CLEVER
Clean Vehicle Research

WP3

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Life Cycle Cost on current fiscal system
Task 3.1

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1. Introduction

Making a car purchase decision nowadays is very complex, especially when it comes to the evaluation of different alternative solutions. Besides the conventional diesel and petrol vehicles, vehicles with alternative fuels such as Liquefied Petroleum Gas (LPG), Compressed Natural Gas (CNG), bio-fuels, biogas and hydrogen or drive trains such as hybrid, fuel cell and battery Electric Vehicles (EVs) are ready to enter the market. The great challenge is if these "clean" vehicle technologies will be accepted by the larger public. In this respect, we analysed previously the process of car decision making in general, and the importance of the environmental awareness in the car purchase decision in specific. Financial factors, such as the purchase price and the operating cost turned out be the most important decision factors, while the environmentally friendliness was found the lowest rated issue in the purchase of a car. Regarding these findings, it is useful to compare these "clean" vehicle technologies mutually and with conventional petrol and diesel vehicles on the level of their cost-efficiency. This gives an indication of their market opportunities. The purchase of an "clean" car can become a rational economic decision if these cars provide lower or equal private consumer costs compared to the conventional petrol and diesel cars. For the society, the cars with the lowest societal costs will be of great importance since they will provide transportation technology at the lowest price. By adding the external costs to the lifecycle cost calculations, one can also draw conclusions about the tax structure related to cars in Belgium.

1.1 Scope of the work

The focus of this study is to compare vehicle technologies which are available at present or will be available soon on the Belgian market. The question is if alternative vehicle technologies can become an economically rational decision when purchasing a new car. Therefore, the life cycle cost methodology has been chosen to determine and quantify the cost of each vehicle technology. The first goal is to develop a life cycle cost model and to calculate the private consumer costs and the societal costs associated with the vehicle technologies. In a second part, sensitivity analysis will be carried out to allow the evaluation of the robustness of the methodology. Finally, the tax structure of cars in Belgium will be analyzed and a new fiscal system based on the environmental performance of cars will be elaborated.

2. Methodology

The private consumer costs can be divided into the following components:

- *The vehicle financial costs*
    - Purchase price (VAT incl.)
    - CO_2 support
    - Vehicle registration tax
    - Opportunity cost
    - Depreciation cost

- *The operation costs*
    - Fuel operation costs
        - Production cost
        - Excises
        - VAT
    - Non-fuel operation costs
        - Yearly taxation
        - Insurance
        - Technical control
        - Battery
        - Tyres
        - Maintenance

In the analysis, cars with the lowest private costs will be the most attractive for the consumers. Private consumer costs include all the costs related to purchasing and operating the car.

The societal life cycle cost can be divided into:

- *Private consumer costs (without taxes)*
- *The external costs*
    - CO_2
    - NO_X
    - SO_2
    - CO
    - CH_4
    - N_2O
    - PM

Since general taxes represent a transfer of funds rather than a cost, we removed all taxes in the societal life cycle cost calculations (Martin, 2005). Likewise, subsidies are included in the consumer private cost calculation, but left out in the societal calculation. Out of the societal cost analysis, cars with the lowest societal costs will be the most interesting for the society as those cars provide transportation at the lowest cost.

3. Parameter assumptions

Within the life cycle cost analysis, several parameters have to be defined. In this section, the main assumptions are briefly explained.

3.1 Definition of the functional unit

Out of work package 2.2, one can say that a functional unit is a quantified description of the performance of product systems, for use as a reference unit. It allows comparing two or several product systems on the basis of a common provided service. Within this study, the functional unit will be defined in such a way that all the life cycle phases of vehicles will be taken into account in the analysis and in the Belgian context. The functional unit is described in the following Table 1. It has been assumed that the vehicle lifetime is 13.7 years,, with an annual driving range of 15.000 km, so be it 205.500 km lifetime travel. As the Belgian consumer uses his car for on average 7 years before reselling it, a useful lifetime of 7 years will be assumed with a total travel distance of 105.000 km.

Table 1: Functional Unit

7	Year useful lifetime
15.000	Km travelled a year
105.000	Travel distance

Source: CLEVER – WP 2.2

3.2 Financial parameters

The financial parameters that will be taken into account can be divided into the vehicle initial financial costs and the operating costs related to the use of the car. Vehicle initial costs comprise the initial investment cost, and the vehicle registration tax. Operating costs are the future expenses related to the use of the car. Operating costs can be divided into the fuel operating costs and the non fuel operating costs (e.g. insurance, maintenance, technical control, yearly taxation). This kind of future costs can be divided into one-time future costs and recurring costs that occur every year. The battery replacement costs, and the tyre costs are examples of one-time costs. In order to accurately combine the initial expenses with the future costs, the present value of all expenses must be determined. Vehicle initial costs occur at the same time, so there is no need to calculate their present value. Their present value is equal to their actual cost. The operating costs are in contrast time dependent costs and their present value has to be calculated. The present value calculation makes use of a discount rate. The discount rate is *"the rate of interest the investor's time value of money"* (Life cycle cost analysis handbook, 1999). The discount rate can either be a real discount rate or a nominal discount rate. The real discount rate excludes the inflation rate, while the nominal discount rate includes it. It is recommended to use the real discount rate for life cycle costs analysis as this eliminates the complexity of accounting for inflation within the present value equation. The nominal interest rate is also known as the long-term interest rate on state bonds. During the last 10 years, this interest rate was on average 4,5% (De Tijd, 2008). Inflation is around 2%. This makes a real discount rate of 2,5%. The discounting of external costs is the subject of considerable debate. With a high discount rate, pollution will be less important in the future as it is today while a discount rate of 0% will give an equal importance to the pollution of today and tomorrow. Out of previous research (Turcksin et al., 2007), there seemed to be a heightened concern about the future climate change. That is why a zero discount rate for the external costs will be applied during the analysis.

To determine the present value of **future one-time costs**, the following formula is used (Life cycle cost analysis handbook, 1999):

$$\boxed{PV = A_t * \frac{1}{(1+I)^T}}$$

Where:

PV = Present Value
A_t = Amount of one-time cost at a time t
I = Real Discount Rate
T = Time (expressed in number of years)

To determine the present value of **future recurring costs**, the following formula is used (Life cycle cost analysis handbook, 1999):

$$\boxed{PV = A_0 * \frac{(1+I)^T - 1}{I*(1+I)^T}}$$

Where:

PV = Present Value
A_0 = Amount of recurring cost
I = Real Discount Rate
T = Time (expressed as number of years)

The lifecycle costs will be calculated in *three steps*:

1) Every stream of periodic costs is first analyzed
2) Calculation of the present value of the one-time and recurring costs
3) Division of the present value by the number of km during the vehicle lifetime in order to produce a cost per km.

3.3 Technology parameters

The following cars and vehicle technologies were included in the life cycle cost analysis:

Table 2: Overview of vehicle technologies

Small city car	*Small family car*	*Large family car*
Citroën C1 petrol (ICE)	Honda Civic petrol (ICE)	Toyota Avensis petrol (ICE)
Citroën C1 diesel (ICE)	Honda Civic LPG (retrofit)	Toyota Avensis diesel (ICE)
Citroën C1 LPG (retrofit)	Honda Civic CNG (retrofit)	Toyota Prius (HEV)
Citroën C1 CNG (retrofit)	Honda Civic IMA (HEV)	Saab 9-5 Estate petrol
Citroën C1 bio-diesel (ICE)	Toyota Corolla petrol (ICE)	Saab 9-5 Estate BioPower
Citroën C1 bio-ethanol (ICE)	Toyota Corolla diesel (ICE)	Saab 9-5 Estate diesel
Peugeot 106 Electric	Toyota Prius (HEV)	
Reva city car Electric		

Source: own set-up

The chosen vehicle technologies are the so-called "near-term" technologies because there are already available on the Belgian market. Therefore, the fuel cell and hydrogen vehicles are not included in this study. Within a certain class, the different models were chosen based on their performance, measured by their acceleration time from 0 till 100 km/hour. Two types of hybrid cars were included. The Honda Civic IMA is a midsized serial hybrid car, which is regarded as being the alternative counterpart to the Honda Civic petrol. Series hybrid cars are tend to be more expensive since they require not only an full-sized electric motor, but also an internal combustion engine and a generator (Lipman and Delucchi, 2006). The parallel hybrid Toyota Prius is somewhat more difficult to classify, as it is rather to be positioned between the Corolla (midsized car) and the next-higher model Toyota Avensis (large family car). Therefore, the Toyota Corolla as well as the Toyota Avensis were included in the analysis. We assume that the battery of the Prius lasts the lifetime of the vehicle. Maintenance costs of hybrid cars are estimated to be the same as for conventional petrol cars (Martin, 2005). The Peugeot 106 electric and the Reva are being introduced as the electric counterparts of the Citroën C1. As the Peugeot 106 is not available on the Belgian market anymore, the prices are for the model of 1998. The electric car has a Nickel-Cadmium battery which is to be leased at 1122€/year (Funk and Rabl, 1999). Nickel-Cadmium batteries have a long live span and are characterized by their high battery cost (Emis-Vito, 2007). We assume that the batteries of the Peugeot have to be replaced after 5 years of car use. The Reva is a small city car, especially designed for low speed, congested, urban conditions. It has a speed up to 80 km/hour and a driving range up to 80 km (Reva, 2008). The power pack of the Reva consists of eight 6-Volt EV lead acid batteries, which have to be replaced every 3 years. The battery replacements costs are on average 1080€. This battery pack has to be replaced every 3 years. This relative low battery cost compared to the Peugeot 106 is due to the fact that the Reva is a so-called "neighbourhood electric vehicle" (NEV). A NEV has a smaller battery, and a very short driving range (Delucchi and Lipman, 2001). The LPG Citroën C1 and Honda Civic are retrofitted conventional petrol cars with a surplus cost of 2000€. The retrofitted CNG Citroën C1 and Honda Civic have a surplus cost of 2500€ compared to their comparable petrol car (Emis- Vito, 2007). The bio-diesel Citroën C1 is a converted conventional car that can drive on 100% pure bio-diesel. The conversion costs are estimated to be around 250€. The surplus cost for the Citroën C1 bio-ethanol car is derived from the surplus cost of the Saab 9-5 Estate BioPower, currently the best selling Flexi Fuel Vehicle (FFV) on the Belgian market. This flexi-fuel car has a surplus cost of 1000€ compared to the conventional petrol car and drives on 85% bio-ethanol and 15% petrol (E85). Moreover, insurance costs of FFVs are 7% more expensive than the conventional petrol car. Currently, there are no cars on the Belgian market that drive purely on bio-ethanol. Finally, the Saab 9-5 Estate diesel is equipped with a standard particulate filter.

In order to compare the vehicle technologies more properly, it is convenient to compare the energy consumption (in Mj/km) of the different technologies compared to the conventional petrol car. The energy consumption of the petrol car will be thereby set at 100%. Table 3 shows the energy consumption assumptions that will be respected throughout the analysis.

Table 3: Energy consumption assumptions

Technology	***Energy consumption (MJ/km)***
Baseline petrol	100%
Diesel	77%
LPG	127%
CNG	111%
Bio-Ethanol	140%
Bio-Diesel	87%
Hybrid Electric Vehicle Petrol	67%

Source: Martin (2005); Emis- Vito (2007)

According to the used vehicle technologies, different depreciation rates will be established. Loss of value due to depreciation is in the first few years of a vehicle's life a very critical cost parameter. The depreciation rate vary not only along the used fuel or drive train, but also according to the brand image, the new model pricing, the mileage range, comfort and convenience features and the vehicle class (Spitzley, 2005). The depreciation rates, established in table 4 are based upon the used fuels and drive trains. The impact of other depreciation rates will be investigated in section 6: sensitivity analysis.

Table 4: Depreciation rate assumptions

Fuel/ Drive train	***Depreciation rate (in %)***
Petrol	79%
Diesel	74%
Bio-Ethanol	79,4%
Bio-Diesel	79,04%
LPG	82,4%
CNG	83,11%
BEV/HEV	84%

Source: BIM-IBGE (2001)

3.3. External cost parameters

In order to calculate the external costs related to the vehicle technologies, the external costs which are included in the Ecoscore methodology, will be taken into account. The Ecoscore includes several damage categories like: global warming, human health impairing effects and harmful effects on ecosystems. The methodology is based on a well to wheel approach. Next to the direct tailpipe emissions (Tank-to-Wheel), the indirect emissions (Well-to-Tank), due to the production and the distribution of the fuel, are taken into account as well. This approach allows comparing different fuel (petrol, diesel, LPG, CNG, bio-fuels,…) and drive train technologies (internal combustion engines, hybrid electric drive trains, battery electric drive trains,…). Emissions resulting from the vehicle assembly and from the production of its constituting components are not taken into account. Nor are the maintenance phase and recycling phase of end-of-life vehicles. Table 5 shows an overview of the parameters used for the Ecoscore methodology. The different damage categories are given, with their contribution to the end score, their different contributing pollutants and their damage factors (Timmermans et al, 2006).

Table 5: Summary of the parameters used for the Ecoscore methodology

Classification	**Weighting**	**Inventory**	**units**	**Characterisation**	
	α			***rural***	***Urban***
1) Global Warming	50%	CO_2	GWP	1	1
		CH_4	GWP	23	23
		N_2O	GWP	296	296
2) Air Quality	(40%)				
2a)Human Health	20%	KWS	€/kg	3	3
		CO	€/kg	0.0008	0.0032
		PM10	€/kg	103.49	418.61
		NO_X	€/kg	1.152	1.483
		SO_2	€/kg	6.267	14.788
2b) Ecosystems	20%	NO_X	€/kg	0.176	0.176
		SO_2	€/kg	0.113	0.113
3) Noise	10%	Sound level	dB(A)	x-40	

Source: Timmermans et al. (2006)

The environmental impact of the considered vehicles is based on information provided by the Ecoscore website. Table 6 summarizes those environmental parameters which will be taken into account for the societal life cycle cost calculation. The specification of the amount of the emissions is therefore necessary.

Table 6: Summary of the parameters used for the societal cost calculation

(g/km)	*CO2*	*HC*	*NOX*	*SO2*	*CO*	*CH4*	*N2O*	*PM*	*Noise*
C1 P	109	0.050	0.010	0.003	0.370	0.020	0.005	0.000	70
C1 D	109	0.280	0.240	0.003	0.180	0.010	0.008	0.011	71
106 EV	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	74
Civic P	139	0.043	0.011	0.004	0.300	0.020	0.005	0.000	70
Civic HEV	109	0.055	0.012	0.003	0.190	0.020	0.005	0.000	68
Corolla P	167	0.040	0.010	0.005	0.550	0.020	0.005	0.000	73
Corolla D	150	0.220	0.200	0.005	0.280	0.010	0.008	0.020	73
Avensis P	187	0.040	0.030	0.005	0.450	0.020	0.005	0.000	71
Avensis D	156	0.000	0.240	0.005	0.020	0.010	0.008	0.020	72
Prius	104	0.020	0.010	0.003	0.180	0.020	0.005	0.000	69
9-5 Estate P	220	0.060	0.010	0.007	0.460	0.020	0.005	0.000	72
9-5 Estate D	184	0.200	0.175	0.006	0.201	0.010	0.008	0.001	73
9-5 Biopower	191	0.036	0.014	0.008	0.449	0.020	0.005	0.000	69

Source: Ecoscore website (2008)

In order to calculate the total external costs, one has to multiply the quantity of the emissions with the monetary valuation of the pollutants. Table 7 presents the monetary valuation of the environmental parameters used for the Ecoscore methodology. For the convenience, the external cost of CO_2 is set at 0.000025 €/g. This is the recommended value for the external costs of climate change, expressed as a central value between lower and upper values for the year 2010 (Maibach et al., 2007). Congestion cost, accident costs and noise costs are not taken into account as they are supposed to be the same for all vehicle technologies and make thereby no difference in the final societal cost calculation. Though, one has to note that the lower noise could be an advantage or an external benefit for the electric vehicles (Funk and Rabl, 1999).

Table 7: Monetary valuation of the pollutants (in €/g)

Pollutants	*Monetary valuation (in €/g)*
CO2	0,000025
CH4	0,000575
N2O	0,0074
CO	0,0000032
PM10	0,41816
SO2	0,014921
NOX	0,001659

Source: Maibach et al.,(2007), Timmermans et al., (2006)

4. Situation in Belgium

The analysis is based upon the current fiscal system in Belgium.

4.1 Tax system in Belgium

The Belgian fiscal system related to cars can be divided into three parts:

1) Taxes related to the purchase of the car
2) Taxes related to the possession of the car
3) Taxes related to the use of the car

4.1.1 Taxes related to the purchase of the car

When purchasing a car in Belgium, the following taxes and reductions occur:

- VAT of 21% on the purchase price
- Vehicle registration tax, based on power of the car (fiscal horsepower, kilowatts)
- Reduction of 298 € of the vehicle registration tax for LPG and CNG vehicles
- Reduction of the vehicle registration tax related to the age of the car (2nd hand cars)
- Reduction of the purchase price for vehicles with low CO_2 emissions
- Reduction of the purchase price for diesel vehicles, standard equipped with a particulate filter

Since the first of July 2007, the reduction of the purchase price for low CO_2-emitting vehicles will be received immediately when purchasing the car. The dealer will calculate the discount based on the purchase price of the car (VAT incl.) by the following rules (FOD Financiën, 2007):

- CO_2 levels between 105 g/km and 115 g/km: The purchase price will be reduced with 3% (VAT incl.), with a maximum of 800 Euro (indexed amount in 2007)
- CO_2 levels lower than 105 g/km: The purchase price will be reduced with 15% (VAT incl.), with a maximum of 4270 Euro (indexed amount in 2007).

The purchase price of a diesel vehicle, standard equipped with a particulate filter, can be obtained in the same way as the reduction for low CO_2 emissions. The dealer will reduce the purchase price (VAT incl.) with a maximum of 200 € (indexed amount in 2007) when (FOD Financiën, 2007):

- CO_2 level is lower than 130 g/km
- PM level is lower than 5 mg/km

4.1.2 Taxes related to the possession of the car

When possessing a car in Belgium, the following taxes occur:

- Yearly circulation tax, based on the power of the car (fiscal horsepower, cc)
- Compensating circulation tax for LPG and CNG cars
- Excise compensating tax for diesel cars (abolished 1st of January, 2008)

4.1.3 Taxes related to the use of the car

When using a car in Belgium, a lot of fuel costs will occur. The fuel taxation system in Belgium is quite complex. The composition of the maximum fuel price in Belgium consists of (Belgische Petroleumfederatie, 2007):

- Price ex-refinery
- Distribution range
- Contribution to APETRA (Agence PETRolière – PETRoleumAgentschap)
- Contribution BOFAS (Soil rationalization fund for filling stations)
- Excises and energy contribution
- VAT (21%)

In the life cycle cost analysis, the average maximum fuel prices of the month December 2007 will be applied:

Table 8: The applied fuel prices

(€/l)	*Petrol*	*Diesel*	*Bio-E*	*Bio-D*	*LPG*	*CNG*	*Electricity*
VAT	0.26	0.21	0.26	0.21	0.11	0.10	0.02
Excises	0.59	0.33	0.59	0.33	0.00	0.00	0.00
Fuel Price	1.48	1.18	1.50	1.19	0.62	0.59 (€/m^3)	0.10 (€/kWh; nightrate)

Source: De Belgische petroleumfederatie (2007); Stroomtarieven.be (2007); Personal communication Bioro en Alco bio-fuel (2007)

In the analysis, the excises for bio-diesel and bio-ethanol are set equal to the excises of respectively diesel and petrol. This results into higher fuel costs for the bio-fuels, taken into account their higher production cost. At this moment, Total is the only Belgian filling station that provides diesel with a mix of 5% FAME (pure bio-diesel). Pure biodiesel (100%) is not provided by the normal filling pumps. Nor is bio-ethanol currently available. The fuel prices are derived from the production costs, provided by Alco biofuel and Bioro a bio-ethanol and bio-diesel refinery in Belgium.

5. Results

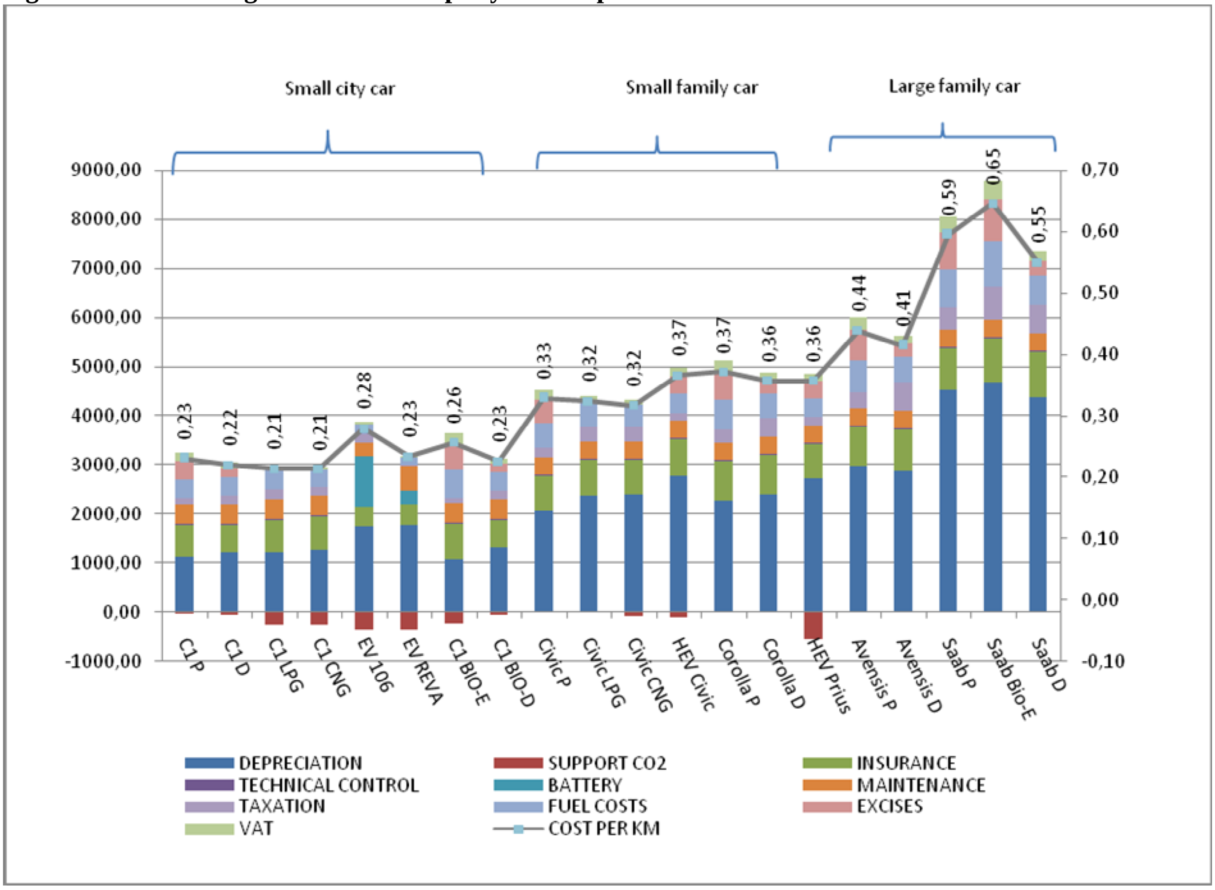
This section presents the results under the standard parameter assumptions from sections 3 and 4. The impact of different assumptions will be discussed in section 6: sensitivity analysis. The results are presented in absolute as well as in relative terms. The vehicle data, used for the cost calculations, are presented in Annex A.

5.1 Absolute lifecycle costs

5.1.1 Private consumer costs

Figure 1 shows the private average consumer costs per year and per kilometre for the different vehicle technologies. These costs depend on the amount of yearly covered kilometres. The results are displayed for the scenario of 15.000 kilometres covered on a yearly basis.

