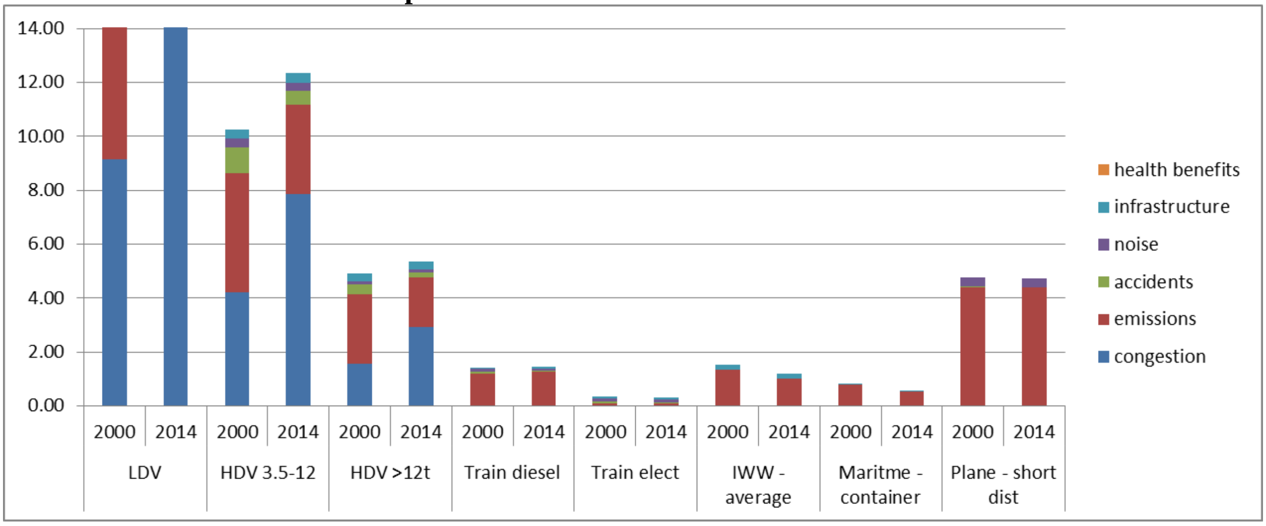


Figure 9: Marginal external costs of freight transport (Flanders, 2000 and 2014), euro per 100 tonne-km. Source: TML



For maritime shipping, we assume that not all emissions which happen on the North Sea reach the main land, leading to lower damage costs of emissions from maritime shipping.

Figure 10: Marginal external costs of freight transport (Flanders, 2000 and 2014) - zoom, euro per 100 tonne-km. Source: TML



The *marginal external environmental costs* are the costs due to climate change (CO_2, CH_4 and N_2O) and air pollution (SO_2, NO_x, NMVOC, heavy metals, $PM_{2,5}$ and PM_{10}). The non-exhaust emissions of PM and heavy metals are also taken into account in the calculation of the marginal external environmental costs – as are the indirect emissions. They are calculated as the product of the different emission factors[8] (in kg/km) with the respective monetary valuations[9] (in euro/kg). The figure shows that the share of the marginal external environmental costs (as a consequence of emissions) in the total external costs decreased between 2000 and 2014

The *marginal external noise costs* are very low for all modes, both in absolute and relative terms. The methodology used is based on Ecorys (2005), the impact is based on Dekonink, L. (2016) and the valuation on Standaardmethodiek MKBA transport

The *marginal external accident costs* of road transport are the additional accident costs for society due to a road user driving an additional kilometre. The damage costs covered by the insurance of the vehicle are not included in these external costs. The methodology is based on Lindberg (2006), while the monetary values are based on HEATCO and GRACE and the accident risk is calculated using national statistics. Especially motorcyclists have high marginal external accident costs due to their high accident risk, especially accidents leading to severe physical damage. Cyclists also have relatively high accident costs, mainly as a consequence of their relatively high accident risk – although they have a much smaller “external” part. Lorries are, per driven kilometre, relatively less involved in accidents. However, a larger part of the accident costs are external for lorries as the probability that the lorry driver himself gets hurt is lower than the probability that the other party in the accident gets severely injured. For all vehicle types, we see a decrease in the accident risk over the years, leading to a decreasing marginal external accident cost over time.