Figure 1: Total average consumer cost per year and per kilometre



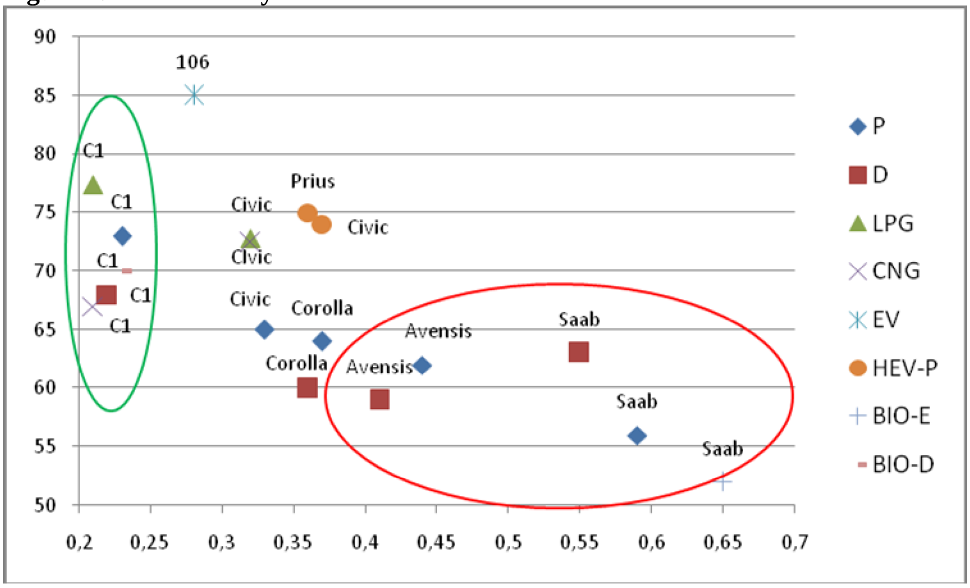
Source: own set-up

The large dispersal of the results in Figure 1 is very striking: a vehicle can have a yearly cost from 3.000 up to 9.000 Euro with a private cost per km that can vary from 0,21 Euro (small city car) up to 0,65 Euro (large family car).

The prices of diesel and petrol have been increasing steadily during the last couple of years and make environmentally friendly alternatives more and more attractive. The retrofitted LPG and CNG cars seem to have lower private costs compared to their conventional counterparts. The high purchase price (due to small-scale production) and the high battery price still keep the price of the electric Peugeot 106 high, especially at a limited yearly distance. The Reva can have an attractive cost per kilometre of 0.23 € if the CO_2 reduction of the purchase price is granted. However, this is currently not the case as the Reva is classified as a quadricycle. Without reduction, the Reva will have a private consumer cost of 0.26 € per kilometre. For bio-fuels, and especially bio-ethanol, the imposed excises will determine whether or not they can be an attractive alternative. The excises and the VAT on the fuels are displayed separately, so that the influence on the total yearly cost can be seen. This analysis shows that the government has the possibility to make bio-fuels more attractive by adapting the excises. Furthermore, the reduction on the purchase price for vehicles with low CO_2 emissions favours hybrid vehicles (especially the Toyota Prius) and small city cars. The hybrid Prius has an attractive private cost, even when it is classified as a small family car. The hybrid Honda Civic is less attractive because of its higher initial costs (purchase price).

Figure 2 shows a combination of the Ecoscore and the private cost analysis. Within this figure, the balance between cost and environmental friendliness can be assessed. This approach is also known as the eco-efficiency..

Figure 2: Eco-efficiency



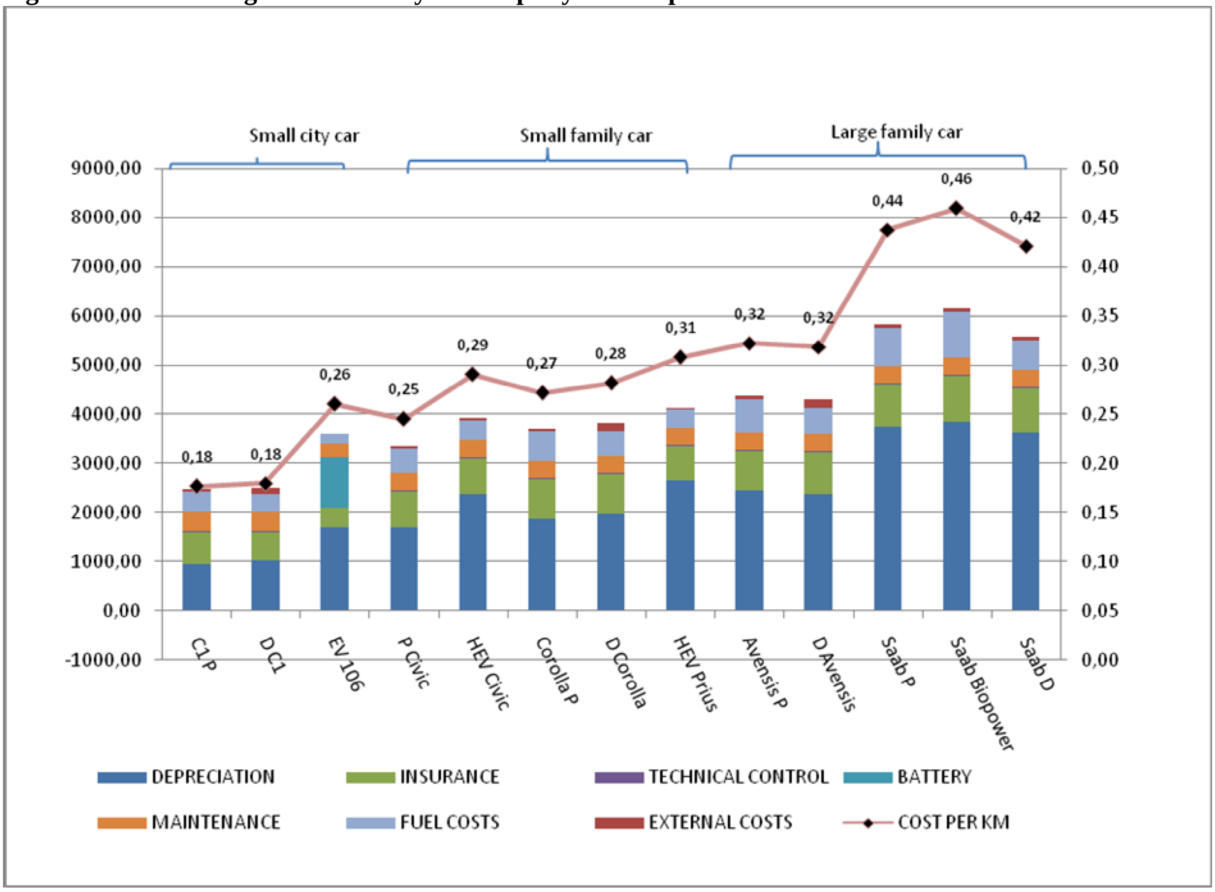
Source: own set-up

Figure 2 shows on the horizontal axis the cost per kilometre and on the vertical axis the Ecoscore. The small city cars are clearly situated in a low cost-environment friendly region (indicated in green).Although the battery electric vehicle has an attractive Ecoscore, the high purchase price (because of the small scale production) and the expensive battery replacement still keep the price per kilometre of the electric car high, especially when driving a limited yearly distance. Within the segment of the small family cars, the LPG and CNG Honda Civic have a good Ecoscore and are cheaper than their conventional counterparts. The hybrid version of the Honda Civic has a very attractive Ecoscore, but the cost per kilometre remains somewhat high because of its higher purchase price. The Prius has in contrast an attractive cost per kilometre and is cheaper than the Toyota Corolla and the Toyota Avensis. The large family cars Toyota Avensis and Saab 9-5 Estate have a low Ecoscore and a high cost per kilometre and are thereby classified into the expensive and not environment friendly region (indicated in red).

5.1.2 Societal lifecycle costs

Figure 3 shows the societal lifecycle costs per year and per kilometre for the different vehicle technologies. The results are displayed for the scenario of 15.000 kilometres covered on a yearly basis. As there are no emission date available for the Reva and the LPG, CNG and bio-fuel cars, the results cover especially the petrol, diesel and hybrid cars. The societal lifecycle costs comprise the private consumer costs without taxes and subsidies (VAT on purchase price, vehicle registration tax, vehicle circulation tax, excises and VAT on fuel and reduction purchase price for low CO_2 emissions and particulate filter) and the external costs. For the external cost calculation, a discount rate of 0% was assumed as the pollution of today and tomorrow are of equal importance.

Figure 3: Total average societal lifecycle cost per year and per kilometre



Source: own set-up

Figure 3 shows that small city cars represent the lowest costs for the society while small family cars and especially large family cars represent the highest transportation costs. Within the small city car segment, the C1 petrol and diesel show similar societal costs. The diesel car has a higher fuel efficiency, but the pollution costs are slightly higher because of higher PM and NO_x emissions. Lifecycle costs are again very high for the electric Peugeot. The low fuel costs and pollution costs can not counterbalance the high purchase price and battery cost. The hybrid Honda Civic displays a high societal cost, compared to the conventional counterparts. The higher efficiency and somewhat lower pollution costs are not able to compensate its high purchase price. The same is true for the Prius, which has a high societal cost compared to the small family cars, but an attractive cost compared to the large family cars. So, one could say that there is no real societal cost advantage for hybrid cars. The CO_2 reduction on the purchase price is thereby necessary to make these cars more attractive for the larger public. In absolute terms, the Saab Bio-Power represents the largest societal cost. Although it has a low pollution cost, its lower fuel efficiency combined with the high ex-refinery price of bio-ethanol makes it a car with a high cost for the society.

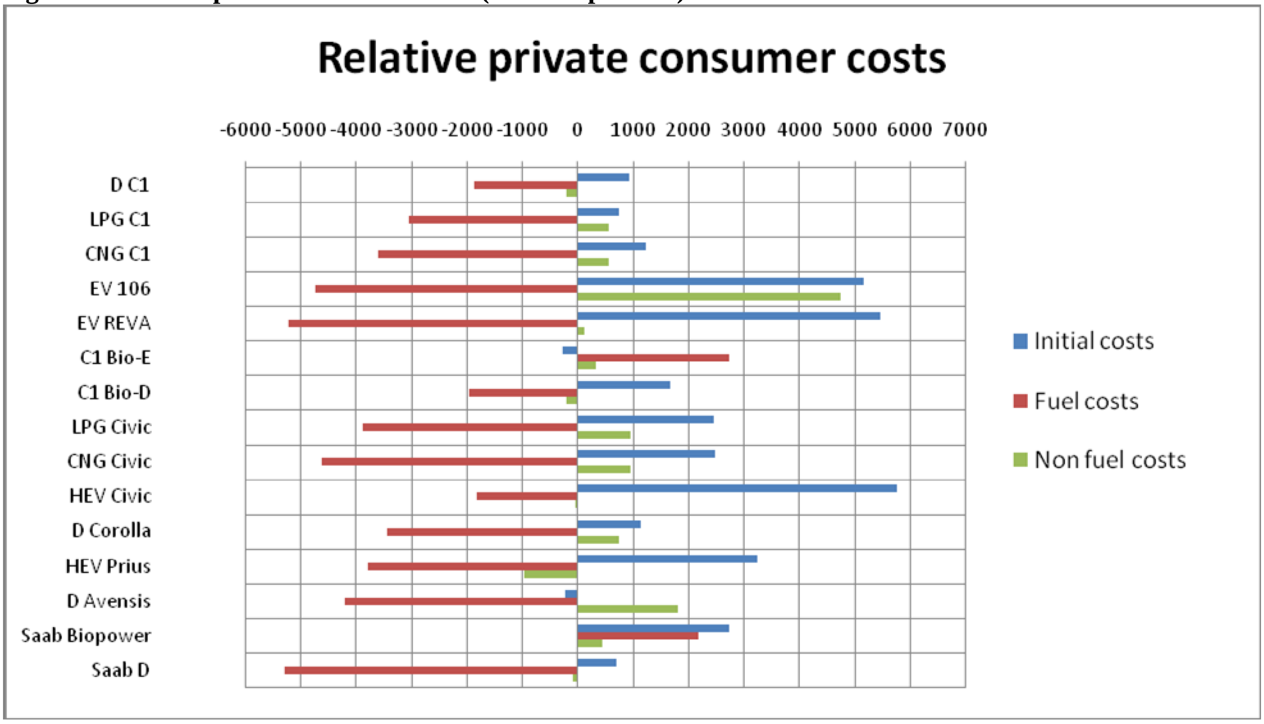
5.2 Relative lifecycle costs

In this section, the relative lifecycle costs are represented under the standard assumptions, made in sections 3 and 4. By presenting the results relative to the baseline petrol car of each car segment, differences can be analyzed and conclusions can be drawn.

5.2.1 Relative private consumer costs

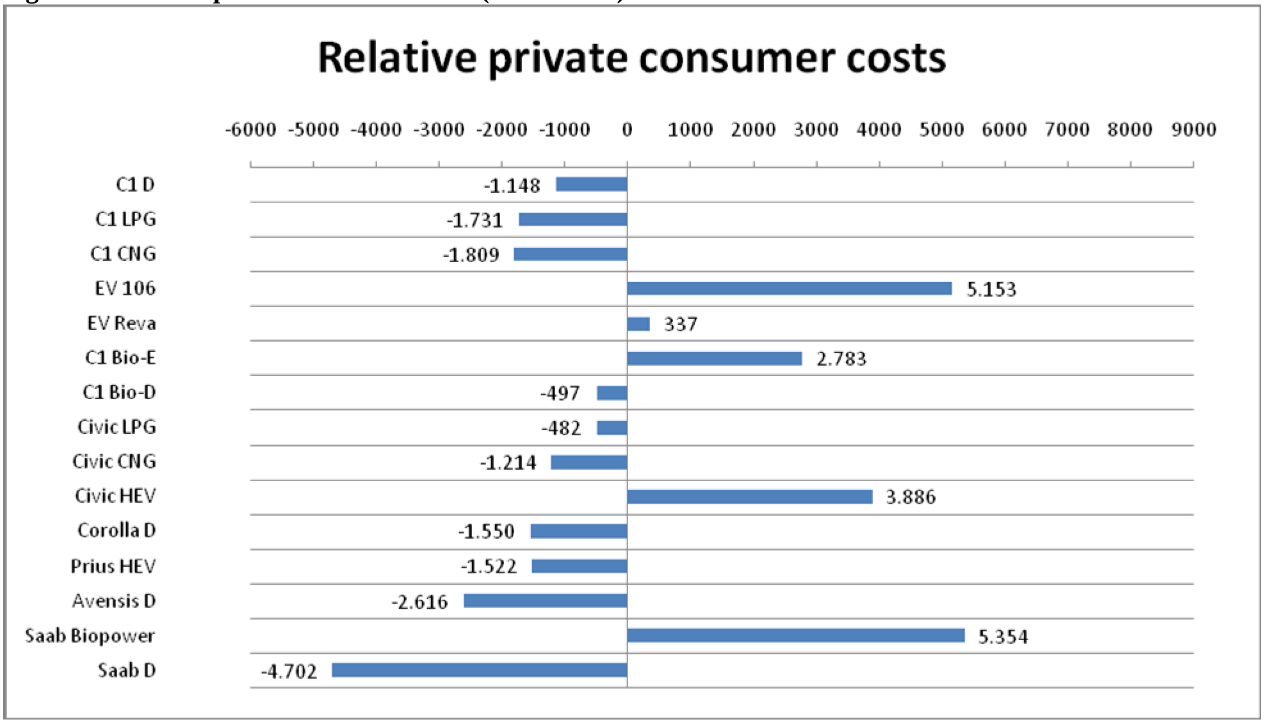
Figures 5 and 6 show the results of the relative private consumer costs. The lifecycle costs of each car is calculated relative to the baseline petrol car of each car segment. The lifecycle costs of the Toyota Prius were compared to the Toyota Corolla petrol. In Annex B, the relative private consumer costs of each car segment can be found. This allows comparing the Prius to the Corolla as well as to the Avensis. Figure 5 presents the relative results, divided in the three main cost components of a car, namely the vehicle financial costs, the operating fuel costs and the operating non fuel costs. For a thorough overview of these cost components, see section 2. Figure 6 presents the sum of the cost.

Figure 5: Relative private consumer costs (cost components)



Source: Own set-up

Figure 6: Relative private consumer costs (sum of cost)



Source: own set-up

Out of these calculations, one can see again that the retrofitted LPG and CNG cars represent low private costs and are attractive for the consumer. This lower private costs can be explained by the low fuel price at the filling station. This low fuel price results out of the low production cost and the exemption of excises on these fuels. The electric Peugeot seems to have large costs (+ 5100 €) compared to the baseline car, especially due to the high initial costs and the high non fuel operating costs (battery replacement). The Reva looks a bit more attractive. However, this is only the case where the Reva receives the CO_2 reduction. Otherwise, the Reva would have a surplus cost of 2940 €. Overall, it seems that the battery cost and the high initial costs are the most important parameters within the electric car cost analysis. The bio-ethanol C1 and Saab Biopower represent high surplus costs of respectively 2780 and 5350 €. This is totally due to the high ex-refinery price of bio-ethanol, the higher energy consumption (see also table 3) and the high excises on petrol. Bio-ethanol could thus be stimulated by exempting the excises and thereby delivering a fuel advantage. The bio-diesel C1 is in contrast more attractive, due to its lower energy consumption compared to the petrol C1, combined with the lower fuel price because of the lower excises on diesel. Under the current tax system, the hybrid Prius is very attractive for the consumer, even when it is compared to the Toyota Corolla. Its attractiveness results mainly from its low fuel consumption compared to the conventional Corolla petrol. The hybrid Civic has in contrast a surplus cost of 3880 €. This may be explained by its very high initial costs (high purchase price). Finally, it seems that diesel cars are attractive for the consumer at a yearly coverage of 15000 kms. The impact of the yearly coverage on the private consumer costs will be investigated in section 6: sensitivity analysis.

5.2.2 Relative societal costs

Figures 7 and 8 show the results of the societal costs relative to the baseline petrol car. The societal lifecycle costs comprise the private consumer costs without taxes and subsidies and the external costs. The relative societal costs are only presented for the cars of which the external costs are known. The relative external costs are represented in figure 9. A discount rate of 0% was assumed since the pollution of today and tomorrow are of equal importance. An overview of the relative societal costs of the different car segments can be found in Annex C.

Figure 7: Relative societal costs (cost components)

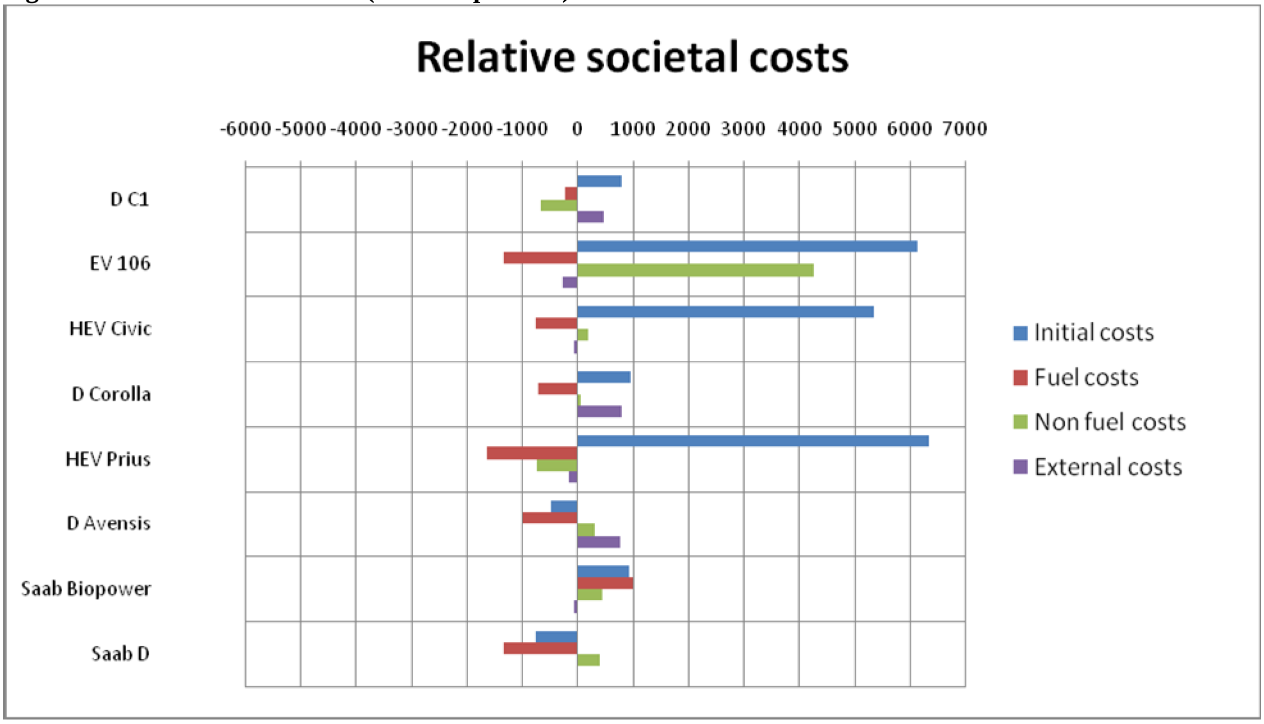


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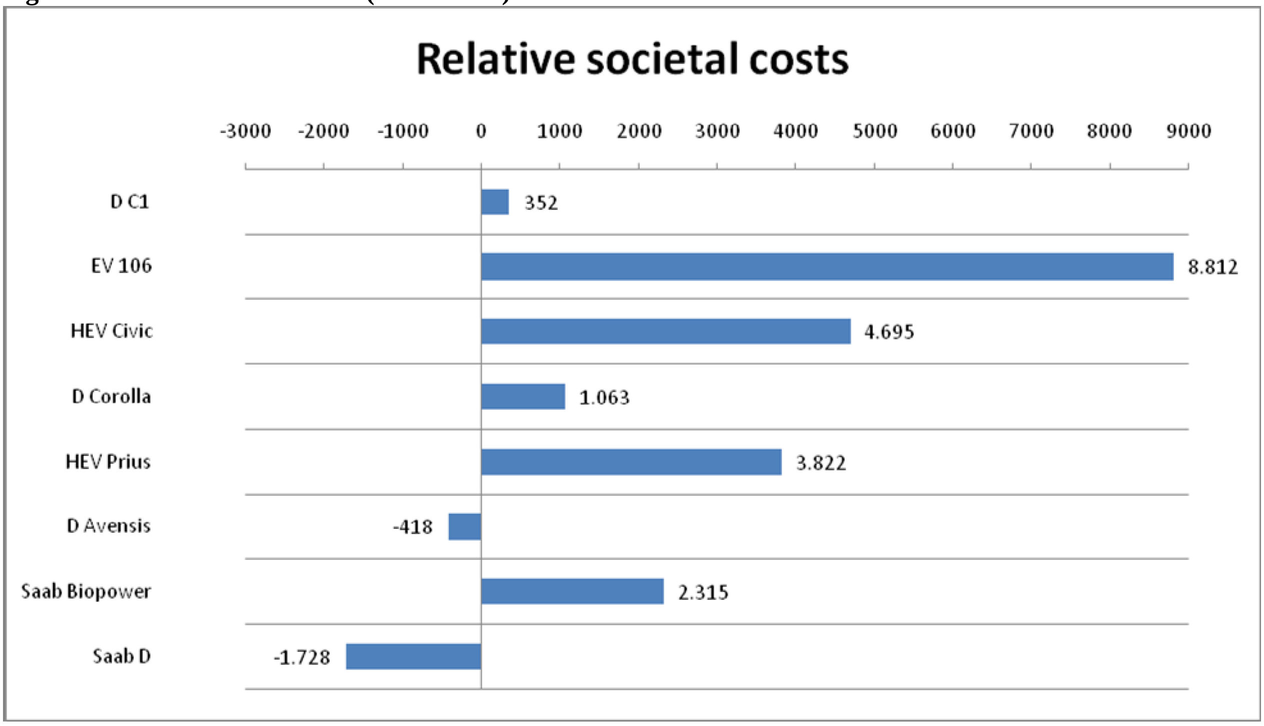
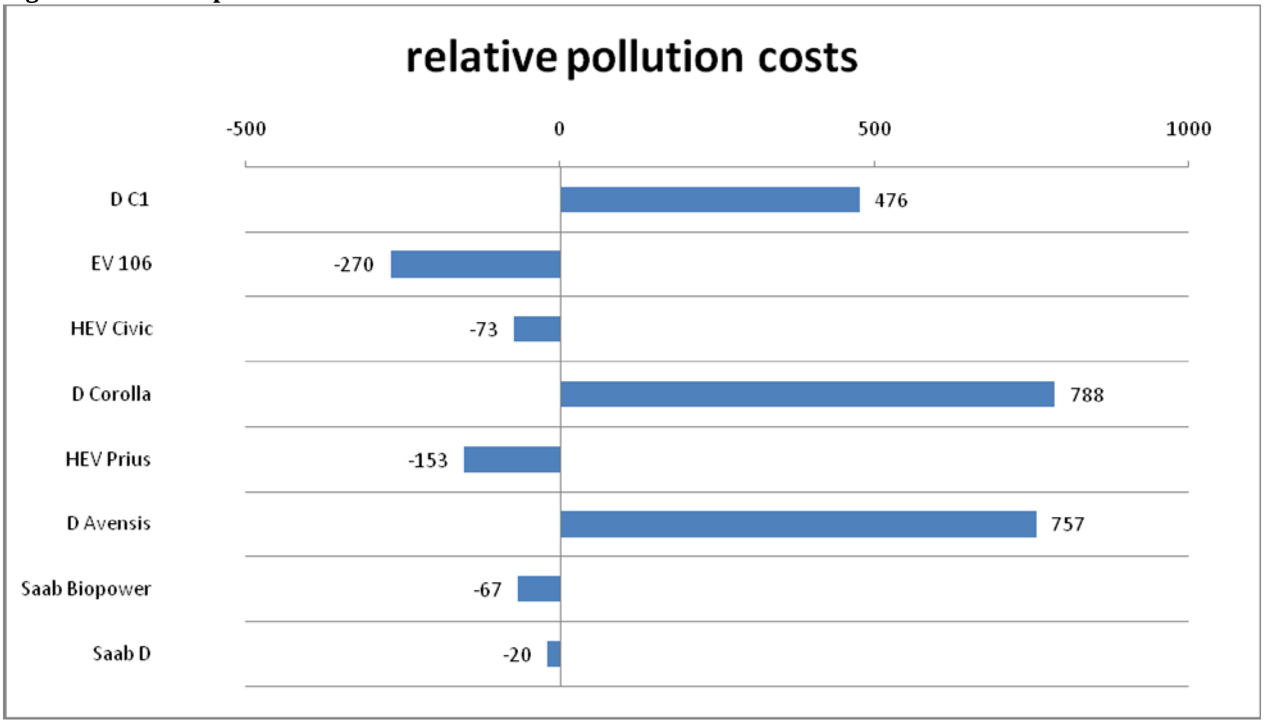
Figure 8: Relative societal costs (sum of cost)