The *marginal external infrastructure costs* are the additional costs for maintenance and repair of the road surface, locks, docks, etc., which are dependent on the traffic volume. An additional lorry damages, depending on its axle weight, the road surface to a lesser or greater

[8] Direct emissions of road transport are based on Vlaamse Emissie-Inventaris lucht (VMM). Direct emissions of rail, inland waterways and maritime start from the EMMOSS model and of air transport from the EMMOL model. Indirect emissions are based on CE Delft (2011) and CE Delft (2015)
[9] For air pollutants based on VITO (2010) and for greenhouse gasses based on Ricardo-AEA (2014).

extent. For passenger vehicles these marginal costs equal zero as the axle weight is very limited. For lorries, these costs represent only a small portion of the total external costs. Also for the other modes, we see that the marginal external infrastructure costs are relatively low. The methodology for road transport is again based on GRACE. Information on infrastructure costs were taken from De Ceuster (2012). For rail, we used the value given by Munduch (2002), for inland waterways and maritime Schroten, A. et.al. (2010). For air transport they are assumed to be internalised via the airport charges.

The *marginal benefits of health a*re unique for cyclists. These benefits are threefold: improved health for the cyclist in the form of avoided early death and/or increase in quality of life, savings for the social security system, and increase in productivity due to lower absence rates. They were calculated in Delhaye et.al (2017) on the base of a literature review.

When we focus on the differences in marginal external costs between the different modes of passenger transport (Figure 7 and Figure 8) we can make the following conclusions. The marginal external costs per passenger kilometre increased over time for passenger cars. For the other passenger modes, they remained relatively constant, for electric rail they decreased. In 2014, the highest marginal external costs (per passenger-km) for passenger transport were for motorbikes, followed by passenger cars. Over time, the marginal external costs for motorcycling remained relatively constant, but the relative shares of the different costs changed. The environmental and accident costs decreased over time, while the congestion cost increased. Cyclists have marginal health benefits. The differences between the passenger cars are relatively low due to the predominance of the congestion costs – even when comparing with alternative fuel passenger cars. The differences that exist are entirely attributable to differences in environmental costs. In 2014, the marginal external costs of an electric care were about 82 % of the external costs of a diesel car. These figures express the marginal external costs per passenger-km, hence transport (bus and rail) and aviation have much lower marginal external costs due to their economies of scale. Hence, the occupancy rate is very important for this comparison. For buses, there is a strong decrease in the marginal external environmental costs, but this is set off by the increase in the congestion costs. For aviation, the most important costs are the environmental costs, and greenhouse gasses in particular. The electric train has the lowest marginal external costs – in which noise has the largest share (41 %).

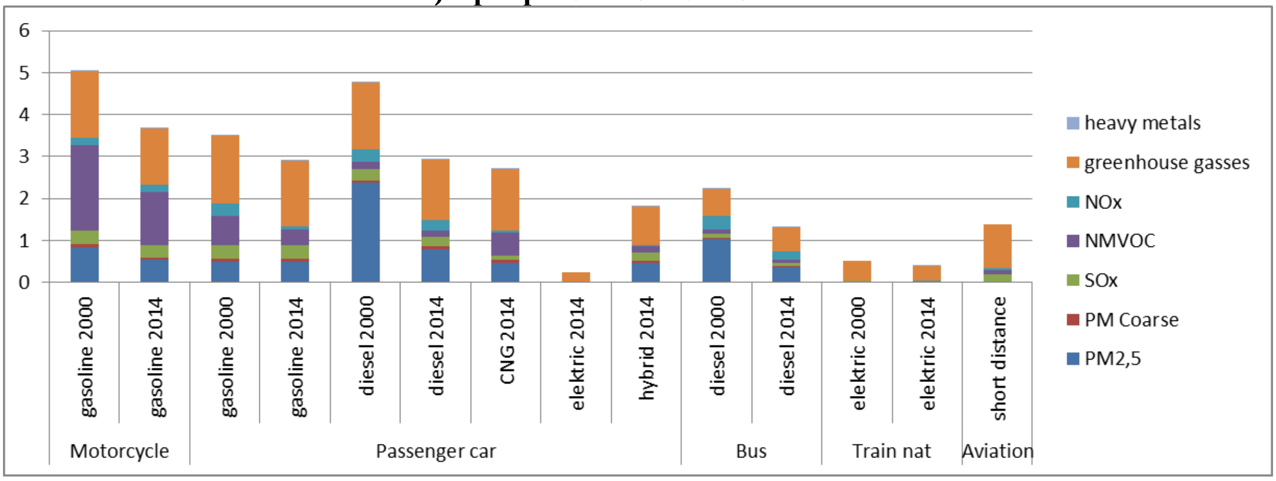
For freight transport, it is clear that road transport performs worse than rail, inland waterways and maritime transport (Figure 9 and Figure 10). There are two reasons for this. Firstly, congestion plays an important role in the external costs of road modes. This is not the case for the other modes. For heavy-duty vehicles the marginal external congestion costs represented 55 % to 64 % of the total external costs in 2014; in 2000 this was only one third. Secondly, the very low loading factors for road play a negative role in the comparison. The loading factor for road is below 50 %, whereas a loading factor of 71 % is assumed for inland waterways and maritime transport.

Per tonne-km the light-duty vehicle performs worst due to its low occupancy rate. For this mode, the decrease in accident and environmental costs is notable. This decrease dominates the increase in congestion costs. For heavy-duty vehicles between 3.5 and 12 t the marginal external costs increase due to the increase in congestion; for heavy-duty vehicles >12 t this increase is compensated by the improved environmental performance. The heavy-duty vehicle >12t and short-haul aviation have comparable marginal external costs. Aviation is outperformed by shipping. Electric rail has the lowest marginal external costs.

Figures 11 and 12 below focus on the different environmental costs of the different passenger and freight modes. Figure 11 shows the marginal environmental costs per pollutant for the year 2000 (when available) and 2014 for passenger transport. In absolute terms, the marginal environmental costs decreased for each vehicle type, inter alia, as a consequence of the stricter emission legislation for new vehicles. The fuel use and hence the CO_2 emissions also decreased for most vehicle types. This figure clearly shows the importance of the costs linked to greenhouse gases. Due to the relatively high valuation, they represent about half of the total environmental costs in most cases in 2014. In 2000, the diesel car had much higher environmental costs than the gasoline car. However, by 2014 this difference is almost non-existent. This is due to the very sharp decline in $PM_{2,5}$ emissions – a pollutant with a relatively high valuation. For gasoline cars, we mainly see a decrease of NMVOC. Note that CNG cars do not perform much better than the classical gasoline and diesel cars. For buses we see a strong improvement over time, in particular for $PM_{2,5}$. Per passenger-km the bus outperforms the passenger car – with the exception of the electric car.

Comparing the different modes, the motorcycle has the highest marginal external environmental cost per passenger-km in 2014. Next are the passenger cars using conventional fuels. Of the passenger cars using alternative fuels, the electric car performs better than all other modes. Aviation and buses have a similar level of environmental costs.