Source: own set-up

Within this calculation, it seems that the electric and hybrid electric technology provide the highest societal lifecycle costs. This confirms the results out of section 5.1.2 that revealed no societal lifecycle cost advantage for (hybrid) electric cars. The costs of these cars are higher compared to the conventional counterparts. For (hybrid) electric cars, the energy efficiency is higher, so the cost advantage may increase with higher crude oil prices and a higher valuation of the pollution costs. For a hybrid car to be competitive in terms of cost, the fuel savings and the damage cost reduction must compensate the higher initial costs of the car. The results show also that the societal lifecycle cost of bio-ethanol cars are higher compared to the baseline petrol car. This is again due to the high ex-refinery price, combined with the higher fuel consumption. The speed of the biofuel expansion may be questioned as long as its refinery price is higher than the price of petrol. Finally, it seems that in general diesel cars have more or less equivalent societal costs compared to the petrol cars. The higher fuel efficiency of diesel cars is often offset by their higher pollution costs, except in the case where they are equipped with a particulate filter (Saab).

Figure 9: Relative pollution costs

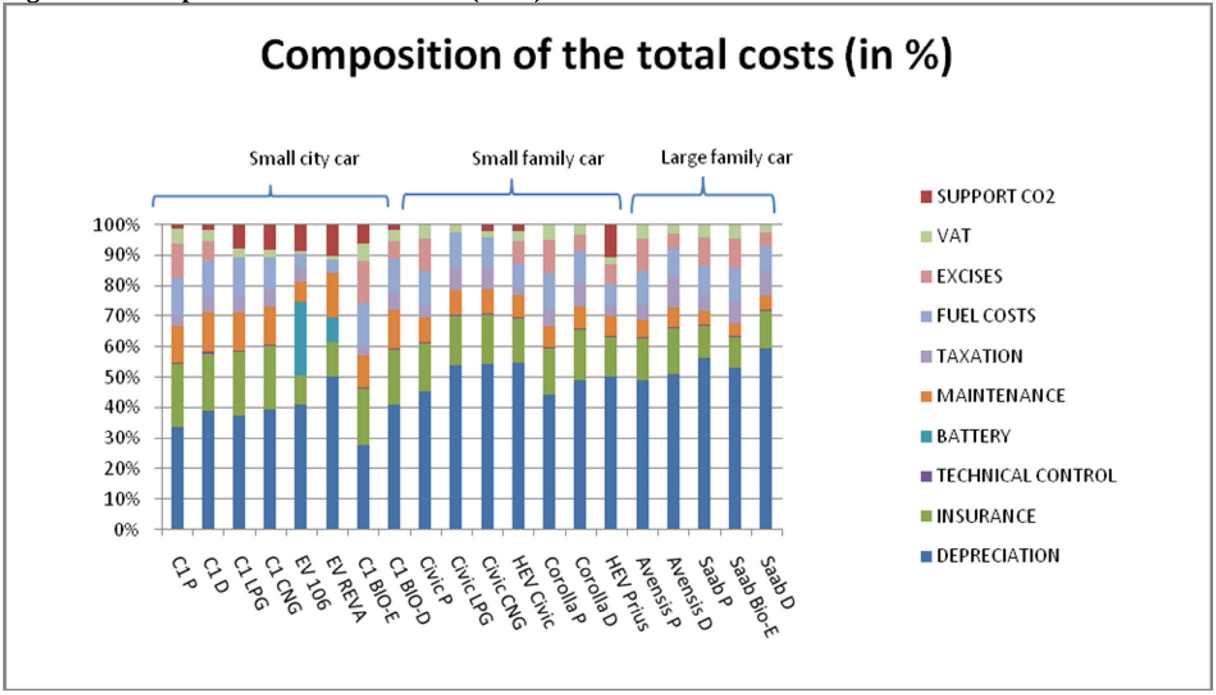


Source: own set-up

6. Sensitivity analysis

The calculations of section 5 were based upon several assumptions, many of which have uncertainties. To examine the robustness of these findings, sensitivity analysis will be carried out by varying the key parameters. Standard assumptions, such as the yearly coverage and years of car use will be varied. The impact of the depreciation rates and the total fuel costs will be investigated as well, as Figure 10 shows their large importance within the total costs. The impact of the taxation scheme will be analyzed in section 7.

Figure 10: Composition of the total costs (in %)

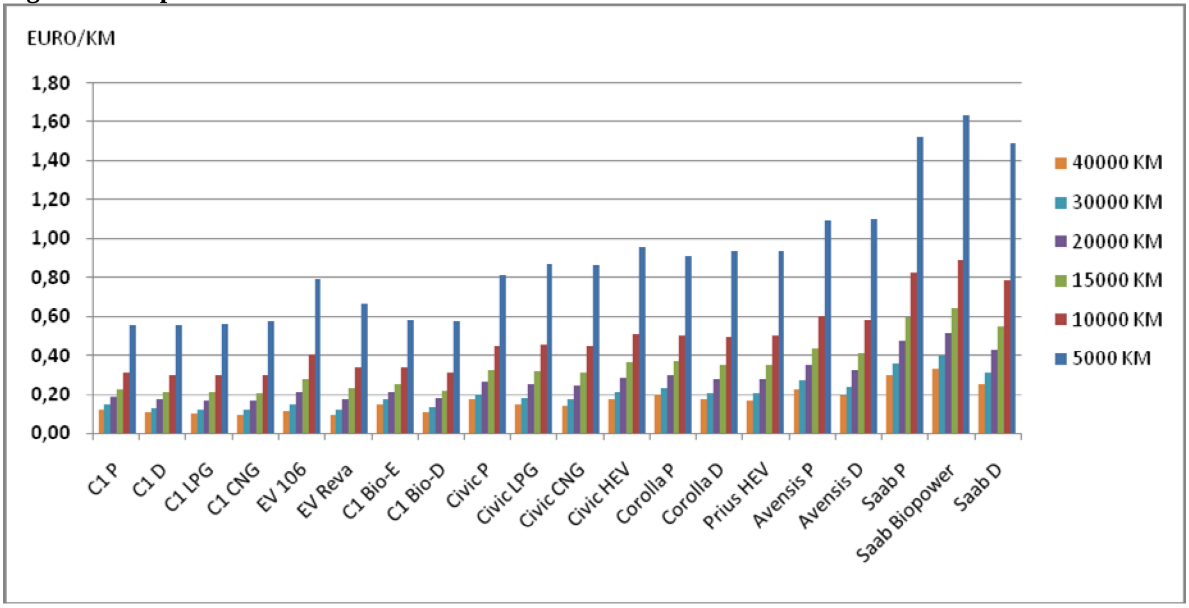


Source: own set-up

6.1 Impact of the yearly coverage

A key parameter for the life cycle cost per kilometre is the distance driven each year. Figure 11 shows the evolution of the costs per kilometre when driving respectively 5.000, 10.000, 15.000, 20.000, 30.000 and 40.000 kilometres a year, taking into account the standard assumptions set up in sections 3 and 4. For an overview of the costs/km, see Annex D.

Figure 11: Impact of different kilometre scenarios



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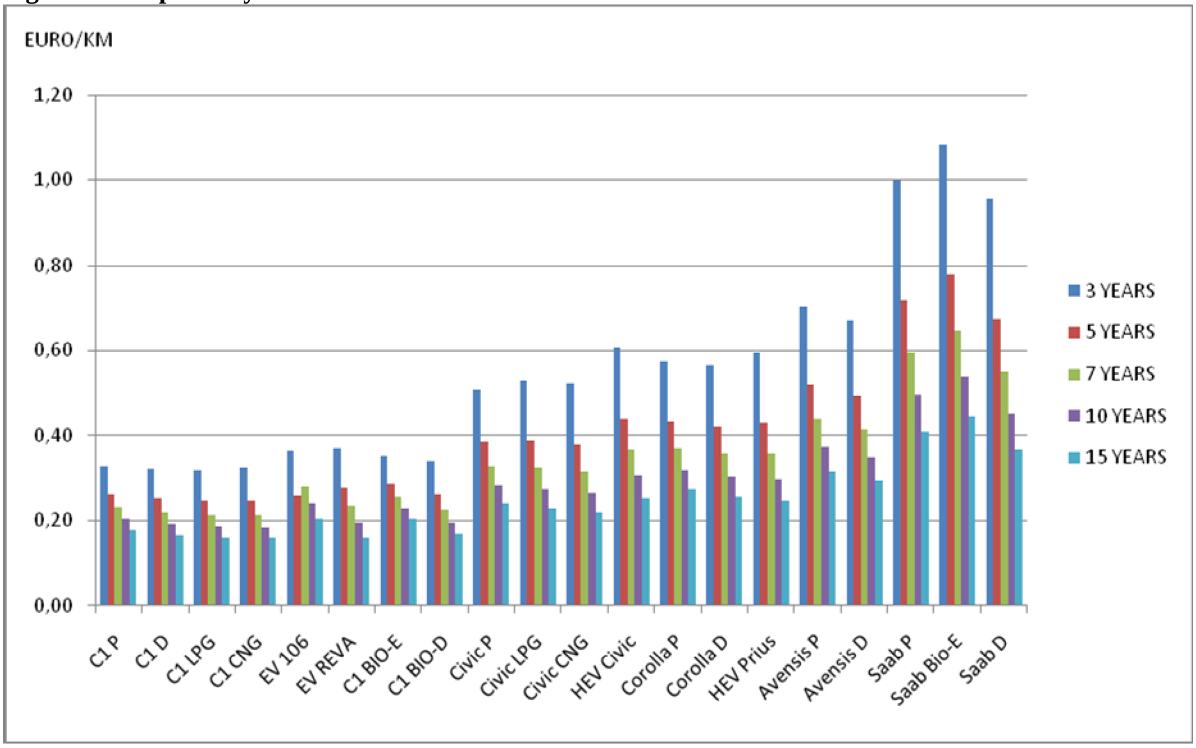
This figure shows that the retrofitted C1 LPG and CNG become already cost-efficient when driving 10.000 kms/year. The Honda Civic LPG and CNG become attractive at a yearly coverage of 15.000 kms/year. The private costs of the small electric Peugeot remain high, even when driving more than 30.000 kms/year. The attractivity of the Reva appears at 20.000 kms/year, in case the CO_2 reduction is granted. However, as the Reva is designed for driving in urban conditions, it is less likely that it will be driven more than 7.500 km/year. The hybrid Honda Civic appears not to be a cost-efficient solution, even when driving 40.000 kms/year. The private costs of the hybrid Civic are to high to become a commercial success. Mass production could lower the price of the complex hybrid components, thereby decreasing the initial costs and increasing its cost-efficiency. The Prius is in contrast an attractive small family car when driving 15.000 kms and becomes cost-efficient at 5.000 kms when classified as a large family car. As already pointed out, bio-ethanol cars seem not to be cost-efficient technologies due to their high fuel costs. The government could make them more attractive by exempting them from their current (petrol) excises. Because of its lower energy consumption and the lower (diesel) excises, the bio-diesel car becomes attractive at a yearly coverage of 15.000 kms. Finally, the higher purchase price of diesel cars is compensated by lower fuel costs at increasingly covered kilometres (e.g. 10.000 kms/year). Overall, the technologies with the lowest private costs at increasingly covered kilometres are the LPG, CNG and diesel cars.

6.2 Impact of years of car use

An important parameter within the cost calculations is the years of car use. In the previous cost calculations, a car use of 7 years was assumed. Figure 12 shows the cost calculations for a car use of 3, 5, 7, 10 and 15 years, based on the assumptions made in sections 3 and 4. As the years go by, the cost components that will be affected are the vehicle initial costs and the non fuel operating costs (costs of technical control, the battery costs and the maintenance costs). For an overview of the costs/km, see Annex E.

Figure 12: Impact of years of car use



Source: own set-up

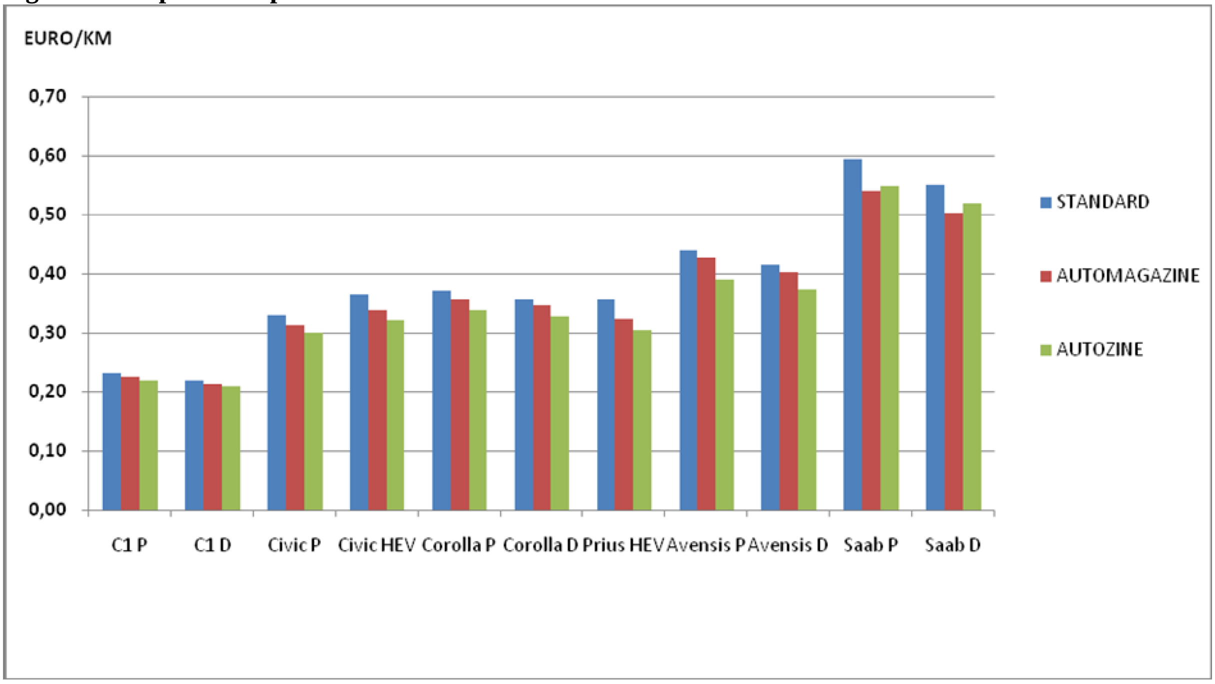
The general tendency within this figure are the lower private costs over time. This is mainly due to the lower depreciation costs. New cars depreciate automatically the moment they are bought. Within the first 5 years, a car depreciates very fast and this results clearly in a higher cost/km. Furthermore, it seems logical that the financial costs are lower when a car is used for many years, as the fixed financial costs can be spread over those years. A closer look at the vehicle technologies reveals that especially the electric cars are affected by the time of car use. When electric cars are used during the battery lifetime (3 years for the Reva and 5 years for the Peugeot 106), no additional battery replacement costs occur. In that case, electric cars become more cost-efficient. The same is true for the hybrid cars. In section 3, we assumed that the battery of the hybrid cars will last for the vehicle lifetime, as indicated by the constructors themselves. However, it may occur that during the use, some battery components will have to be replaced resulting in a higher cost per km.

This figure reveals lower private consumer costs over time. However, societal costs will probably increase due to the higher pollution costs. It is known that the environmental impact of cars used for several years is higher compared to new bought efficient cars.

6.3 Impact of the depreciation rate

One of the main components within the cost calculations is the depreciation of the car. As a new car depreciates very fast, it is useful to take into account the resale values when purchasing a new car. Especially consumers who will keep their car for just a few years, should look closely at the depreciation. A new car can easily depreciate around 15 to 20% in the first year of car use. By using depreciation rates, one can identify which cars hold their value over time. In figure 13, the cost per kilometre is presented based upon the standard depreciation (section 3), and depreciation rates from Automagazine and Autozine.nl. The depreciation rates from Automagazine and Autozine.nl were determined by taking the transaction price and the correlation with the forecasted value after 7 years. These depreciation rates can be found in the annex F together with the costs/km.

Figure 13: Impact of depreciation rates



Source: own set-up

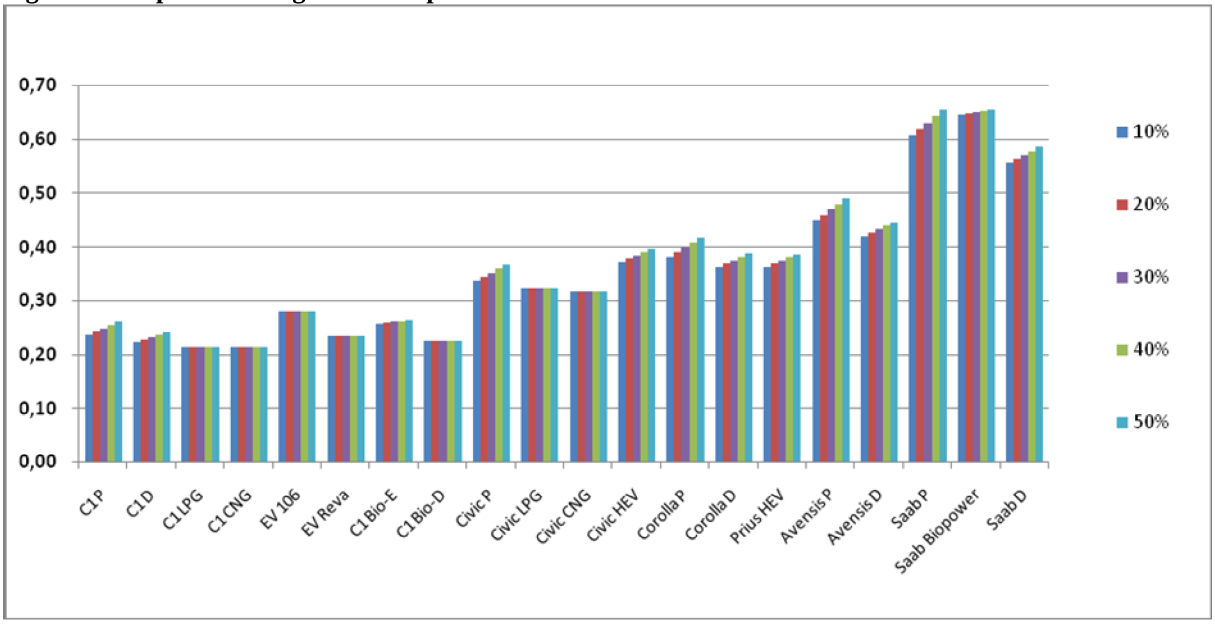
This figure shows some major tendencies. First of all, the standard depreciation rates seems to be higher compared to the depreciation rates from Automagazine and Autozine.nl. However, compared to Automagazine, this difference in costs/km is rather small (0,01 €/km) for the small city cars and small family cars and becomes somewhat larger (0,05 €/km) for the large family cars. The differences in depreciation rates may be explained by the fact that the depreciation rates in the standard case are based upon the used fuel or drive train, while the other depreciation rates are either based upon the models. Secondly, petrol cars seem to depreciate faster than diesel cars. It is still not clear if hybrid cars will depreciate faster (standard), at the same rate (Autozine.nl), or less fast (Automagazine) compared to the petrol car. Finally, it seems that the large family cars lose the most value over time, while more fuel efficient and smaller cars will hold their value better. Overall, depreciation rates appear to vary upon the models (brand image, comfort features,…), the used fuels and the car segment.

6.4 Impact of the fossil fuel prices

Since 1990, the fuel price of petrol and diesel have increased with 96% (FOD economie, 2007). This increase in fuel prices can be explained by the strong increase in the costs of the crude oil per barrel and the refining products. The main causes for these increases are structural as well as incidental. Structural problems are among others the increasing world demand and the increasing shortage of oil. Incidental causes are for example the oil crisis in 2000; tensions in the Middle-East; the economic recession in 2001 and natural disasters such as the hurricane Katrina that damages the fuel stocks and changes in the exchange rates. The increase in fuel prices can have a large impact on the increasing demand for mobility today. Alternative fuels or drive trains could become very interesting options in order to reduce the dependency on fossil fuels.

A look at the evolution of the maximum fuel prices in Belgium in the period 1990-2007 reveals that since 2000, the diesel and petrol price have augmented with respectively 35% and 30%. Last year, diesel and petrol prices rose with respectively 1 and 2%. As fuel prices are expected to rise further in the future, an investigation of the impact of rising fuel prices on the total lifecycle cost is thereby useful. In this respect, scenarios with an increase of respectively 10, 20, 30, 40, 50% of the fuel prices are elaborated in Figure 14. For the overview of the costs per km, see Annex G.

Figure 14: impact of rising fossil fuel prices



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Out of Figure 14, it appears that the rising fuel prices will have the smallest impact on the fuel efficient cars such as the small city cars. Alternative vehicle technologies will become more attractive as consumers will probably spend more time evaluating the fuel economy when purchasing a new car (Santini et al., 1999). At rising fuel prices, cars on LPG and CNG are the most attractive options with very low private consumer costs. The electric cars become very cost-efficient too because of the increased cost advantage due to their higher energy efficiency. Although the bio-ethanol cars will be affected by the higher fuel prices, they will become more cost-efficient compared to their conventional counterparts as their fuel consists of 85% of bio-ethanol and only 15% of petrol. Hybrid cars will be effected by the fuel prices too. However, their cost advantage may increase due to their higher energy efficiency compared to their conventional counterparts. Overall, clean vehicle technologies appear to become very interesting options at rising fuel prices.

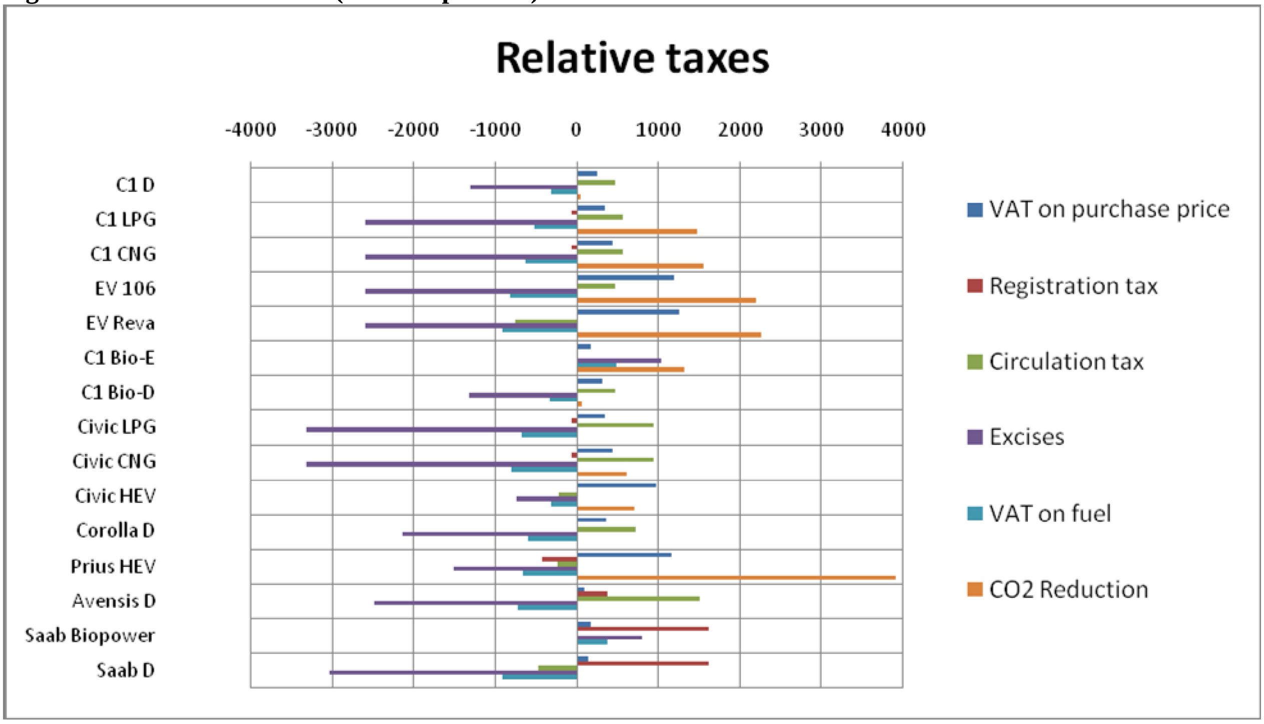
7. Tax impact analysis

Within this section, the current taxation scheme will be analyzed and a new fiscal system, based on the environmental performance of cars, will be introduced.

7.1 Current fiscal system

Figure 15 and 16 show the overall taxes paid over the lifetime of the car and relative to the baseline petrol car. The baseline assumptions from sections 3 and 4 are respected. Figure 15 distinguishes the following tax components: VAT of 21% on the purchase price, the vehicle registration tax, the circulation tax, the excises on the fuel and the VAT on the fuel. Also, the reduction of the purchase price for low CO_2 emissions was taken into account. Figure 16 makes the total sum of the taxes.

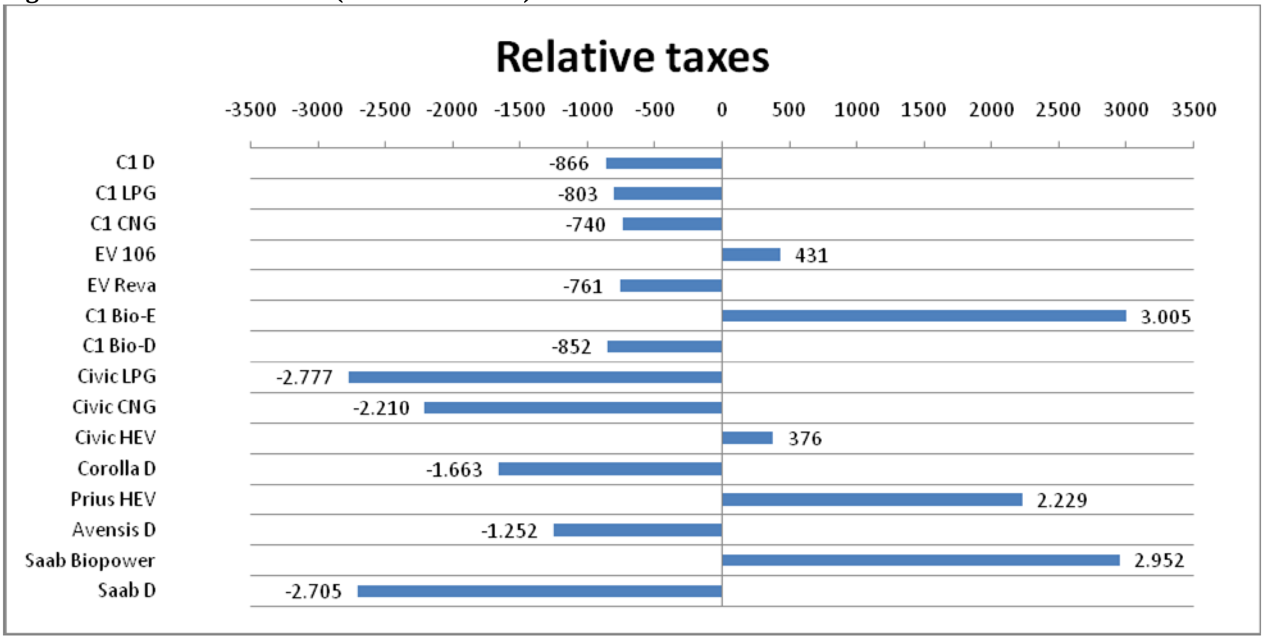
Figure 15: The relative taxes (cost components)



Source: own set-up

Figure 15 shows the large importance of the fuel excises within the total relative taxes over the lifecycle of the car. CO_2 reductions could have a great impact too. The circulation tax seems to influence the relative taxes too, in contrast to the vehicle registration tax.

Figure 16: The relative taxes (sum of the costs)



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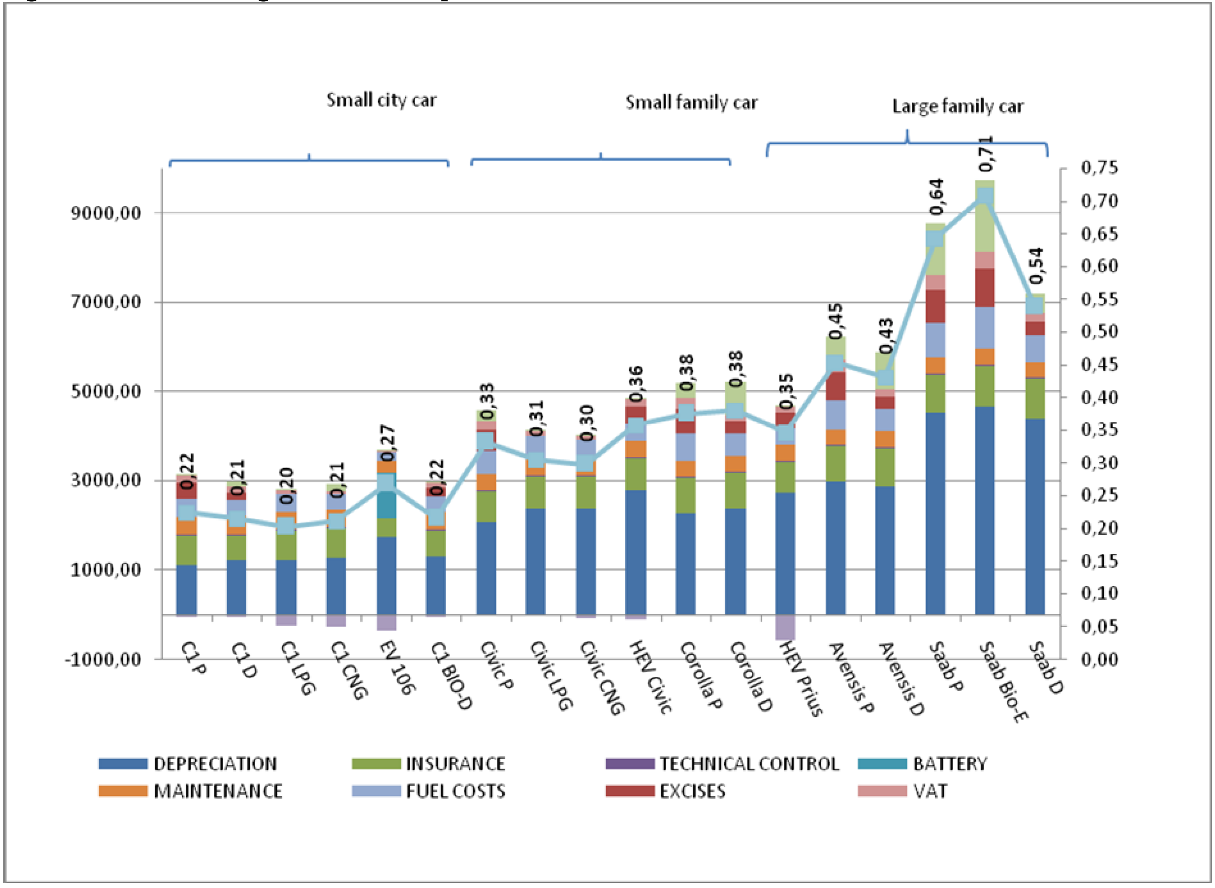
In the figure, negative values indicate a tax advantage, while positive values indicate a tax disadvantage or a subsidy advantage. The positive values of the Peugeot 106, the hybrid Civic and the Prius are for example due to the subsidy because of low CO_2 emissions. The CO_2 reduction for the C1 bio-ethanol is offset by the high fuel excises. The bio-ethanol Saab suffers from a huge tax disadvantage due to the high excises on petrol. An adaptation of the excises for bio-ethanol is thereby necessary in order to make those cars more attractive for the larger public. All the other vehicle technologies are subsidized. It seems that LPG and CNG cars benefit from the exemption of the excises. The main conclusion that can be drawn is that all diesel cars are subsidized while they have the larger pollution costs compared to petrol cars (see figure 9). Taxes such as the vehicle registration tax and the circulation tax are not able to offset these excise advantage. In the ideal case, the taxes should compensate the external costs. That is why a new fiscal system in function of the environmental performance of cars will be investigated in next section 7.2.

7.2 Life cycle costs based on the Ecoscore

A new fiscal system based on the environmental performance of cars could higher the taxes for the more polluting cars, while lowering it for the more environmentally friendly ones. This can be done by taking the Ecoscore as a new fiscal basis. The advantage of taking the Ecoscore it that it not only promotes clean vehicle technologies, but also small efficient cars. Within this new hypothetical system, cars with an Ecoscore higher than 70 will be appointed as environmentally friendly and will have to pay less taxes, while polluting cars will have to pay more taxes compared to the current fiscal system. In this respect, the vehicle registration tax as well as the circulation tax can be reformed. The following formula is therefore used: Tax = a* Total Impact + b, where the parameters a and b will be chosen in a way that environmentally friendly cars pay less, and polluting cars pay more. The total impact can be derived out of the Ecoscore by the formula: Total Impact = -ln (Ecoscore/100)/0.00357. For the set up of this new tax functions, we may refer to the results obtained within a project for the Brussels Capital Region (VUB-MOSIL/ETEC; VITO and FUCAM, 2007). Figure 17 shows the impact of this new fiscal system in absolute terms, while figure 18 gives an insight into the relative results. For an overview of the costs/km, see Annex H.

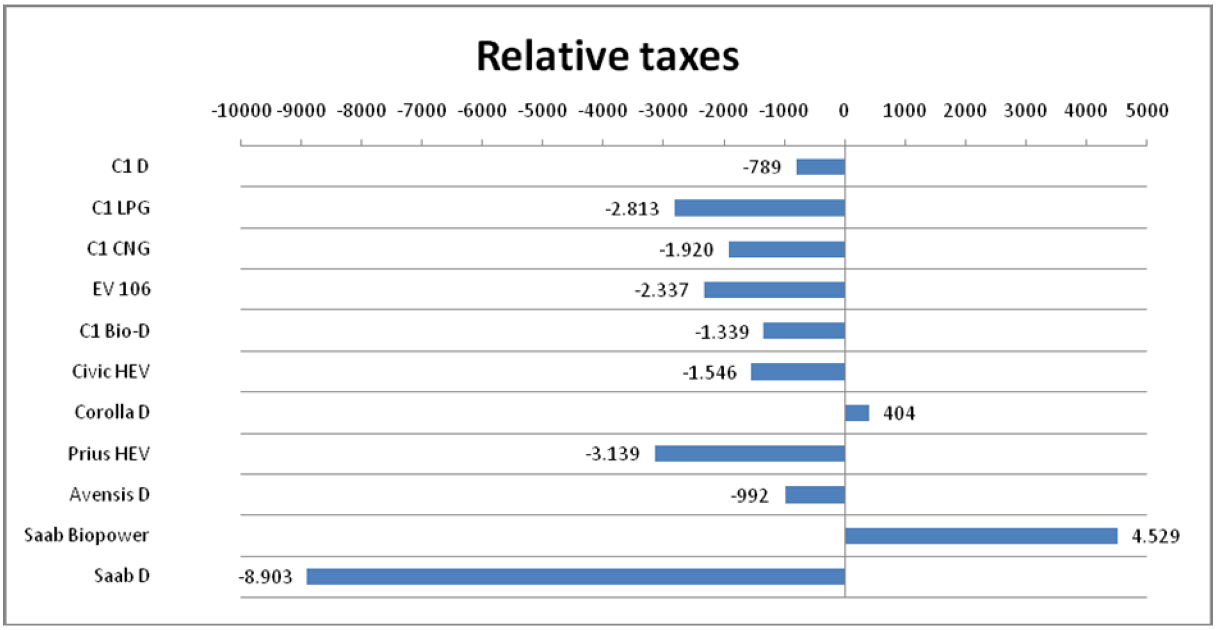
Figure 17: Total average cost and cost per kilometre based on the Ecoscore



Source: own set-up

When comparing these results with the private cost calculations made in section 5.1, one can see that environmentally friendly vehicles become more cost-efficient. All small city cars become on average 0.01 € cheaper. In the segment of the small family cars, the LPG, CNG and hybrid car become respectively 0,01€, 0,02€ and 0,01€/km cheaper while the cost per km remains the same for the Honda Civic Petrol. The cost per kilometre becomes more expensive for the Toyota Corolla diesel and petrol, while it becomes 0.01 € cheaper for the Prius. The large family cars become more expensive, except for the Saab diesel, which has a diminishment of 0.01€ due to the presence of a particulate filter. From this figure, it seems that such a new fiscal system could promote the use of clean vehicle technologies.

Figure 18: Relative taxes within the new fiscal system



Source: own set-up

When comparing this figure with the figure 16, the following can be noticed. The effect of this new fiscal system on the diesel cars is quite remarquable. The C1 and Corolla diesel have to pay more taxes because of their lower Ecoscore compared to the petrol car. In the current tax system, the Corolla Diesel has a tax advantage of 1660 €, while it has a tax disadvantage of 400 € in the new fiscal system. The Saab diesel gets an even higher tax advantage compared to the Saab petrol. This is because of its higher Ecoscore due to the presence of a standard particulate filter. Within this new system, the (hybrid) electric vehicles are clearly subsidized compared to their conventional counterparts. Their positive values under the current tax system (see figure 16) become now negative values or tax advantages in the new system. This system promotes also the CNG and LPG cars as their higher Ecoscores compared to the conventional car results in greater tax advantages up to 2800 € instead of the 800 € in the current system. As the Ecoscore of the Saab Biopower is lower than the Saab petrol, it tax disadvantage from the current system becomes even higher in the new fiscal system. To conclude, this fiscal system can indeed stimulate the use and purchase of clean vehicle technologies, but the impact factor remains small compared to the impact factor of the fuel excises. By adapting the fuel excises for clean vehicle technologies, one could probably have a larger impact on the total car park in Belgium.

8. Conclusion

Within this report, a life cycle cost model has been developed to calculate the private consumer costs and the societal lifecycle costs of different vehicle technologies. The model includes the vehicle financial costs, the vehicle operational costs and the external costs. The model was applied for different vehicle technologies which are currently available or will be available soon on the Belgian market. The costs-benefits of these technologies and the tax structure in Belgium was analyzed. The following results appear. Under the current tax system, the private consumer costs and the societal costs of vehicles which use LPG or CNG are significantly lower compared to other vehicle technologies. The main reason for this advantage is the lower fuel price at the filling station. In contrast, electric cars and cars on bio-ethanol seem to have the highest costs. Reasons for the high electric costs are the high initial price and the high battery replacement costs. At increasing fossil fuel prices, the electric car could become more cost-efficient due to its high energy efficiency. The high cost of the bio-ethanol car results out of the combination of the high ex-refinery price, its higher energy consumption and the high excises on petrol. Bio-ethanol could become more attractive if they would be exempted from their current excises. The private costs and attractiveness of the hybrid electric cars depend on their initial cost. It is nevertheless shown that hybrid cars provide no societal cost advantage. However, the cost advantage may increase with higher crude oil prices and a higher valuation of the pollution costs. Regarding the current tax system, it appears that diesel cars are subsidized compared to petrol cars, although they have larger pollution costs. A new fiscal system based on the environmental performance of cars can therefore be useful. A fiscal system based on the Ecoscore can indeed stimulate the use and purchase of clean vehicle technologies, but the impact factor remains small compared to the impact factor of the fuel excises. By adapting the fuel excises for clean vehicle technologies, one could probably have a larger impact on the total car park in Belgium.

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Annex A: Vehicle data for private consumer costs

Table A.1 Vehicle data for the cost calculations for the small city car (in Euro)

	Small City Car							
	P	D	LPG	CNG	EV	EV	Bio-E	Bio-D
	C1	C1	C1	C1	106	Reva	C1	C1
Purchase price (VAT incl.)	9740	11190	11740	12240	16594	16940	10740	11490
CO_2 (g/km)	109	109	101	84	0	0	97	113
Inscription tax	61,50	61,50	0,00	0,00	61,50	61,50	61,50	61,50
Yearly road tax	118,80	191,93	207,96	207,96	191,93	0,00	118,80	191,93
Insurance	742,50	636,55	742,50	742,50	446,00	446,00	794,48	636,55
Vehicle control	33,50	33,50	34,50	34,50	0,00	0,00	33,50	33,50
Fuel price (€ per l, m³,kWh)	1,48	1,18	0,62	0,59	0,10	0,10	1,50	1,19
Consumption (l, m³,kWh/100 km)	4,60	4,10	5,84	5,11	18,70	13,40	6,44	4,00
Maintenance Cost	327,13	327,13	327,13	327,13	203,01	453,53	327,13	327,13

Table A.2: Vehicle data for the cost calculations for the small family car (in Euro)

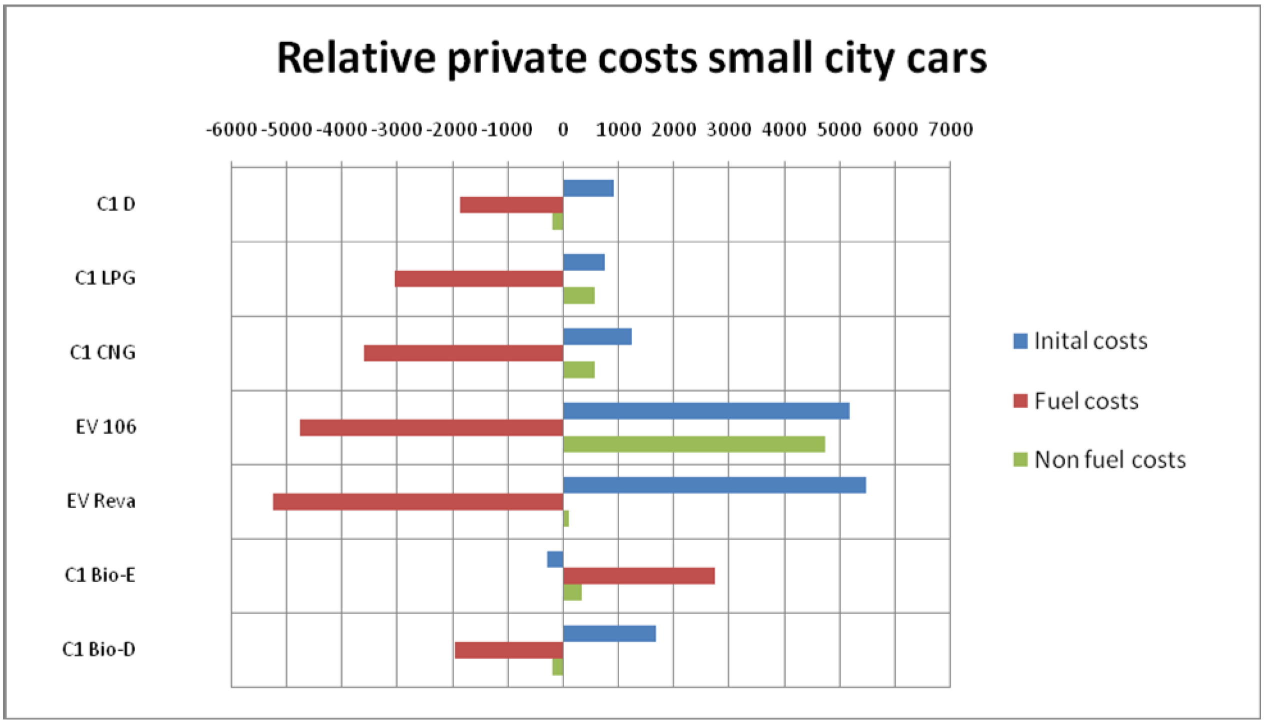
			Small Family Car				
	P	LPG	CNG	HEV-P	P	D	HEV-P
	Civic	Civic	Civic	Civic	Corolla	Corolla	Prius
Purchase price (VAT incl.)	17590	19590	20090	23200	19290	21370	26000
CO_2 (g/km)	139	129	107	109	167	150	104
Inscription tax	61,50	0,00	0,00	61,50	495,00	495,00	61,50
Yearly road tax	191,93	340,61	340,61	155,23	228,76	340,61	191,93
Insurance	792,82	792,82	792,82	821,05	889,93	896,41	779,88
Vehicle control	33,50	34,50	34,50	33,50	33,50	33,50	33,50
Fuel price (€ per l, m³,kWh)	1,48	0,62	0,59	1,48	1,48	1,18	1,48
Consumption (l, m³,kWh/100 km)	5,90	7,49	6,55	4,60	7,00	5,70	4,30
Maintenance Cost	271,58	271,58	271,58	271,58	271,58	271,58	253,06

Table A.3: Vehicle data for the cost calculations for the big family car (in Euro)

	Big Family Car				
	P Avensis	D Avensis	P Saab	Bio-E Saab	D Saab
Purchase price (VAT incl.)	25260	25760	38550	39550	39300
CO_2 (g/km)	187	156	220	191	184
Inscription tax	495,00	867,00	867,00	2478,00	2478,00
Yearly road tax	264,92	501,47	340,61	340,61	264,92
Insurance	902,88	951,42	951,42	1022,63	1012,92
Vehicle control	33,50	33,50	33,50	33,50	33,50
Fuel price (€ per l, m³,kWh)	1,48	1,18	1,48	1,50	1,18
Consumption (l, m³,kWh/100 km)	7,70	5,90	9,20	10,60	6,80
Maintenance Cost	253,06	253,06	253,06	253,06	253,06