Figure 11: Marginal external environmental costs of passenger transport (euro per passenger-km) – per pollutant. Source: TML

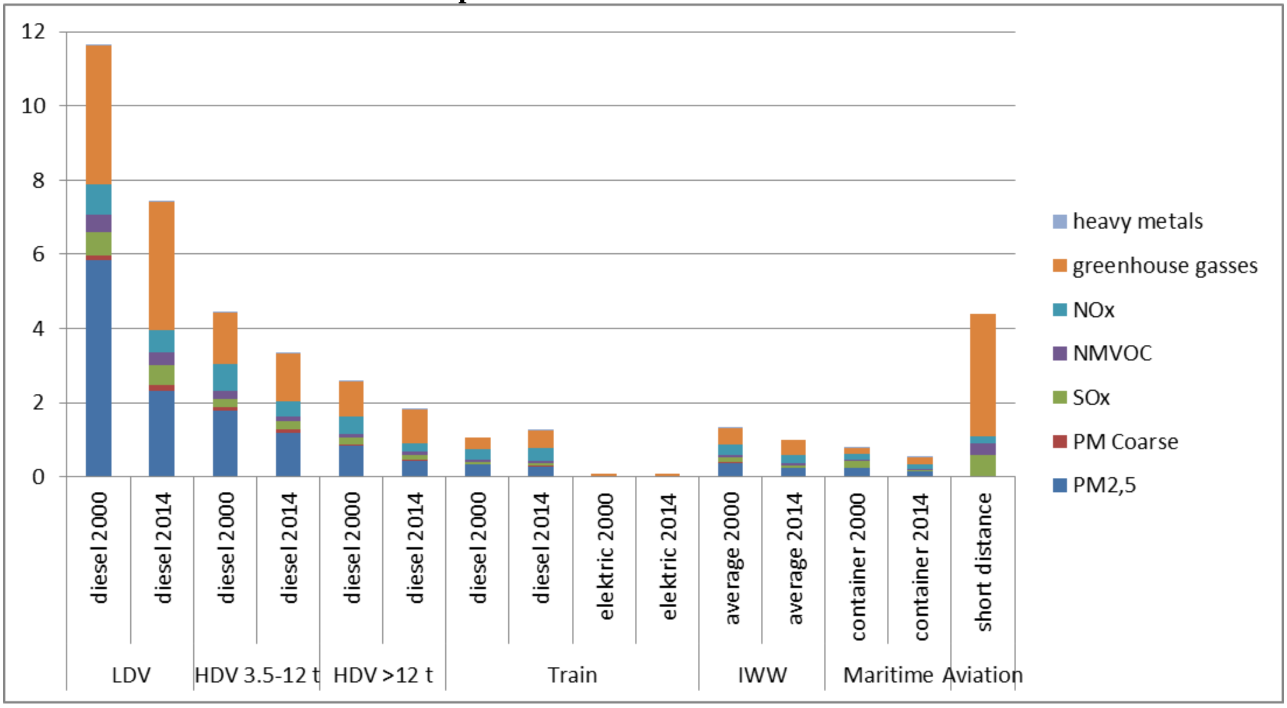


PM coarse= PM_{10}-$PM_{2,5}$

For freight transport, and especially for the non-road modes, the marginal environmental costs account for a much larger part of the total external costs. For most modes the marginal environmental costs decreased between 2000 and 2014. For freight transport using road and inland waterways, the most important pollutants are $PM_{2,5}$, CO_2 and NO_x . Due to the use of heavy maritime fuels, the emissions of SO_2 and $PM_{2,5}$ are the most important – especially in the earlier years, next to NO_x and CO_2 in maritime transport. In the valuation of the emissions of maritime transport, we did take into account that emissions on sea have a lower impact and hence lower damage costs. For aviation, the most important element is the emissions of greenhouse gasses.

In 2014, the electric train has the lowest marginal environmental costs, followed by shipping. The diesel train slightly outperforms the heaviest-duty truck and due to economies of scale the heavy-duty trucks outperform the light-duty trucks. Aviation scores better than light-duty trucks but worse than heavy-duty trucks.

Figure 12: Marginal external environmental costs of freight transport (euro per tonne-km) – per pollutant. Source: TML



PM coarse= PM_{10}-$PM_{2,5}$

8. <u>How are private costs and taxes calculated?</u>

Even today, the user already pays for the use of transport modes. Transport is not for free. There are costs for the user, the so-called private costs (such as the cost of a train or bus fee, fuel costs, vehicle purchase costs, insurance costs, etc.) and there are taxes and levies.