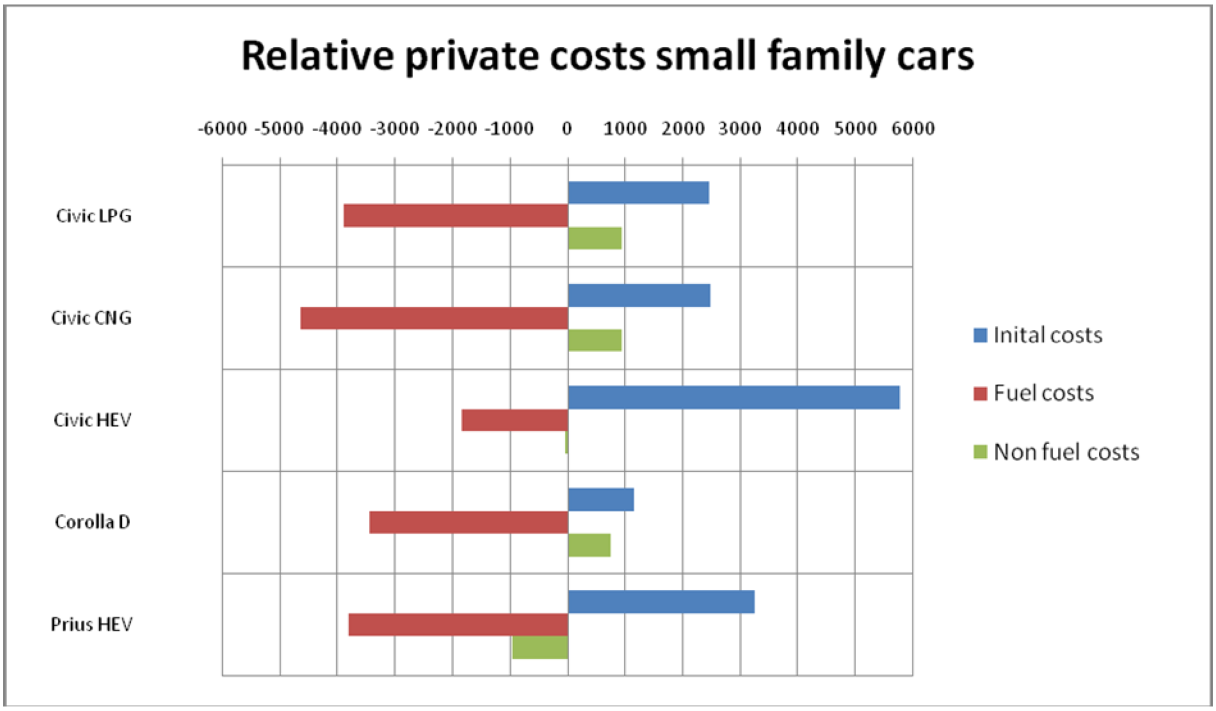
Annex B: Relative private consumer costs

Figure B.1: Relative private consumer costs small city cars



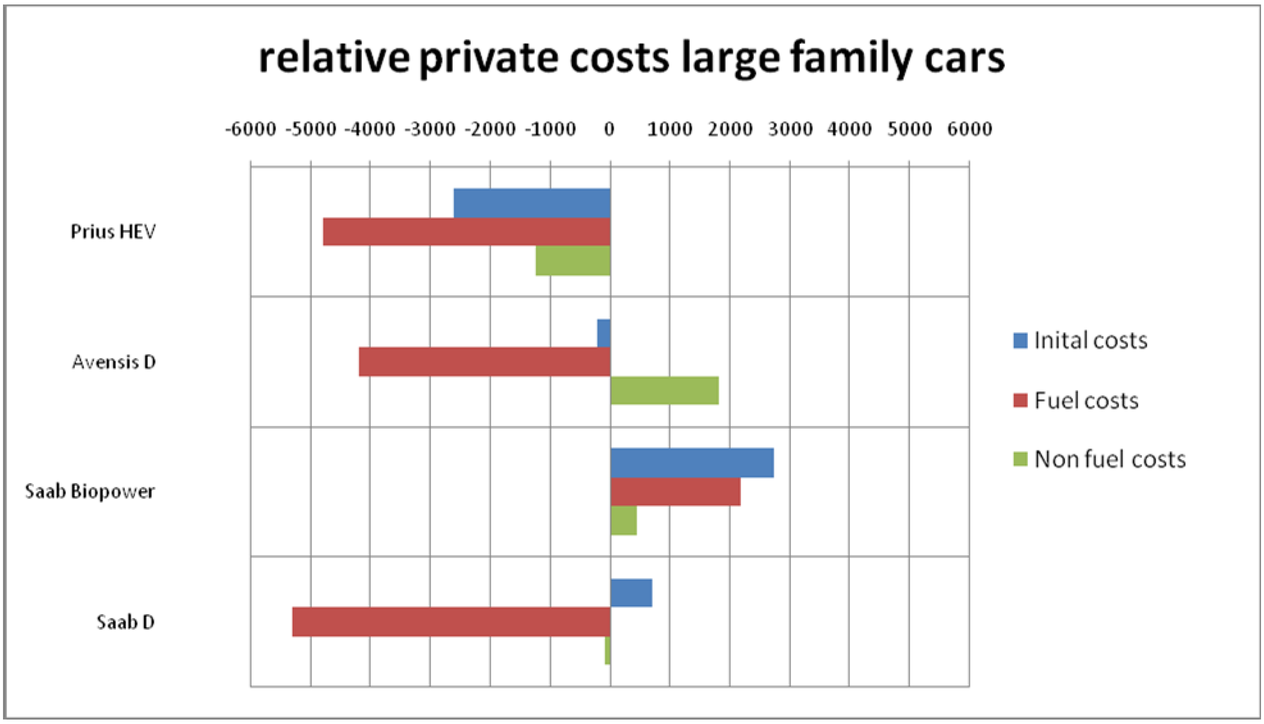
Source: own set-up

Figure B.2: Relative private costs small family cars



Source: own set-up

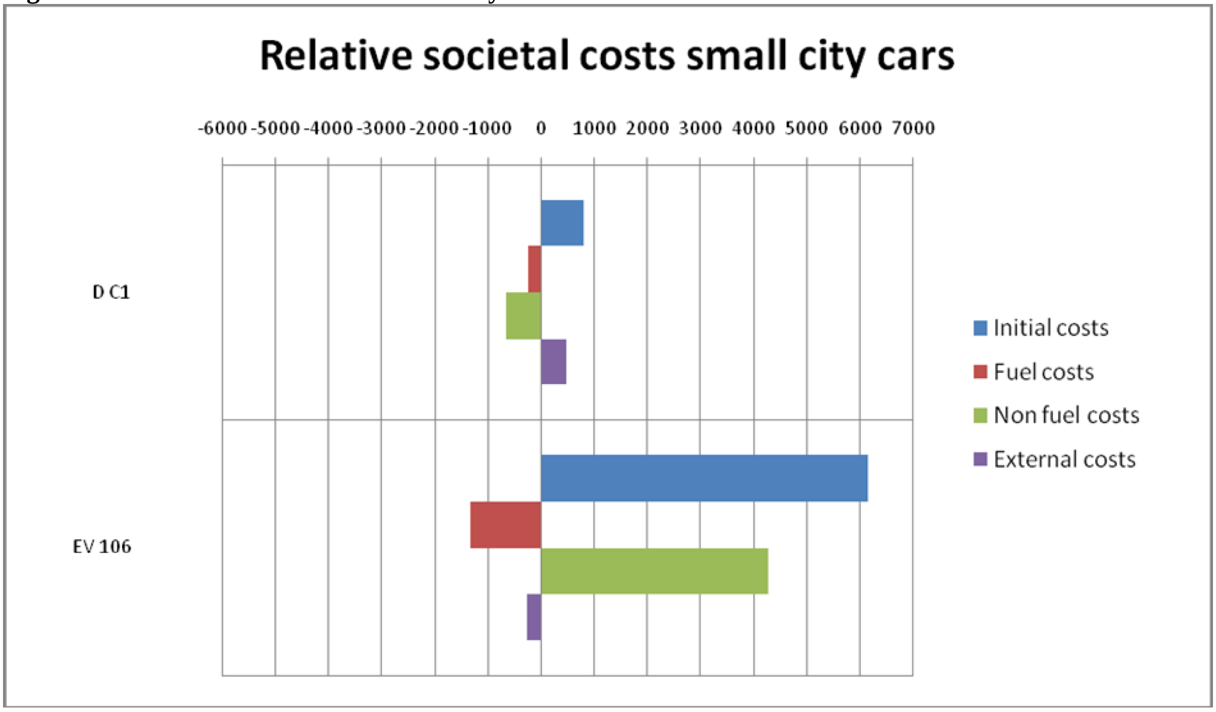
Figure B.3: Relative private costs large family cars



Source: own set-up

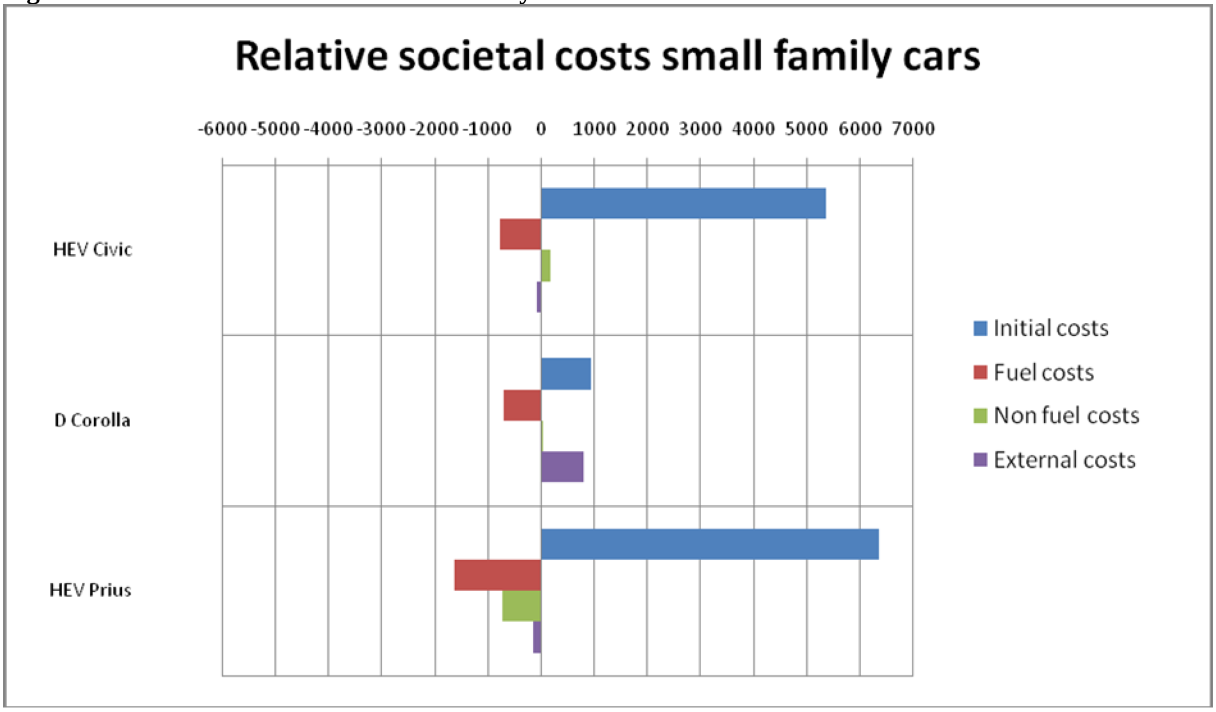
Annex C: Relative societal costs

Figure C.1: Relative societal costs small city cars



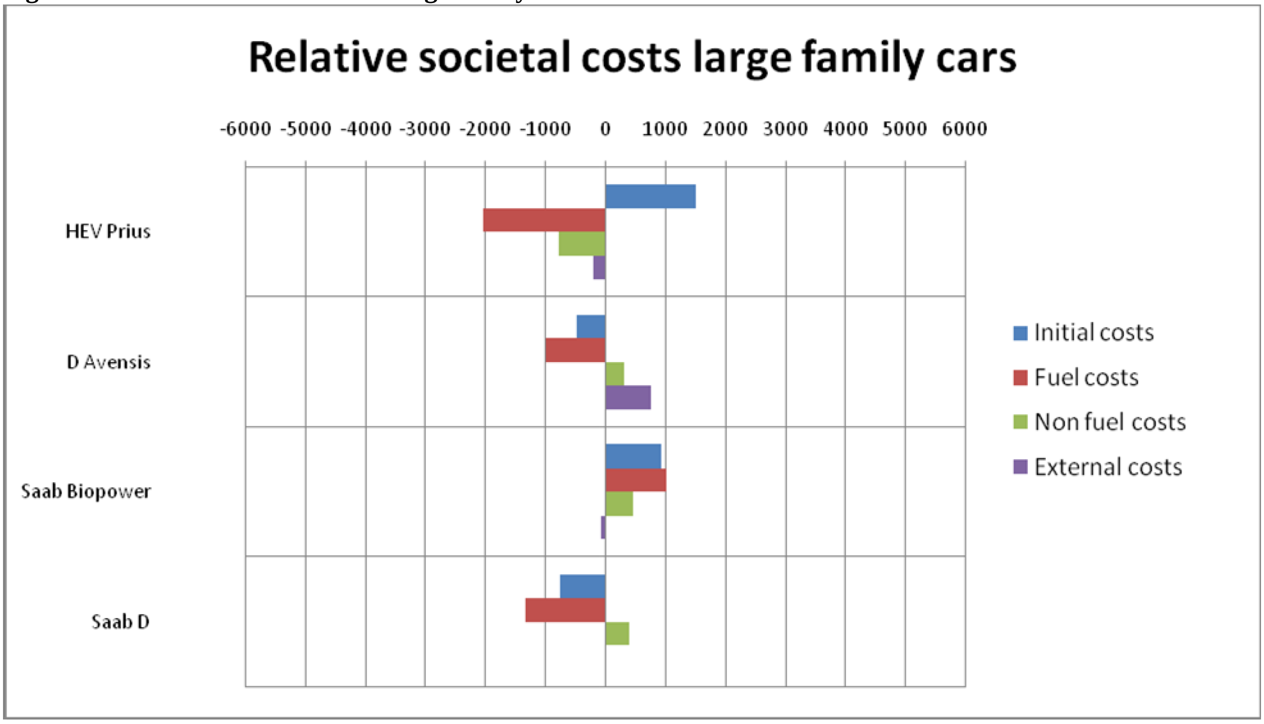
Source: own set-up

Figure C.2: Relative societal costs small family cars



Source: own set-up

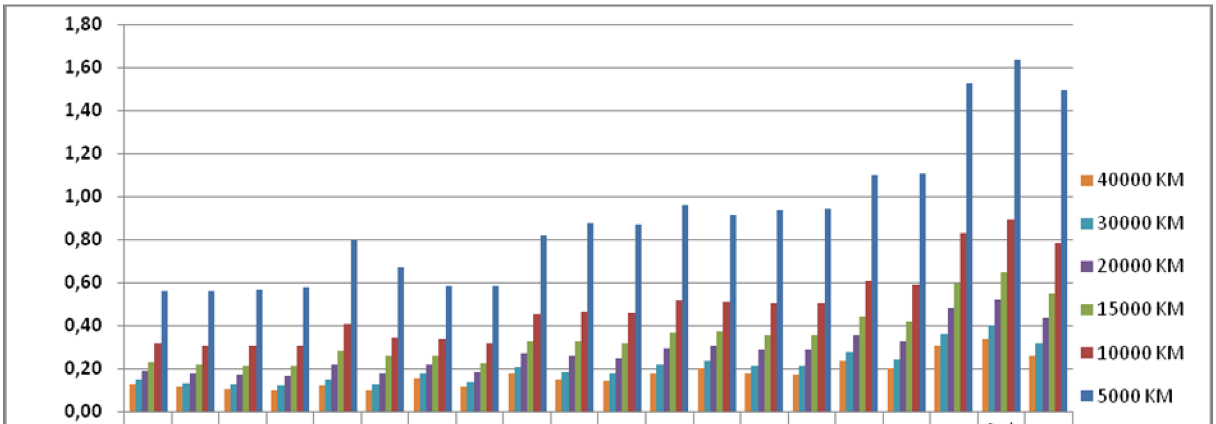
Figure C.3: Relative societal costs large family cars



Source: own set-up

Annex D: Impact of the yearly coverage

Figure D.1: Impact of the yearly coverage

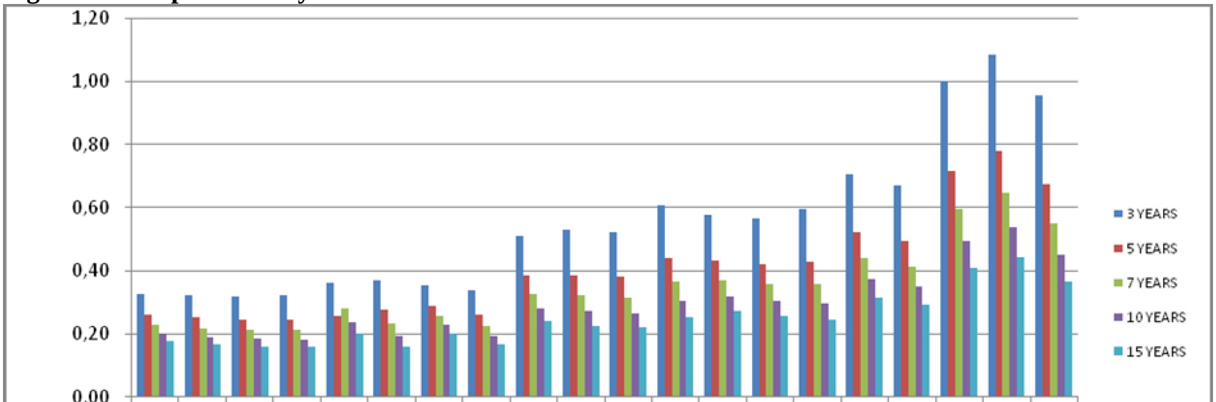


	C1 P	C1 D	C1 LPG	C1 CNG	EV 106	EV Reva	C1 Bio-E	C1 Bio-D	Civic P	Civic LPG	Civic CNG	Civic HEV	Corolla P	Corolla D	Prius HEV	Avensis P	Avensis D	Saab P	Saab Biopower	Saab D
40000 KM	0,13	0,11	0,10	0,10	0,12	0,10	0,15	0,11	0,18	0,15	0,14	0,18	0,20	0,18	0,17	0,23	0,20	0,30	0,34	0,26
30000 KM	0,15	0,13	0,13	0,12	0,15	0,12	0,17	0,14	0,21	0,19	0,18	0,22	0,24	0,21	0,21	0,27	0,24	0,36	0,40	0,31
20000 KM	0,19	0,18	0,17	0,17	0,21	0,18	0,22	0,18	0,27	0,25	0,25	0,29	0,30	0,28	0,28	0,36	0,33	0,48	0,52	0,43
15000 KM	0,23	0,22	0,21	0,21	0,28	0,26	0,26	0,23	0,33	0,32	0,32	0,37	0,37	0,36	0,36	0,44	0,41	0,59	0,65	0,55
10000 KM	0,31	0,30	0,30	0,30	0,41	0,34	0,34	0,31	0,45	0,46	0,46	0,51	0,51	0,50	0,50	0,60	0,59	0,83	0,89	0,79
5000 KM	0,56	0,56	0,57	0,58	0,80	0,67	0,59	0,58	0,82	0,88	0,87	0,96	0,92	0,94	0,94	1,10	1,10	1,52	1,64	1,49

Source: own set-up

Annex E: Impact of the years of car use

Figure E.1: Impact of the years of car use



	C1 P	C1 D	C1 LPG	C1 CNG	EV 106	EV REVA	C1 BIO-E	C1 BIO-D	Civic P	Civic LPG	Civic CNG	HEV Civic	Corolla P	Corolla D	HEV Prius	Avensis P	Avensis D	Saab P	Saab Bio-E	Saab D
3 YEARS	0,33	0,32	0,32	0,32	0,36	0,37	0,35	0,34	0,51	0,53	0,52	0,61	0,58	0,57	0,59	0,70	0,67	1,00	1,08	0,96
5 YEARS	0,26	0,25	0,25	0,25	0,26	0,28	0,29	0,26	0,38	0,39	0,38	0,44	0,43	0,42	0,43	0,52	0,49	0,72	0,78	0,67
7 YEARS	0,23	0,22	0,21	0,21	0,28	0,23	0,26	0,23	0,33	0,32	0,32	0,37	0,37	0,36	0,36	0,44	0,41	0,59	0,65	0,55
10 YEARS	0,20	0,19	0,19	0,18	0,24	0,20	0,23	0,20	0,28	0,27	0,27	0,31	0,32	0,30	0,30	0,37	0,35	0,50	0,54	0,45
15 YEARS	0,18	0,17	0,16	0,16	0,20	0,16	0,20	0,17	0,24	0,23	0,22	0,25	0,27	0,26	0,25	0,31	0,29	0,41	0,45	0,37

Source: own set-up

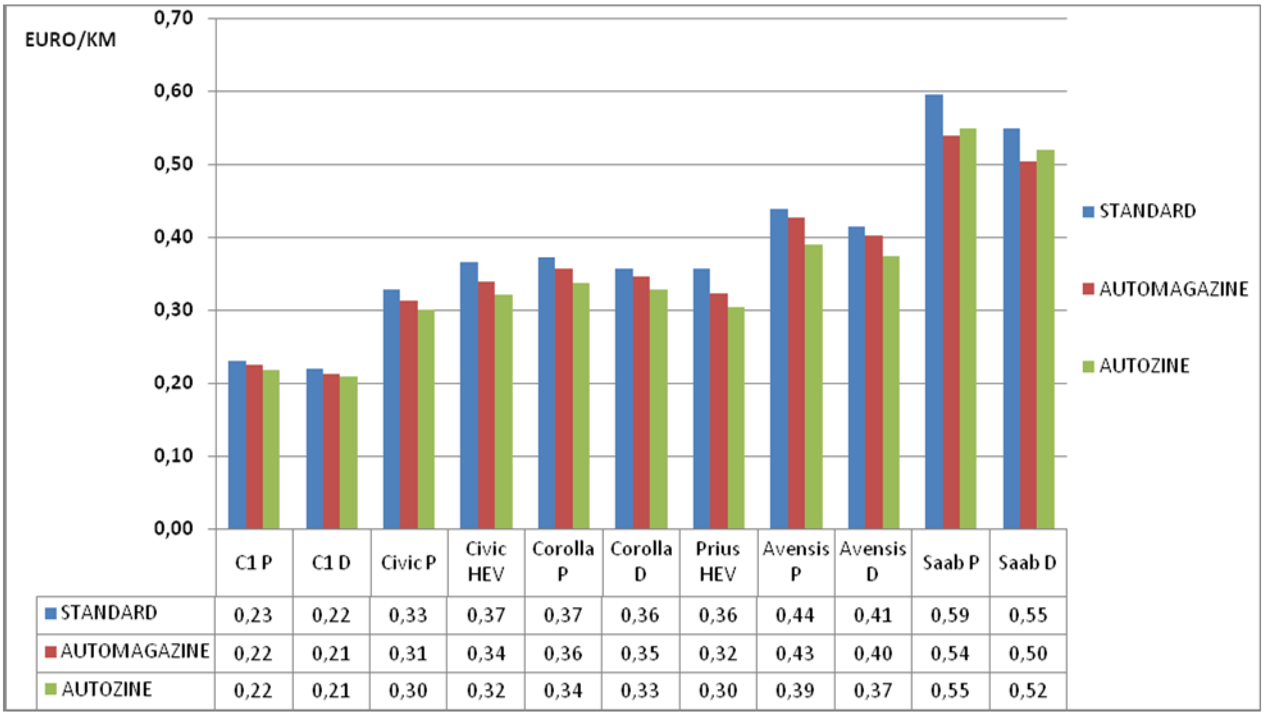
Annex F: Impact of the depreciation rate