For *road transport* the costs are calculated in great detail, distinguishing between fuel costs, costs and subsidies when purchasing a vehicle (purchase costs, VAT and taxes), and yearly costs such as the road tax, maintenance, insurance and the Eurovignet (replaced by the kilometre charge in 2016). Figures 13, 14 and 15 below show the private costs distinguishing between net costs (purchase cost, maintenance, etc. including labour taxes) and taxes (including VAT).

It is clear that electric vehicles are still expensive. Disregarding this type of vehicles, we see that the user pays between 12 and 32 euros per 100 passenger kilometres. The purchase costs and the VAT have the largest share in the total costs a car user has to pay. The difference in purchase price per kilometre is mainly determined by the differences in the number of kilometres people drive with their car. On average, the absolute purchase costs are higher for diesel cars than for gasoline cars, but this is compensated by the fact that diesel cars drive more kilometres due to the lower fuel costs.

Riding a motorbike is more expensive than a car with a cost of about 71 euros per 100 kilometres. The tax level is about the same, but the purchase cost and insurances per kilometre are higher for the motorbike rider.

Taking into account the subsidies, the costs for buses is about -9.18 euros per 100 passenger kilometres. This indicates that buses are over-subsidised as the subsidies are higher than the costs.

For *rail* we calculated the costs in detail. Passenger transport via rail only pays 6 % VAT. The difference with the normal VAT rate of 21 % is considered to be an indirect subsidy and hence is added to the other subsidies. It is clear from this picture that rail is heavily subsidized.

Figure 13: Total price per passenger km in 2014, passenger modes, in constant prices euro$_{2015}$. Source: TML.

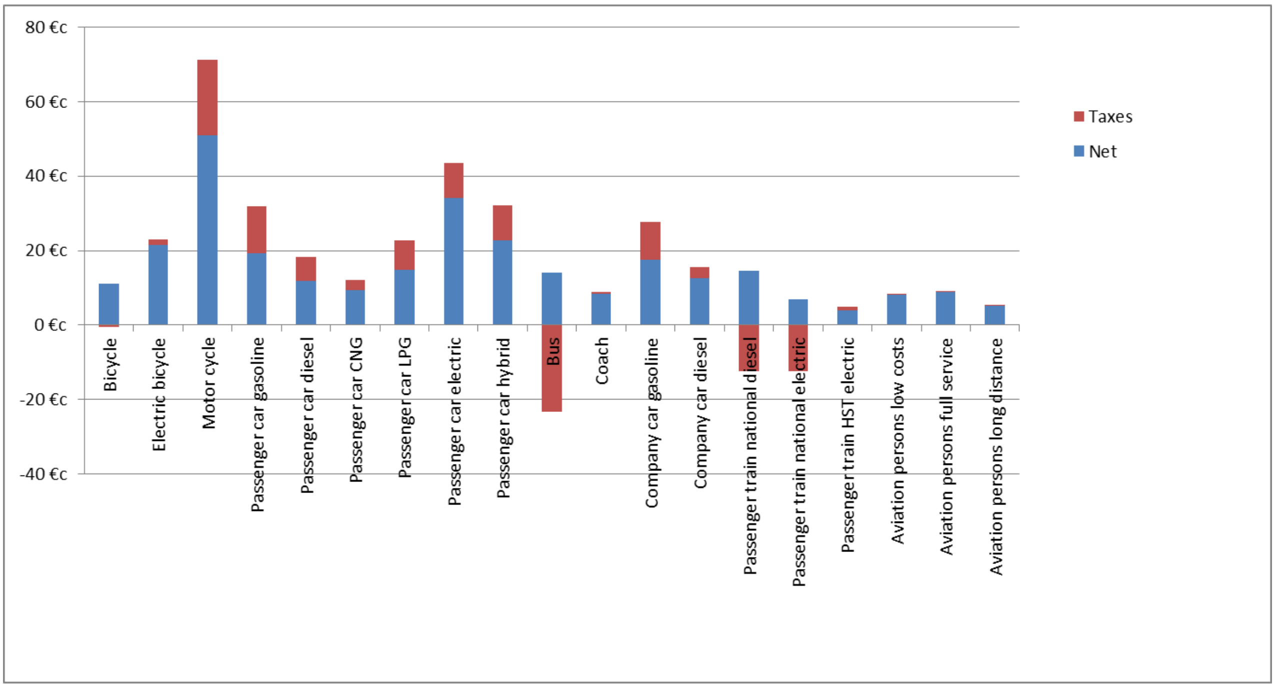


Figure 14 below shows the net costs (including labour taxes) and the transport taxes (including VAT) of freight transport per 100 tonne-km. In Figure 15, we zoom in on the same graph. The cost or road freight transport varies between 11 and 140 euros per 100 tonne-km. For road freight the most important cost element are the labour costs and labour taxes (varying from 37 % of total costs for the heaviest-duty vehicle and about 70 % for the light-duty vehicle). For freight transport the cheapest mode per tonne-km is maritime shipping (with the exception of RoRo), followed by the larger inland waterway vessels.

For *inland waterways* the costs for three types of vessels were calculated: “spits”, a “European Ship” and a large cargo ship. We distinguished between fixed costs (personnel costs, costs for maintenance and repair, etc.) and the variable costs such as energy and taxes. The most important costs for inland waterways are the fuel costs and the personnel costs.

For *maritime shipping* we distinguish between three types of vessels: RoRo, container and bulk. For the costs, we distinguish between personnel costs, insurance costs, maintenance and repair costs, port costs, fuel costs, etc. For maritime transport, we see more variation with respect to the most important cost categories. Important cost components are again the fuel costs, the capital costs (depreciation and interest costs) and the personnel cost.

For *aviation,* we distinguish between short and long hauls. With respect to the costs we distinguish between purchase/leasing cost, costs of air traffic control, take-off fees, passenger fees, maintenance, ground services, fuel costs and personnel costs.

Figure 14: Total price per tonne-km in 2014, freight modes, in constant prices euro$_{2015}$. Source: TML.