Table F.1: Depreciation rates from Automagazine and Autozine.nl

Automagazine.be	Initial Price	Residual Value	%	Autozine.nl	Initial Price	Residual Value	%	Standard Assumption	%
C1 1.0	9740	2700	***72%***	**C1 1.0**	8090	2985	***63%***	**C1 1.0**	**79%**
C1 1.4 HDI	11190	3800	***66%***	**C1 1.4HDI**	9790	3612	***61%***	**C1 1.4HDI**	***74%***
Civic 1.4i	17590	5700	***68%***	**Civic 1.4i**	21500	8763	***59%***	**Civic 1.4i**	***79%***
Civic IMA	23200	7300	***69%***	**Civic IMA**	23900	9741	***59%***	**Civic IMA**	***84%***
Corolla 1.6	19290	6000	***69%***	**Corolla 1.6**	19290	8295	***57%***	**Corolla 1.6**	***79%***
Corolla 2.0 D-4D	21370	6900	***68%***	**Corolla 2.0**	21370	9189	***57%***	**Corolla 2.0**	***74%***
Prius	26000	11943	***65%***	**Prius**	25990	11943	***54%***	**Prius**	***84%***
Avensis 1.8	25260	6900	***73%***	**Avensis 1.8**	27650	12706	***54%***	**Avensis 1.8**	***79%***
Avensis 2.2	25760	8300	***68%***	**Avensis 2.2**	32150	14774	***54%***	**Avensis 2.2**	***74%***
9.5 Estate	38550	15000	***61%***	**9.5 Estate**	38550	13878	***64%***	**9.5 Estate**	***79%***
9.5 Estate	39300	16000	***59%***	**9.5 Estate**	39300	14148	***64%***	**9.5 Estate**	***74%***

Source: own set-up, based on Automagazine and Autozine.nl

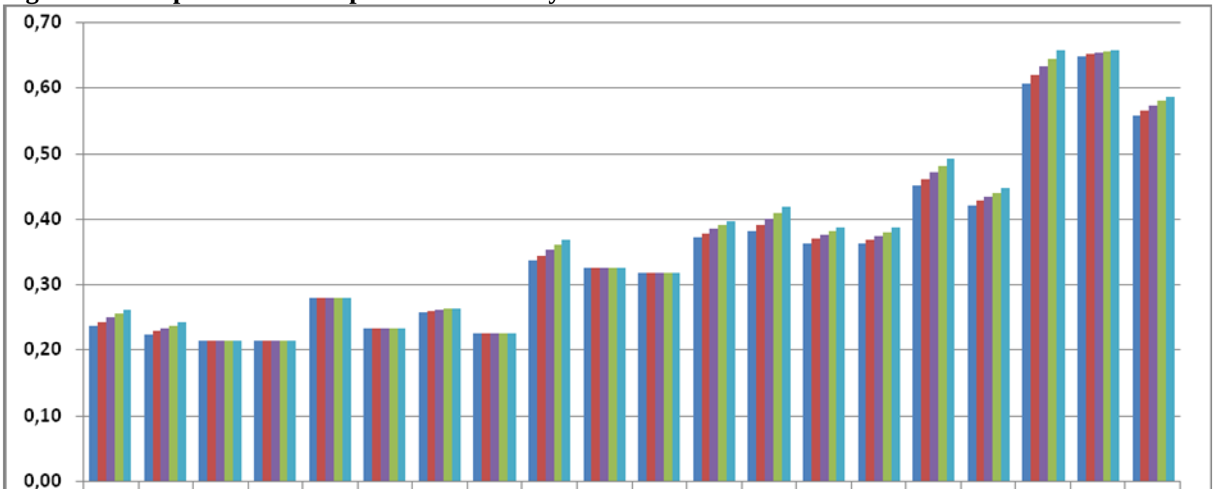
Figure F.1: Costs per kilometre based on different depreciation rates



Source: own set-up

Annex G: Impact of the fuel prices

Figure G.1: Impact of the fuel prices on the lifecycle costs

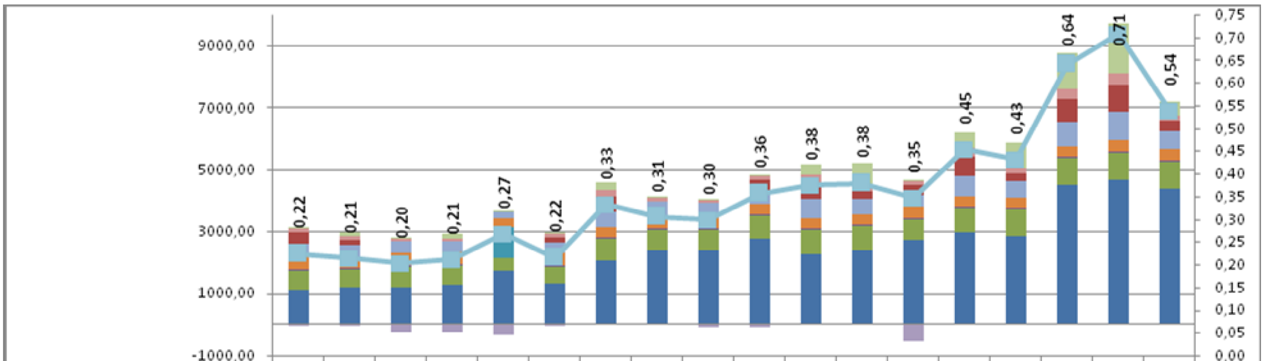


	C1 P	C1 D	C1 LPG	C1 CNG	EV 106	EV Reva	C1 Bio-E	C1 Bio-D	Civic P	Civic LPG	Civic CNG	Civic HEV	Corolla P	Corolla D	Prius HEV	Avensis P	Avensis D	Saab P	Saab Biopower	Saab D
10%	0,24	0,22	0,21	0,21	0,28	0,23	0,26	0,23	0,34	0,32	0,32	0,37	0,38	0,36	0,36	0,45	0,42	0,61	0,65	0,56
20%	0,24	0,23	0,21	0,21	0,28	0,23	0,26	0,23	0,34	0,32	0,32	0,38	0,39	0,37	0,37	0,46	0,43	0,62	0,65	0,56
30%	0,25	0,23	0,21	0,21	0,28	0,23	0,26	0,23	0,35	0,32	0,32	0,38	0,40	0,37	0,37	0,47	0,43	0,63	0,65	0,57
40%	0,25	0,24	0,21	0,21	0,28	0,23	0,26	0,23	0,36	0,32	0,32	0,39	0,41	0,38	0,38	0,48	0,44	0,64	0,65	0,58
50%	0,26	0,24	0,21	0,21	0,28	0,23	0,26	0,23	0,37	0,32	0,32	0,40	0,42	0,39	0,39	0,49	0,45	0,66	0,66	0,59

Source: own set-up

Annex H: Fiscal system based on the Ecoscore

Figure H.1: Costs per kilometre with fiscal system based on the Ecoscore



	C1 P	C1 D	C1 LPG	C1 CNG	EV 106	C1 BIO-D	Civic P	Civic LPG	Civic CNG	HEV Civic	Corolla	Corolla	HEV Prius	Avensis	Avensis	Saab 9	Saab Bio	Saab D
SUPPORT CO2	-41,7	-47,9	-251,	-262,	-355,	-49,2	0,00	0,00	-86,1	-99,4	0,00	0,00	-557,	0,00	0,00	0,00	0,00	0,00
TAXATION	31,57	115,1	26,22	155,6	16,30	35,78	238,5	31,57	32,96	30,21	333,8	730,5	28,86	529,0	833,8	1154,	1610,	430,6
VAT	160,7	114,5	85,24	71,14	42,88	112,1	206,1	109,1	91,69	160,7	244,6	159,2	150,2	269,1	164,8	321,5	375,4	189,9
EXCISES	370,6	184,7	0,00	0,00	0,00	180,2	475,3	0,00	0,00	369,2	561,9	256,7	346,4	620,4	265,7	741,2	854,0	306,3
FUEL COSTS	394,8	360,6	405,9	338,7	204,1	353,9	506,4	519,9	436,6	396,2	603,0	501,4	369,1	661,0	519,0	789,7	933,7	598,2
MAINTENANCE	398,3	398,3	398,3	398,3	274,2	398,3	356,0	356,0	356,0	356,0	356,0	356,0	350,4	350,4	350,4	350,4	350,4	350,4
BATTERY	0,00	0,00	0,00	0,00	1017,	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
TECHNICAL CONTROL	13,66	13,66	14,07	14,07	0,000	13,66	13,66	14,07	14,07	13,66	13,66	13,66	13,66	13,66	13,66	13,66	13,66	13,66
INSURANCE	673,4	577,3	673,4	673,4	404,5	577,3	719,1	719,1	719,1	744,7	807,2	813,0	707,3	818,9	862,9	862,9	927,5	918,7
DEPRECIATION	1111,	1211,	1214,	1275,	1743,	1311,	2068,	2384,	2388,	2782,	2268,	2385,	2732,	2971,	2875,	4534,	4670,	4386,
COST PER KM	0,22	0,21	0,20	0,21	0,27	0,22	0,33	0,31	0,30	0,36	0,38	0,38	0,35	0,45	0,43	0,64	0,71	0,54

Source: Own set-up

CLEVER
Clean Vehicle Research

Price elasticity
Task 3.2
Part 1

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Table of contents

1. Introduction

Previous research analysed the importance of the factor price and environmental friendliness in the car purchase decision of consumers (see CLEVER task 1.4). The **purchase price**, followed by the **fuel consumption** and the **reliability and security** of the car turned out to be the most important purchase factors. Based on these factors, consumers will select a couple of alternatives. Their final choice will depend on the evaluation of the intrinsic characteristics of the car (e.g. design, performance, comfort) and personal, cultural, social and household characteristics. It has been found that the **environmental friendliness** of the car is not taken into consideration at the purchase of a new car. Consumers do not want to give up other car attributes for the environmental benefit. The willingness to pay for a more environmental friendly car thus depends on the price and vehicle characteristics to be fully competitive with conventional cars. These findings have been tested by means of **two inquiries**. The first inquiry was presented face-to-face on the European Motor show in Brussels (17-25 January 2008). This inquiry was continued online through a web-based survey (March-September 2008). These surveys investigated if the increasing media-attention for environmental problems has an impact on the role of the environmental friendliness in the purchase behaviour of cars. Moreover, it has been researched if policy measures can be an effective instrument in promoting the purchase and use of environmental friendly vehicles. These results are presented in **part A: Survey**. In a second **part B: Literature Review**, a framework will be set up for the evaluation of policy measures. Policy measures will only be effective if they induce the right behavioural changes. In order to evaluate the effectiveness of policy measures, one should not only take the **travelers'attitudes** into account, but also the **price elasticities**. A scheme for the evaluation of policy proposals will be presented where the psychological view (travelers'attitudes) will be linked to the economical view (elasticities) to get an insight in the effectiveness of policy proposals. Based on this scheme, recommendations for the use of policy measures in Belgium can be established.

A. SURVEY

A.1 Scope of the work

The theme of the European Auto & Motor show in Brussels (2008) was **“Sustainable Mobility”** and provided an unique opportunity to investigate if the increasing media-attention for environmental problems has an impact on the role of the environmental friendliness in the purchase behaviour of cars. The survey also investigated if policy measures can be an effective instrument in promoting the purchase and use of environmental friendly vehicles. In short, the focus of the study was to find an answer to the following research questions:

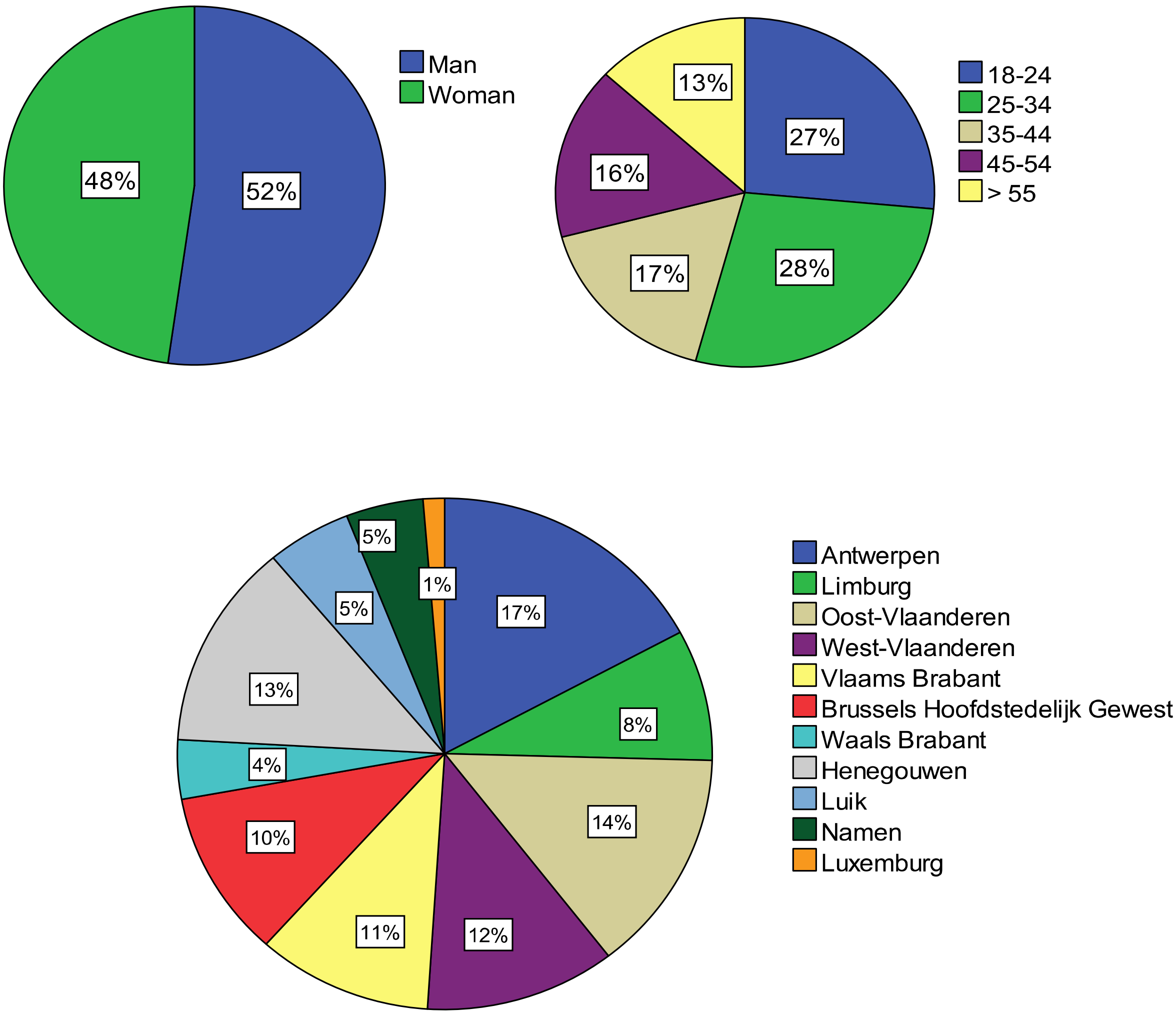
1) Which are the most important purchase factors?
2) Do consumers take the environmental friendliness of the car into account?
3) Are consumers willing to pay more for a cleaner car?
4) Can policy measures have an impact on the purchase and use of cars?

A.2 Sample

The data have been collected by use of **2 inquiries**. The first inquiry was presented **face-to-face** on the European Motor show in Brussels (17-25 January 2008). This inquiry was continued online through a **web-based** survey (March-September 2008). The survey has been screened by the follow-up committee of CLEVER and pretested at the Auto and Motor show. The personal inquiry provided 392 useful answers. The aim of this face-to-face survey was to get more insight in the real purchase behaviour of people within the car purchase process. In an attempt to get a more **representative sample** of the Belgian population, a web-based survey was send around giving another 894 useful answers. Both surveys together provided a total sample size of 1286[1] respondents. It is important to dispose over a representative sample of the Belgian population. In theory, representativeness can be guaranteed if each inhabitant of Belgium has an known and positive chance to be selected. In practice, the representativeness of a sample can be obtained by correcting the deviations of the sample for a number of variables of which the distribution in the population is known. This reweighting of the sample is done by the **post stratification method** (Bethlehem, 2008). Here, it is advised to have an optimal balance between the number of variables and the weighting factors. The larger the number of variables (higher validity with the population), the lower the reliability of the sample (higher weighting factors). In this sample, it was decided to weight the variables **gender** and **living area** of the respondents. The distributions of gender, age and residence are shown in Figure 1.

[1] Both samples could be analysed together since there are only small differences between the face-to-face survey and the online survey without any empirical value **(h_p^2 < 5%).**

Figure 1: Age, gender and residence distribution of the respondents



Source: Own set-up

Additional information has been collected about the **Belgian car park**. 4,2% of the respondents does not possess a car. 32,8% owns one car, almost 50% owns two cars and 14% owns more than two cars. 34,7% of the respondents is planning to purchase a car in the near future (< 6 months). Of these people, 64,2% will purchase a car as a substitute for another car. 67,4% of the people intending to purchase a car, will buy a brand new car. Almost 1/3 (32,6%) prefers a second-hand car. In 22,4% of the cases, the new car will be an extra car, which will positively influence the number of cars in the Belgian car park. 90% of the respondents prefers conventional fuels: almost 2/3 respondents desire diesel, 1/5 choose petrol and 5,7% prefer LPG. More than 1/3 does not know which alternative fuels or driving systems are available.

A.3 Purchase factors

It was investigated which are the **most important car attributes** at the purchase of a new car. First of all, respondents were asked to sum up spontaneously their 3 most important purchase factors (Table 1). Consequently, respondents had to attribute scores from 0 (not important at all) to 10 (very important) to a given list of car attributes (Table 2).

Table 1: Top 10 spontaneously cited purchase factors

Factor	Frequency	Valid percentage
Purchase price	358	31.8%
Fuel consumption	128	11.3%
Comfort	98	8.7%
Design/looks	81	7.2%
Security	80	7.1%
Brand	43	3.8%
Space	42	3.8%
Size	32	3.1%
Reliability	23	2.1%
Environmental friendliness	22	1.9%

Source: Own set-up

Table 1 shows which purchase factors were spontaneously cited by the respondents. It appears that the **purchase price**, **fuel consumption**, **comfort**, **design/looks and security** are the most important purchase factors with a total valid percentage of 66,1% of the answers. With the aim of deriving the relative importance of individual purchase factors, respondents had to attribute scores from 0 (not important at all) to 10 (very important). The 10 most important purchase factors are displayed in Table 2.

Table 2: Top 10 of purchase factors

Factor	Mean (out of 10)	Standard deviation
Reliability	8.90	0.92
Security	8.68	1.02
Fuel consumption	8.52	1.12
Purchase price	8.45	1.21
Comfort	7.73	1.09
Space	7.60	1.22
Maintenance costs	7.57	1.33
Type of car	7.38	1.48
Warranty	7.13	1.44
Size	7.08	1.40

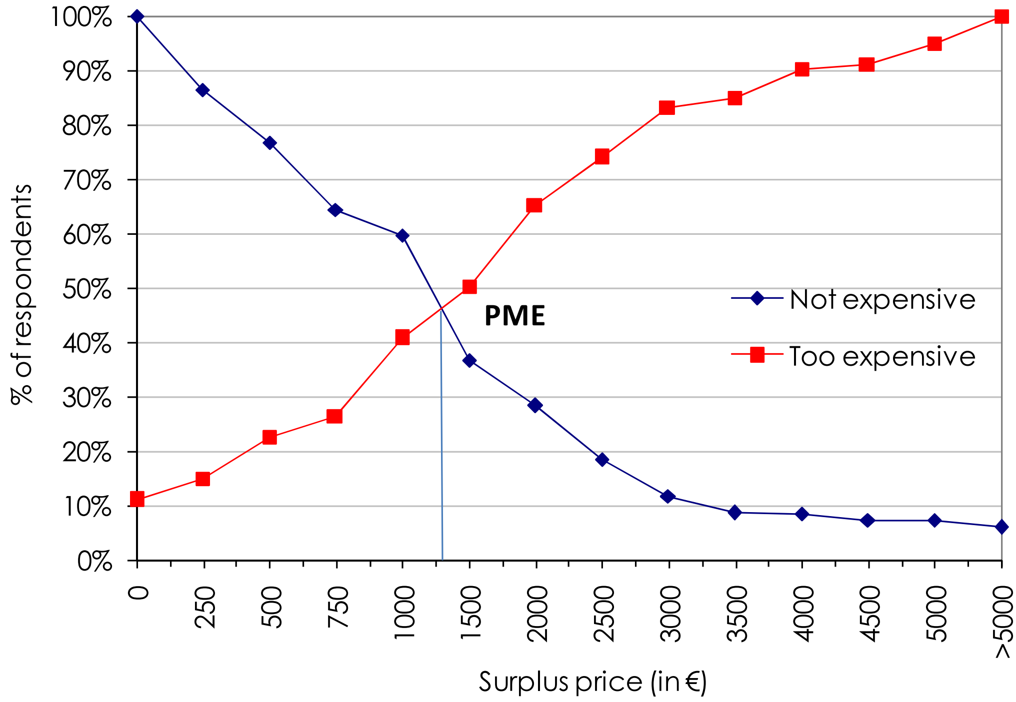
Source: Own set-up

Reliability appears to be the most important purchase factor, followed by **security, fuel consumption, purchase price and comfort**. Space, maintenance costs, type of car, warranty and size finish the top 10. When comparing Table 1 to Table 2, one can notice that 7 factors appear twice in the top 10, namely **reliability, security, fuel consumption, purchase price, comfort, space and size**. These factors can thus be considered as very important. These results confirm previous findings (Turcksin et al., 2007) stating that the first selection of a new car is based upon the evaluation of rational factors (purchase price, fuel consumption and reliability), and where the final choice is based upon the intrinsic characteristics of the car (comfort, space, size, design) and socio-economic characteristics such as personal, cultural, social and household characteristics. The factor **environmental friendliness**, ranked in Table 1 at the 10th position, appears in Table 2 at the 13th position. The mean score for this factor (6.48) is relatively high, which might indicate that a lot of respondents value this factor as important. This score needs however an interpretation with caution since it can also be the result of social desirable answers associated with attitudinal surveys (Gould and Golob, 1998; Kurani et al., 1996).

A.4 Surplus price for environmental friendliness

Consequently, it has been examined if consumers are willing to pay a surplus price for an environmental friendly version of their preferred car. For this purpose the "**Van Westendorp Price Sensitivity Meter"** was used (Socrates technologies, 2005). The theory behind this model is based upon two psychological theories: the "Theory of Reasoned Action" (Fishbein and Ajzen, 1975) and the "Price Signalling Theory" (Spence, 1973). The first theory assumes that consumers can make a rough estimation of the expected cost or cost category of products. The other theory presumes that some low priced products will not be bought, as there are seen as products with poor quality. A disadvantage of the "Price Sensitivity Meter" might be the lack of representing the real purchase behaviour. Two questions have been asked. The first question asked for the respondent's willingness to pay a surplus price for an environmental friendly version of their preferred car (see blue line in Figure 2). In the second question, the respondents had to indicate the maximum amount they were ready to spend on this environmental friendly car (see red line in Figure 2). The first question resulted into a decreasing curve, whereas the second question revealed an increasing curve. The intersection of both curves leads to the **"Point of Marginal Expensiveness" (PME)**. At this point, the amount of respondents that value the surplus price too expensive equals the number of respondents that find the surplus price expensive, but acceptable. In this case, the PME is situated at 1.300 euro. Above this intersection point, the number of respondents that value the surplus price as too expensive will increase. However, it has to be noted that almost 14% of the respondents were not eager to pay an extra amount for an environmental friendly car. This group has not been withheld for the calculation of the PME.