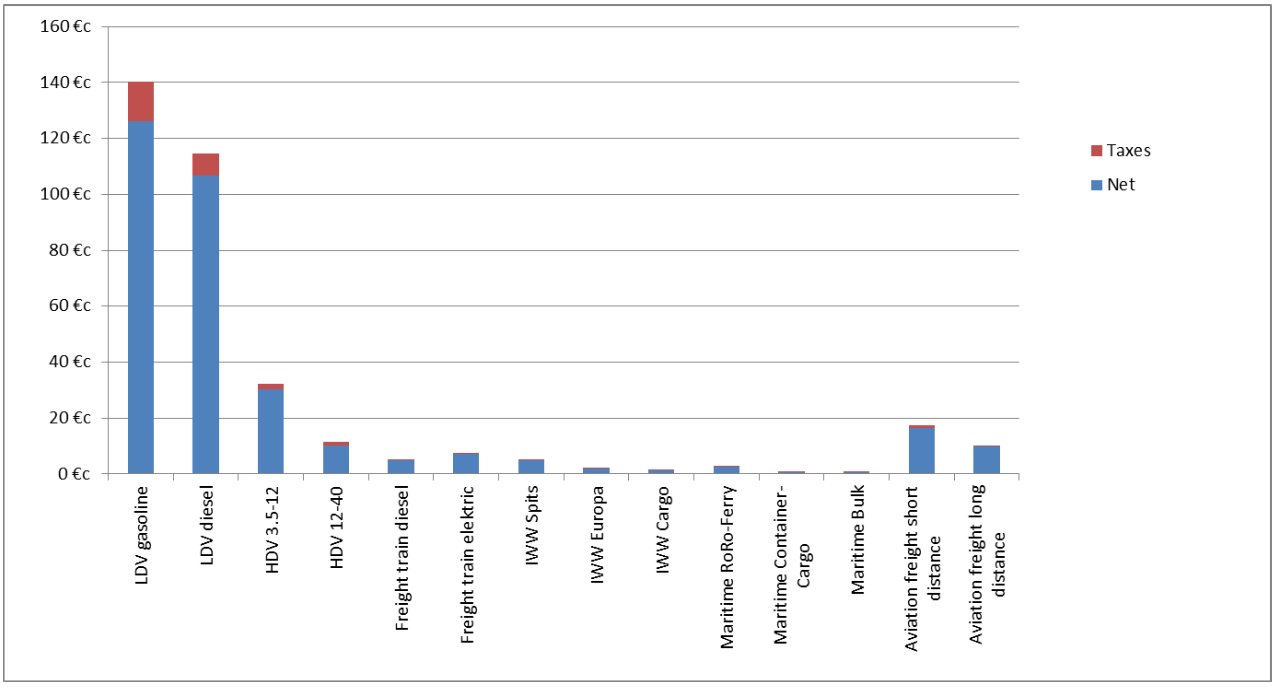
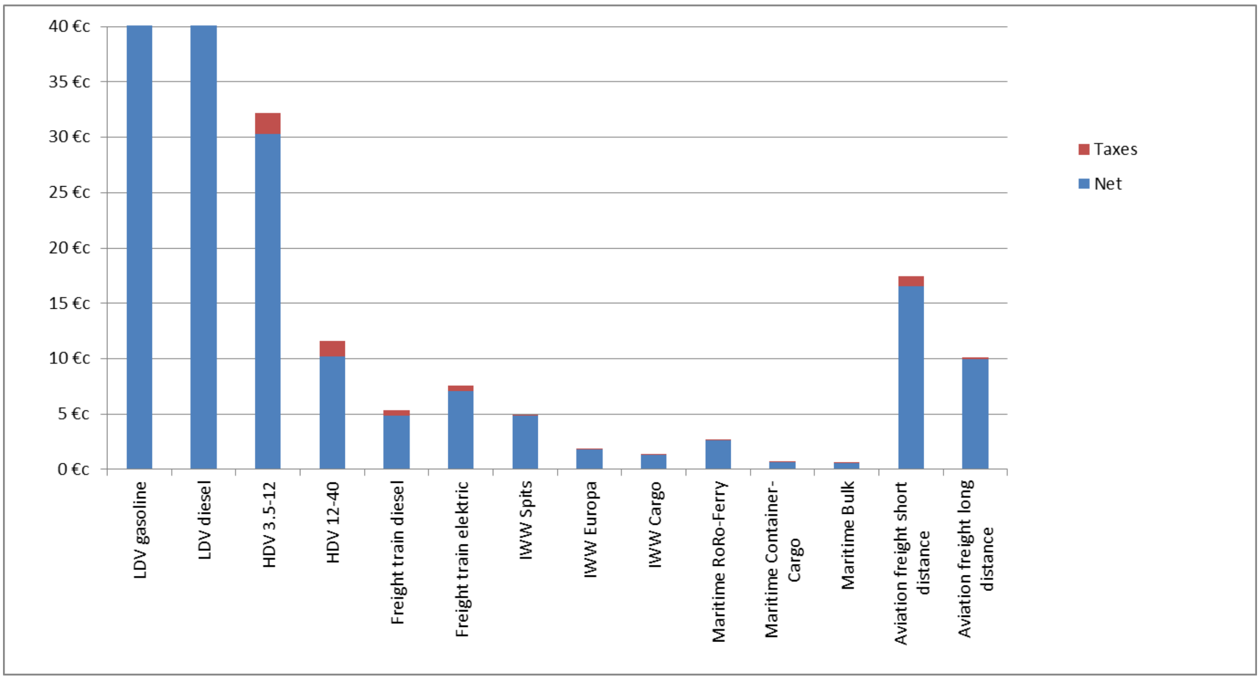


Figure 15: Total price per tonne-km in 2014, freight modes - zoom, in constant prices euro$_{2015}$. Source: TML.



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