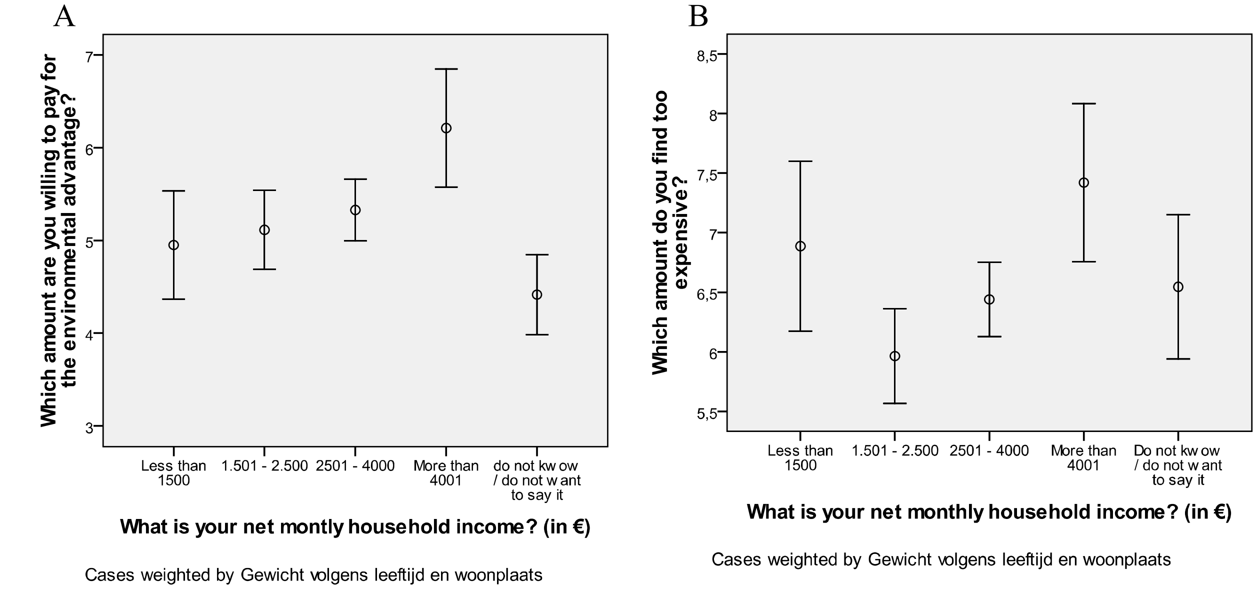
Figure 2: Van Westendorp Price Sensitivity Meter



Source: Own set-up
Blue line: Which net amount are willing to pay for the environmental advantage?
Red line: Which net amount do you find too expensive?

In Figure 3, it has been investigated whether the willingness to pay differs according to the **household income**. Figure 3A displays the amount consumers find acceptable for an environmental friendly version of their preferred car. The lowest mean value is displayed for the group that was not willing to give an indication of their household income. Additionally, the mean value appears to increase along an increasing monthly income. The highest income group displays an average value of 1500 €. In Figure 3B, much more differentiated is noticed regarding the different household income groups. The lowest income group shows an average value of 2000 €, which is the amount that they find too expensive. Surprisingly, the middle income groups display lower mean values of approximately 1500 and 1750 €, which might indicate that lower income groups have a higher willingness to pay an expensive amount for the environmental benefit than middle income classes. The most expensive amount that higher income households are willing to spend is situated around 2250 €. So this might indicate that the lowest and highest income group are willing to pay the largest extra amount for an environmental friendly car, taking into account that these amounts represent a much larger share within the total household income of the lowest income households than in the highest income households. One must however notice that the spread of the results is much higher in these groups, pointing out a larger variation in answers in these two groups.

Figure 3: Willingness to pay according to different income groups



Source: Own set-up

WTP: 3 = 500 €   4 = 750 €   5 = 1000 €   5,5 = 1250 €   6 = 1500 €   6,5 = 1750 €   7 = 2000 €   7,5 = 2250 €   8 = 2500 €   8,5 = 2750 €

A.5 Impact of policy measures

Although the Belgian population shows a heightened concern about the quality of the environment these days, there are not willing to purchase an environmental friendly car even if a reduction of the purchase price for low CO_2 emitting cars and a reduction for diesel cars standard equipped with a particulate filter is granted. The Belgian government could offer these reductions to no more than 43.626[2] cars in 2008. The biggest reduction of 15% could be granted to only 9.637 cars. This is a small amount compared to the 535.947 newly registered cars in 2008. There is however an increasing trend in the purchase of environmental friendly vehicles since the introduction of the reduction for environmental friendly vehicles in 2005. Apart from stimulating the purchase of clean cars by giving reductions, the government can also discourage the purchase and use of energy-inefficient cars by imposing policy measures. Previous research (Peters et al., 2008) demonstrated that a fee at the purchase of a energy-inefficient car has a stronger impact than a reduction of the same amount upon a energy –efficient car as a fee has negative financial implications. In this study, the impact of some policy measures for polluting cars such as (1) **a kilometre charge**, (2) **a congestion charge**, (3) **an increasing parking tariff** and (4) **an extra pollution tax** have been investigated. Consequently, the respondents had to stipulate at which price the policy measure would become so expensive that they would consider the purchase of a cleaner car. Owners of environmental friendly cars would not be affected by these policy measures. Figure 3 shows the buy-response curves. The steepest parts indicate the largest percentual change of the demanded quantity compared to the percentual change of the price (arc elasticity).

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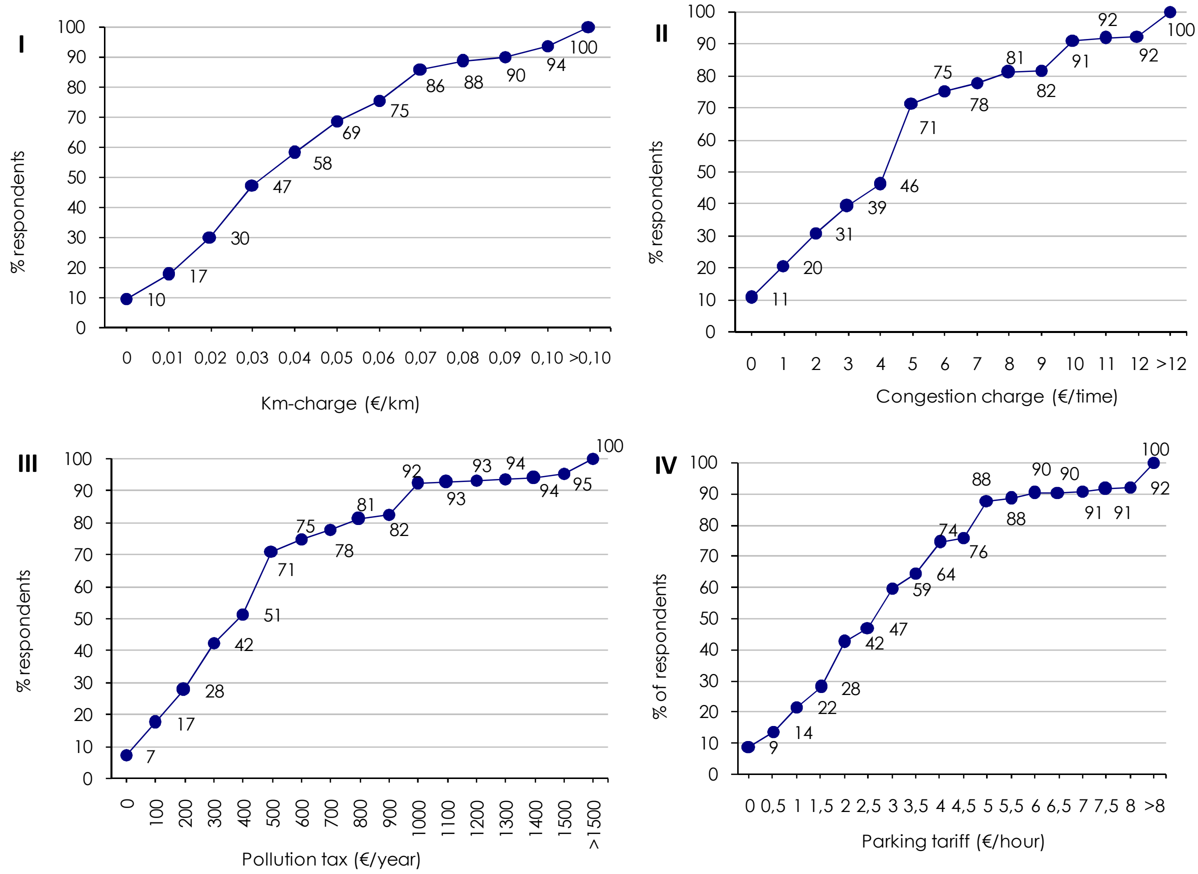
[2] Out of these 43.626 cars, the reductions of 3% and 15% were granted to respectively 18.175 and 9.637 cars. The reduction of the purchase for a diesel car, standard equipped with a particulate filter, could be applied to 15.815 cars.

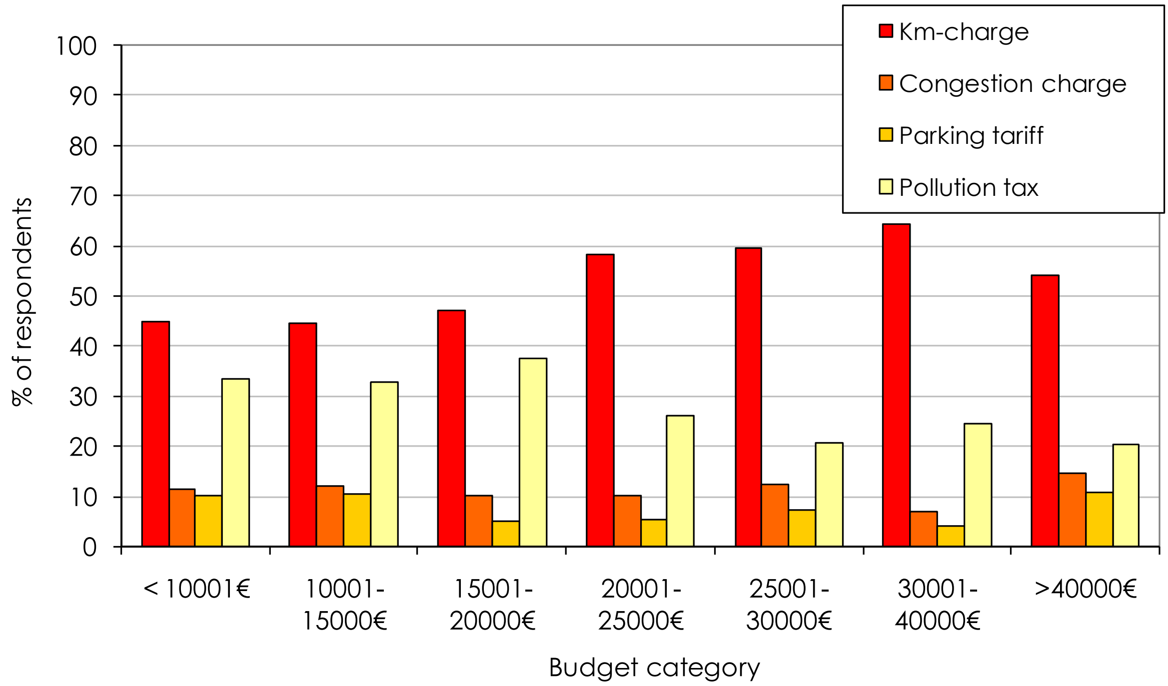
Figure 4: Buy-response curves



Source: Own set-up

For the **kilometre charge** (Figure 4, I), the respondents were asked to precise at which charge/kilometre they would switch to an environmental friendly car. An estimation of this charge on a yearly basis was given, based upon a yearly coverage of 15.000 kilometres. The steepest part is situated between 2 and 3 eurocent/year. This means that a kilometre charge of 2 eurocent/km would stimulate 30% of the respondents to switch to an environmental friendly car, whereas a charge of 3 eurocent/km would already convince 47% of the respondents. A **congestion charge** of 4 euro/time will reach 46% of the respondents (Figure 4, II). At a congestion charge of 5 euro/time, this percentage will increase up to 71%. In case of an **extra pollution tax**, the highest price sensitiveness is situated below 500 euro/year (Figure 4, III). A yearly tax of 300 euro will affect 42% of the respondents, while a yearly tax of 500 euro will have an impact on 71% of the respondents. A **parking tariff** of 3 euro/hour will convince almost 60% of the respondents (Figure 4, IV). At a parking tariff of 4,5 euro/hour, 76% of the respondents would make the shift to an environmental friendly car. A parking tariff of 5 euro would even convince 88% of the respondents. Finally, the respondents had to point out which policy measure would have the largest impact on their purchase behaviour. Out of Figure 5, it seems that a kilometre charge or an extra pollution tax would influence the purchase behaviour the most, independent of the average amount that respondents are ready to spend on the purchase of a new car. In the ideal case, these policy measures should be based on the Ecoscore of the vehicle (Timmermans et al., 2006).

Figure 5: Impact of policy measures



Source: Own set-up

A.6 Conclusion

The results of the face-to-face and web-based survey confirms previous findings demonstrating that the first selection of a new car is based upon the evaluation of rational factors (purchase price, fuel consumption and reliability), whereas the final choice is based on the intrinsic characteristics of the car (comfort, space, size, design) and socio-economic characteristics such as personal, cultural, social and household characteristics. It seems that there is a heightened environmental concern, but which is still of minor importance compared to other car attributes such as reliability, purchase price, security, fuel consumption, comfort, space and size. Moreover, it appears that policy measures such as a kilometre charge or an extra pollution tax can be effective in discouraging the purchase and use of energy-inefficient cars. In the ideal case, these policy measures should be based upon the Ecoscore of cars. This could stimulate the demand for environmental friendly cars evoking a shift in the composition of the Belgian car park towards a more environmental friendly whole.

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B. LITERATURE REVIEW

B.1 Introduction

When evaluating policy measures, it is very important to get an insight in the behavioural responses induced by these governmental incentives. Policy measures will only be effective if they induce the right behavioural changes (Ubbels and Verhoef, 2003). To evaluate the effectiveness of a policy measure, one should take the **travelers'attitudes** (psychological view), as well as the **price elasticities** (economical view) into account. After an introduction to the elasticity concept, this section will consider several factors affecting price sensitivity to research in which direction a price change can influence travel behaviour (psychological view). Next, a literature overview of dissagregated elasticities will be performed with respect to several price components such as vehicle operational costs, parking charges, fuel costs, tolls fees, emissions charges, travel time costs etc. and their resulting changes in travel demand ranging from changes in travel modes, destination, travel routes, departure times and trip patterns to changes of residence and employment location (economical view) (Burris, 2003). Finally, a scheme for the evaluation of policy measures will be presented, developed by Odeck and Brathan (2008). In this scheme, the psychological view (travelers'attitudes) will be linked to the economical view (elasticities) with the aim of getting an insight in the effectiveness of policy proposals. Based on this scheme, recommendations for the use of policy measures in Belgium can be established.

B.2 Elasticities

B.2.1 The elasticity concept

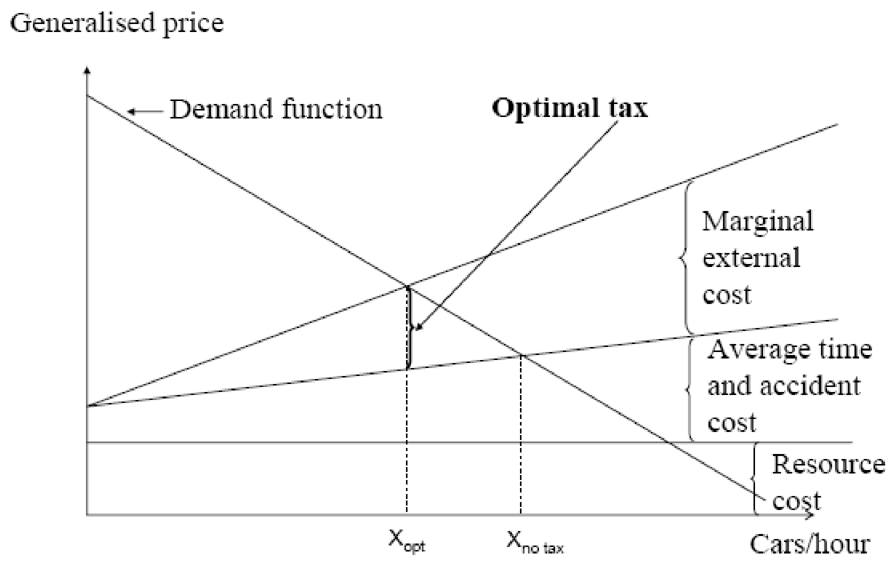
Elasticities are a very important element in the evaluation of policy measures. Car drivers currently base their travel decision upon their **private consumer costs,** including their time and resource costs. However, any individual entering the traffic system will only consider the costs he personally bears (Button, 2003). A car driver will not take the external costs such as accident, congestion and environmental costs into account that he imposes on other road users or the so-called **marginal external costs.** The disparity between the true cost of travelling and the price that drivers are paying is dependent on the price and tax structure.

In Figure 6, it has been assumed that car drivers completely pay for their private consumer costs. The optimal demand for vehicle transport (X_{opt}) is situated at the intersection of the demand curve and the marginal social cost curve. At this point, the price that vehicle users are willing to pay equals the marginal social costs. At $X_{no\ tax}$, the price that vehicle users are willing to pay is lower than the marginal social cost. This current disparity between the true cost of travelling and the price that vehicle users pay leads to an inefficient high travel demand. In theory[3], the optimal flow of traffic would occur if vehicle users are charged an

[3] In practice, it may become difficult to implement policy measures that are closely related to the marginal costs. Due to technical challenges and political objections, there is a strong preference for second-best reasoning, where deviations from the optimal tax scheme are justified (Burris, 2006).

optimal tax. The change in overall price (from private cost to marginal social cost) will evoke a corresponding change in demand (from $X_{no\ tax}$ to X_{opt}). The ratio of these changes is known as the **price elasticity of travel demand** (Mayeres and Proost, 2004; Burris, 2003).

Figure 6: Optimal tax scheme



Source: Mayeres and Proost (2004)

The price elasticity of travel demand measures the reactivity of a change in price on travel demand, both measured in percentage changes (Formule 1). As drivers are a heterogeneous group meaning that every individual driver may react differently to the exact price change when that change occurs in different components of the total driving price, the price elasticity of travel demand in often dissagregated into elasticities with respect to several price components such as vehicle operational costs, parking charges, tolls fees, travel time costs etc. The resulting changes in travel demand are for example changes in travel modes, destination, travel routes, departure times, trip patterns, work schedules, residence, employment location etc. (USEPA, 1998; Burris, 2003).

Formule 1: Price elasticity of travel demand

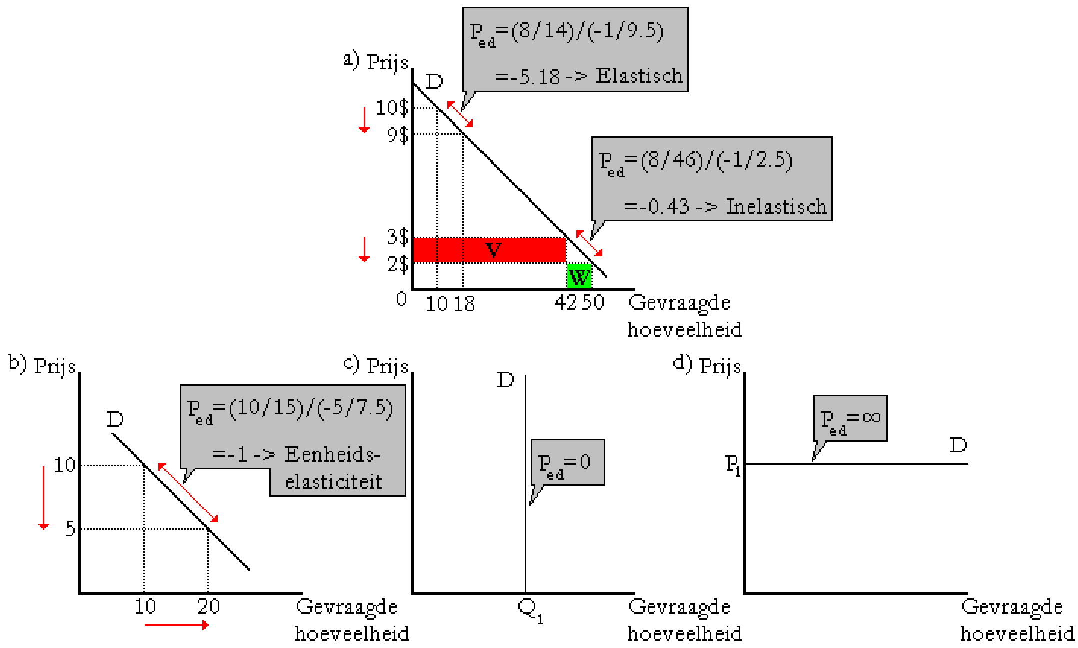
$$elasticity = \frac{\Delta Q}{\Delta P}$$

With:

ΔQ : Percentual change in travel demand
ΔP : Percentual price change

According to the law of demand, price elasticities will always be negative as increasing prices of a certain good or service result into a lower demand of that good or service. The question remains how much the demanded quantity will change as a result of a price change. The demanded quantity is called **elastic** compared to the price change when the absolute value of the elasticity is higher than 1.0. A price change will then result in a more than proportional change of the demanded quantity. The demanded quantity is called **inelastic** compared to the price change when the absolute value of the elasticity is smaller than 1.0. A price change will then result in a less than proportional change of the demanded quantity. An elasticity of 1.0 is called a **unit elasticity** as the demanded quantity will change in exactly the same proportion as the price change. These terms are illustrated in Figure 7.

Figure 7: Elastic – inelastic – unit elastic



Source: Mulhearn et al. (2001)

B.2.2 Measures of elasticity

Several methods can be used to derive price elasticities of travel demand. The first one is the **point elasticity** (Formula 2).

Formula 2: Point elasticity

$$\eta_p = \frac{dQ}{dP} \times \frac{P}{Q}$$

With:

$\frac{dQ}{dP}$ as the partial derivative of the demanded quantity with respect to the price

η_p as the point elasticity

Source: Pratt (2003)

In real world situations, there is often not enough information available to determine the functional relationship between price (P) and demanded quantity (Q). This precludes the calculation of point elasticities from empirical data. As a result, other elasticity measures have been constructed to allow the use of observed changes in price and associated demand. The elasticity measure that most nearly approximates the point elasticity is the frequently used **arc elasticity** (Formula 3)**.**

Formula 3: Arc elasticity

$$\eta = \frac{\Delta \log Q}{\Delta \log P} = \frac{\log Q_2 - \log Q_1}{\log P_2 - \log P_1}$$

With:

Q_1 as the initial demanded quantity before the price change
Q_2 as the final demanded quantity after the price change
P_1 as the original price
P_2 as the new price
η as the elasticity

Source: Pratt (2003)

The arc elasticity is based upon the orginal and final values of demand and price. When one of these values is zero, the **mid-point or linear arc elasticity** (Formula 4) should be used. Except for large price changes of P and Q, this elasticity is a good approximation for the arc elasticity. Mid-point or linear arc elasticities are often used in situations where goods or services become free of charge (f.ex. free public transport).

Formula 4: Mid-point elasticity

$$\eta = \frac{\dfrac{\Delta Q}{(Q_1 + Q_2)/2}}{\dfrac{\Delta P}{(P_1 + P_2)/2}} = \frac{\Delta Q (P_1 + P_2)}{\Delta P (Q_1 + Q_2)} = \frac{(Q_2 - Q_1)(P_1 + P_2)}{(P_2 - P_1)(Q_1 + Q_2)}$$

With:

$\Delta Q = (Q_2 - Q_1)$ expressed in units (number of pieces, etc.)
$\Delta P = (P_2 - P_1)$ expressed in currencies (Euro, Dollar, etc.)

Source: Pratt (2003)

The third and final method is the **shrinkage ratio** or the **shrinkage factor** (Formula 5). This factor is defined as the relative change in demand relative to the original demand divided by the relative change in price relative to the original price.

Formula 5: Shrinkage ratio

$$\eta = \frac{\Delta Q / Q_1}{\Delta P / P_1} = \frac{(Q_2 - Q_1) / Q_1}{(P_2 - P_1) / P_1}$$

With:

$\Delta Q = (Q_2 - Q_1)$ expressed in units (number of pieces, etc.)

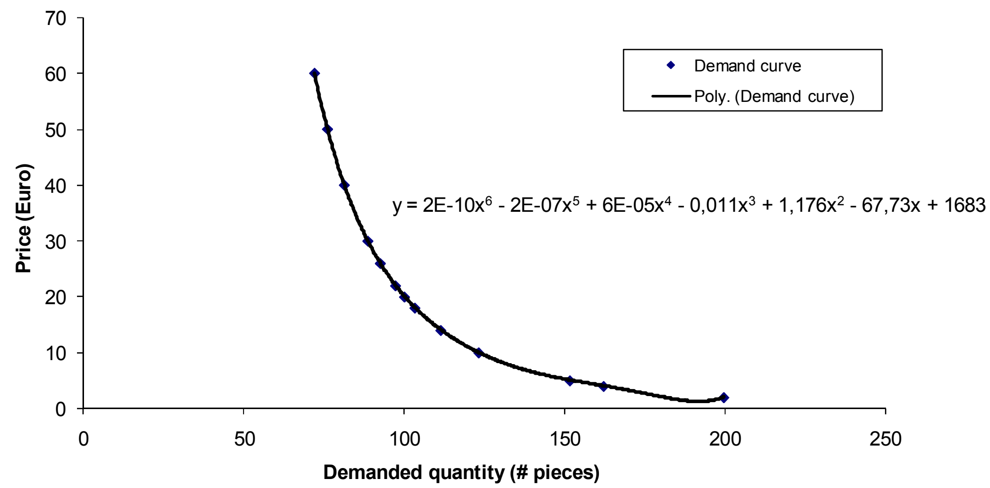
$\Delta P = (P_2 - P_1)$ expressed in currencies (Euro, Dollar, etc.)

Source: Pratt (2003)

B.2.3 Differences between elasticity measures

When the percentage change in price is small, all elasticity measures give approximately the same value (**hypothesis 1**). Large price changes result however in different elasticity values depending on the used elasticity measure (**hypothesis 2).** In this section, these two hypotheses of Pratt (2003) will be tested. Fictive couples of prices and quantities have been used to set up a demand curve (Figure 8, blue points).

Figure 8: Demand curve



Source: David Zimmer (2008)

The first elasticity measure that is tested is the **point elasticity**. As seen in previous section, the functional relationship between P and Q needs to be known to derive point elasticities. The functional relationship has been defined by fitting the couples (P,Q) by a polynoom of order 6 (Figure 8). This polynoom is an approximation of the demand curve. In Table 3, the percentual deviations of the polynoom with respect to the measured couples have been calculated. It has been found that the percentual deviations are smaller than 0,5%, indicating that the polynoom seems to be a good fit of the demand curve. By means of this polynoom, the point elasticities could be derived (Table 4).

Table 3: Fitting the demand curve

Percentual price change	Demand at price P1	Demand at price P2	Original price	New Price	New Price (Polynome approach)	Percentual deviation
	Q1	Q2	P1	P2		
%	# pieces	# pieces	Euro	Euro		%
-90		200		2	2	0,01
-80		162		4	4	0,24
-75		152		5	5	0,39
-50		123		10	10	0,45
-30		111		14	14	0,26
-10		103		18	18	0,18
0	100		20			
10		97		22	22	0,02
30		92		26	26	0,13
50		89		30	30	0,14
100		81		40	40	0,03
150		76		50	50	0,12
200		72		60	60	0,06

Source: David Zimmer (2008)

Table 4: Calculation of the elasticities (2)

Percentual price change	Point elasticity	Arc elasticity	Percentual deviation	Linear arc elasticity	Percentual deviation	shrinkage ratio	Percentual deviation
%			%		%		%
-90	0,041	-0,300	826,35	-0,406	1083,28	-1,106	2777,44
-80	-0,252	-0,300	19,15	-0,355	41,09	-0,776	208,12
-75	-0,319	-0,300	5,88	-0,342	7,19	-0,688	115,72
-50	-0,291	-0,300	2,94	-0,311	6,64	-0,462	58,62
-30	-0,298	-0,300	0,83	-0,303	1,80	-0,376	26,52
-10	-0,302	-0,300	0,77	-0,300	0,68	-0,321	6,22
0	-0,303						
10	-0,303	-0,300	0,94	-0,300	0,88	-0,282	6,93
30	-0,301	-0,300	0,48	-0,302	0,04	-0,252	16,30
50	-0,300	-0,300	0,10	-0,304	1,34	-0,229	23,57
100	-0,298	-0,300	0,75	-0,311	4,37	-0,188	36,95
150	-0,300	-0,300	0,06	-0,319	6,17	-0,160	46,62
200	-0,306	-0,300	1,92	-0,327	6,79	-0,140	54,10

Source: David Zimmer (2008)

In real world situations, lack of information on the functional relationship between P and Q precludes the calculation of point elasticities from empirical data. For that reason, other elasticity measures have been used to measure the observed price changes and associated demand such as the arc elasticity, the linear arc elasticity and the shrinkage ratio (Table 4). Out of table 4, it seems that these elasticity measures are less accurate than the point elasticity, as shown by their percentual deviations. These deviations prove that the arc elasticity is the best approximation of the point elasticity. The extreme values in the first row of Table 4, are due to the fact that the polynoom shows an increasing trend at the end which leads to positive elasticities (Figure 8). Table 4 also points out some irrigularities with respect to the shrinkage ratio. Its elasticities are not the same at increasing and decreasing prices, in contrast the arc elasticity. In Table 5, the calculated elasticities are used to calculate the new demanded quantities Q2. In order to get an adequate comparison of the different elasticity measures, the point elasticity has been kept at a constant elasticity rate of -0,3.

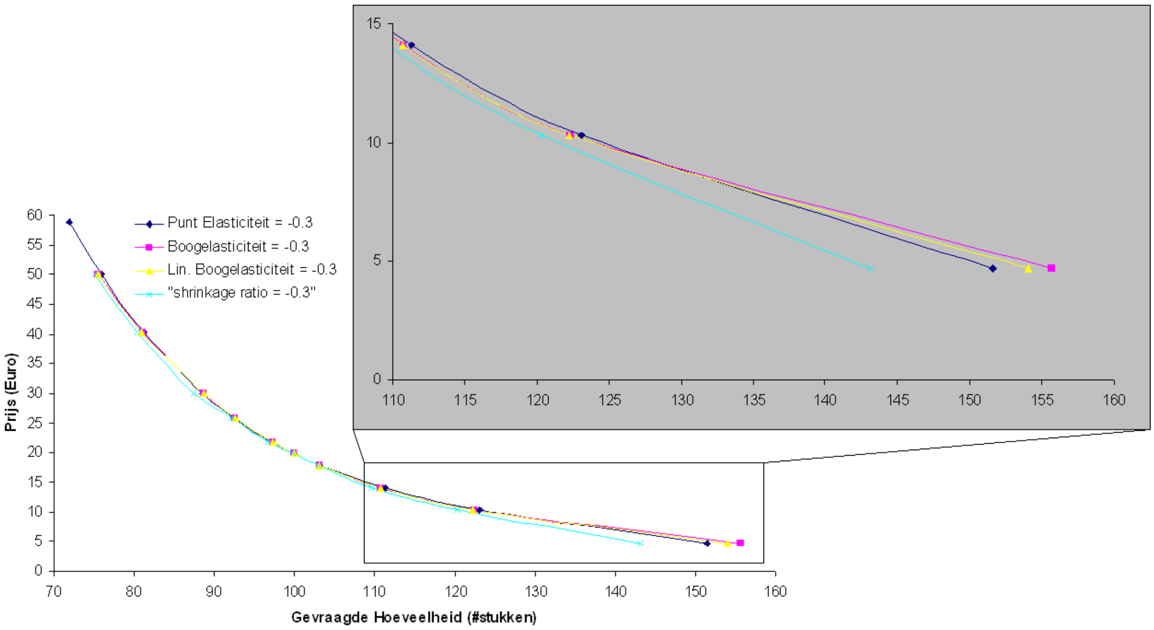
Table 5: Elasticity methods for small price intervals

Demand at P1	Original price	Point elasticity	Arc elasticity = -0.3		Linear arc elasticity = -0.3	shrinkage ratio = -0.3	
Q1	P1		P2	Q2	P2	P2	Q2
# pieces	Euro		Euro	# pieces	Euro	Euro	# pieces
152	5	-0,300					
123	10	-0,300	5	156	5	5	143
111	14	-0,300	10	122	10	10	120
103	18	-0,300	14	111	14	14	110
100	20	-0,300	18	103	18	18	103
97	22	-0,300	20	100	20	20	100
92	26	-0,300	22	97	22	22	97
89	30	-0,300	26	93	26	26	92
81	40	-0,300	30	89	30	30	87
76	50	-0,300	40	81	40	40	80
72	59	-0,300	50	76	50	50	75

Source: David Zimmer (2008)

Table 5 confirms **hypothesis 1** illustrating equivalent results (Q2) for all elasticity measures at small percentual price changes. One exception is the shrinkage ratio showing a larger deviation. This underlines the supposition that the shrinkage ratio is seen as the less suitable approach (Pratt, 2003). In Figure 9, the results are presented graphically.

Figure 9: Demand curves for small price intervals



Source: David Zimmer (2008)

In order to test **hypothesis 2** pretending that large price changes result into significant differences along the elasticity measure, the demanded quantities (Q2) associated with large price changes have been calculated (Table 6).

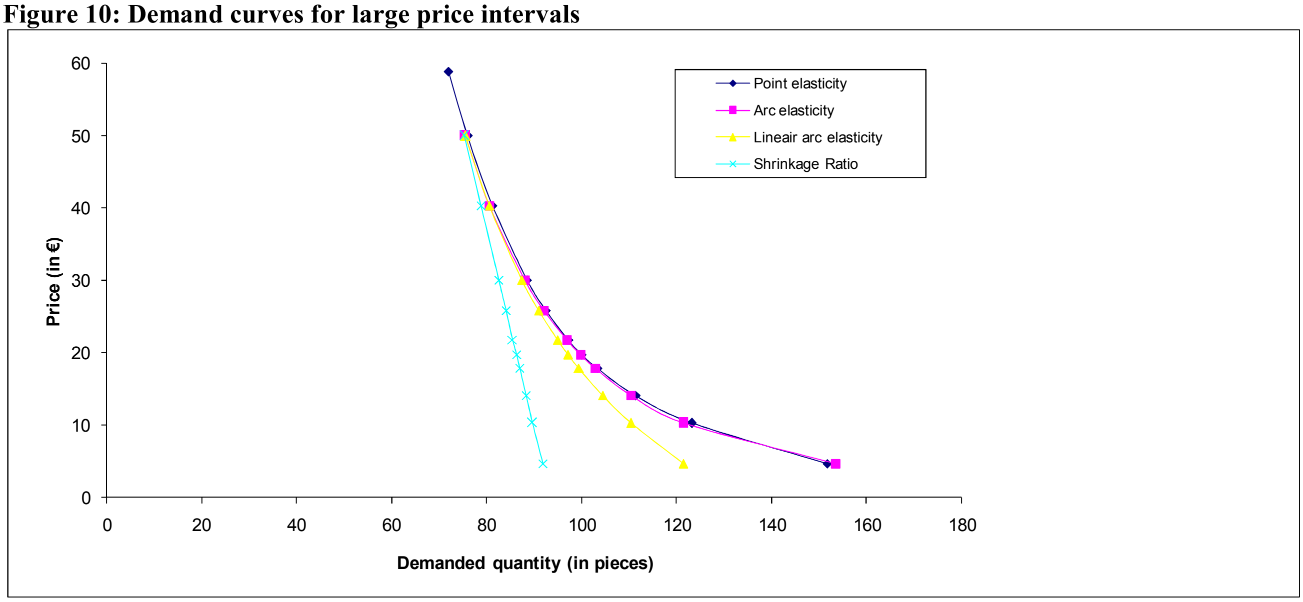
Table 6: Elasticity methods for large price intervals

Demand at P1	Original price	Orginal demand at price P2	Point elasticity	Arc elasticity = -0.3		Linear arc elasticity = -0.3		shrinkage ratio = -0.3	
Q1	P1	Q1(P2)		P2	Q2	P2	Q1	P2	Q1
# pieces	Euro	# pieces		Euro	# pieces	Euro	# pieces	Euro	# pieces
72	59								
72	59	152	-0,300	5	153	5	121	5	92
72	59	123	-0,300	10	121	10	110	10	90
72	59	111	-0,300	14	110	14	104	14	88
72	59	103	-0,300	18	103	18	99	18	87
72	59	100	-0,300	20	100	20	97	20	86
72	59	97	-0,300	22	97	22	95	22	86
72	59	92	-0,300	26	92	26	91	26	84
72	59	89	-0,300	30	88	30	87	30	82
72	59	81	-0,300	40	81	40	80	40	79
72	59	76	-0,300	50	76	50	76	50	75

Source: David Zimmer (2008)

The greater the price change, the greater the elasticity measures differ from the point elasticity. This confirms hypothesis 2. The results are presented graphically in Figure 10.

Figure 10: Demand curves for large price intervals



Source: David Zimmer (2008)

B.3 Factors affecting price sensitivity

In this section, several factors affecting price sensitivity will be identified as it is interesting to determine in which direction a price change can influence travel demand. The identified factors are among others type of price change, characteristics of the pricing policy, type of trip and traveller, quality and price of alternative routes, modes and destinations, scale and scope of pricing and time period.

B.3.1 Type of price change

Different policy measures can have various impacts on travel behaviour (Table 7). **Fixed vehicle taxes** will affect vehicle ownership and vehicle type as the price of car ownership will increase. **Fuel prices** affect vehicle use and causes travellers to switch modes, take shorter trips or change destinations. A fuel price increase seems to affect longer trips more than shorter trips due to the direct proportion of vehicle kilometres travelled. Higher fuel prices also stimulate less rapid acceleration, better maintenance, and other driving-style improvements to reduce fuel consumption. On the longer term, vehicle ownership will also be affected as people will purchase more fuel-efficient vehicles (USEPA, 1998). **Fixed tolls and congestion pricing** will rather affect car use and can induce a destination change, fewer trips and stimulate the use of other modes such as public transportation. **Parking fees** are more likely to affect vehicle ownership, but they have also an impact on trip destinations as well as on vehicle use as the fee has an explicit linkage to the particular trip (USEPA, 1998). **Subsidies** are rather seen as a supportive strategy of another active pricing measure as travel behaviour is less influenced by a cost incentive than a disincentive (USEPA, 1998). This is confirmed by Peters et al. (2008) saying that the improved fuel efficiency of a combination of a rebate for a fuel- efficient car and a fee for a fuel-inefficient car comes from only 5% by consumers choosing other makes, models and classes of vehicles whereas 95% of the improved fuel economy comes through manufacturers. In case of **modal subsidies** increasing the use of less-polluting modes through a reduction in their relative price, small land use effects are expected unless the subsidies are of significant size and permanent. It would also have a large impact on the modal shift as the modes being subsidized become very attractive. **Emission fees** can be designed in several ways. It can be added to the vehicle registration tax and/or circulation tax discouraging vehicle ownership of older and higher-emitting vehicles. Another option is to link the emission fee to the annual travelled vehicle kilometres or by relating it to the actual measured emissions at the time of inspection. In that case, vehicle ownership as well as vehicle use will be affected (USEPA, 1998).

Table 7: Impacts of Different Types of Pricing

Type of Impacts	Vehicle Fees	Fuel Price	Fixed Toll	Congestion Pricing	Parking Fee	Modal Subsidies	Emission Fees
Vehicle ownership. Consumers change the number of vehicles they own.	X				X	X	X
Vehicle type. Motorist chooses different vehicle (more fuel efficient, alternative fuel, etc.)	X	X					X
Route Change. Traveler shifts travel route.			X	X	X		X
Time Change. Motorist shifts trip to off-peak periods.				X	X		
Mode Shift. Traveler shifts to another mode.		X	X	X	X	X	
Destination Change. Motorist shifts trip to alternative destination.		X	X	X	X		X
Trip Generation. People take fewer total trips (including consolidating trips).		X	X	X	X	X	X
Land use changes. Changes in location decisions, such as where to live and work.			X		X	X	X

Source: Litman (2008) and USEPA (1998)

B.3.2 Characteristics of the pricing policy

Policy measures are only effective if they are accepted by the public. It appears that people accept policy measures if they believe that it will not be effective and vice versa (Steg, 2003). Two major factors affect the effectiveness and acceptability of policy measures. The first factor is associated with the individual characteristics. The second factor is related to the exact shape of the policy measure. The shape of the policy measure depends on four items (1) static, dynamic or variable, (2) push or pull, (3) size of price change and (4) terms of payment.

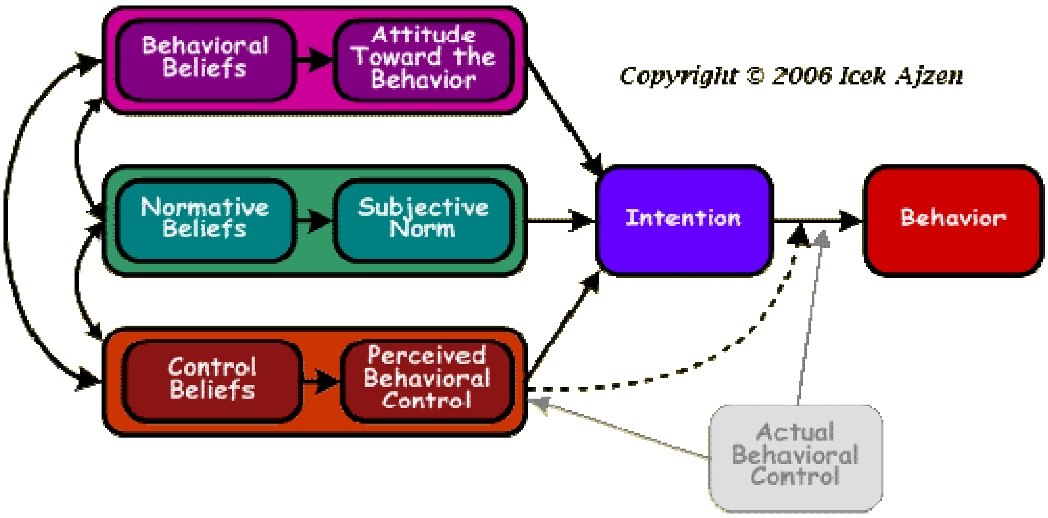
B.3.2.1 Static, Dynamic or Variable policy

Static policy is not differentiated to time, location and type of vehicle. This kind of policy counts for everyone at anytime, anywhere and for any type of vehicle. **Dynamic** policy takes the current traffic situation into account and bases its price dependent on the traffic situation at a certain time. **Variable** policy is the most commonly used policy and it targets specific user groups, roads, vehicle types, time periods etc. (Schuitema, 2003).

B.3.2.2 Push or pull measures

Push measures intent to make car ownership and usage less attractive (f.ex. increasing vehicle costs). This kind of measures is seen as a punishment as they involve negative financial implications. **Pull measures** have in contrast no direct influence on car use (f.ex. stimulating the use of alternative transportation modes). This kind of measures is seen as a reward and offers people more opportunities. The **acceptability** of push or pull measures depends on several factors (Eriksson et al., 2008). A first factor is how the **revenues** will be spend. Road users prefer schemes where the additional receipts are used in the same domain than using it for general public funds. Politicians prefer budgetary neutral proposals keeping the total tax receipts constant. A second factor is the **perceived effectiveness**. The acceptability will be higher when the policy measure is perceived to actually contribute to f.ex. the solution of environmental problems. A third factor is the extent in which the measure is perceived to be **fair**. A final factor is the **individual characteristics** such as intentions shaped by attitudes, subjective norms and perceived behavioural control (Figure 11). Attitudes are the extent in which on assesses something favourable or not favourable. Subjective norm is the perception of a person about the normative expectations of others such as close friends or family. Perceived behavioural control is the personal feeling that one could easily change its behaviour and that one disposes over possibilities to do this. The actual behaviour will be based upon intentions, determined by attitudes, subjective norms and perceived behavioural control. This Theory of Planned Behaviour pretends that if attitudes and subjective norms are favourable, the perceived behavioural control will be larger and the intention for behavioural change will be stronger (Ajzen 1985; Ajzen 1991). In this respect, policy measures will be acceptable if one has a negative attitude towards car use, one does not experience a strong social pressure for car use, and when one has the feeling of being able to change his behaviour (Steg and Schuitema, 2003).

Figure 11: Theory of planned behaviour



Source: Ajzen, 2006

B.3.2.3 Size of the price change

The size of the price change plays a very important role in evaluating policy measures. **Small price changes** evoke only minor effects as these price changes are often not observed. **Large price changes** are in contrast more effective in evoking behavioural changes. In general, large price changes are perceived as less acceptable than small price changes (Steg, 2003). This is first of all related to the fairness of the measure. Secondly, large price changes can evoke reactance as it could restrict the financial freedom of people. Large price changes are nevertheless more effective in changing travel behaviour, as long as it is found acceptable by the public. Price reductions will only be effective if related to large price reductions (Linderhof, 2001). Price reductions are often used to make alternative transportation modes more attractive. Small as well as large price reductions are acceptable as they imply no financial consequences (Schuitema, 2003).

B.3.2.4 Terms of payment

The **shorter** the payment period, the more effective the policy measure. Payments can be done directly or later on. Excises on fuel are for example paid directly, whereas taxes related to car ownership are paid later on. Such fixes taxes have no influence on car use as they are associated with car ownership. Price changes on the **long term** will rather influence the behaviour on the long term (with respect to car ownership), than on the short term (with respect to car use). Variable taxes such as excises on fuel can affect long term as well as short term behaviour. As a result, variable taxes can influence more types of behaviour than fixed taxes (Schuitema, 2003).

B.3.3 Type of trip and traveller

Commuting trips tend to be less elastic than other trips. At increasing car costs, **shopping and visiting trips** will be most affected, while commuting trips will be less affected (Schuitema et al., 2007). **High income travellers** tend to be less price sensitive than **low income travellers**. Some demographic groups such as people with lower incomes, people without a driver's licence, students, disabled persons or elderly people appear to be more dependent on public transportation. As a result, price changes will only have minor effects on the use of public transportation. If the transit system wants to attract more people while reducing car use, transit prices will have to go down meanwhile improving the supplied services in order to attract more price sensitive discretionary travellers (Litman, 2004). **Big cities** tend to have lower elasticity values than the **suburbs** as they have a larger amount of transit dependent users. The bigger the city, the larger the use of public transportation. This is the result of the increasing traffic congestion, parking tariffs and better transit services (Litman, 2004).

B.3.4 Quality and price of alternative routes, modes and destinations

There is a higher price elasticity if **alternative routes, modes and destinations** are of good quality and affordable. A tolled highway is for example more price elastic when there exists a parallel untolled highway (Litman, 2008).

B.3.5 Scale and scope of pricing

Peak-period travelling on a certain road can be price elastic as this may shift travelling to alternative routes, destinations, modes and travel times. Most policy measures (tolls, parking charges, fuel taxes) will be price inelastic as these extra costs represent a small share within the total user costs of a car. Driving is however elastic when the total costs of the car are taken into account. If fuel costs make up 15% of the total costs of the car, its elasticity of -0,2 will actually be an elasticity of -1,3 if one takes into account the total financial costs (Litman, 2008).

B.3.6 Time period

Transportation elasticities tend to increase over time as consumers will take prices into account when making long-term decisions (Figure 12). That is why it can take some time before the full effect of the price change appears. **Short-term elasticities** are usually defined as responses made within less than two years, whereas **long-term elasticities** are rather related to periods of 5 to 10 years, within which the greatest part of the response is in the first 3 to 5 years. Long-run elasticities are estimated to be larger, usually by a factor 2 to 3, than short-run elasticities (Goodwin, Dargay and Hanley, 2003).

Figure 12: Dynamic elasticity

Source: Dargay and Hanly in: Litman, 2004

B.3.7 Comparing distant places and times

Price changes seem to have similar effects in **distant places and time**. As a result, it may be appropriate to evaluate a policy measure relative to the local wages or incomes, so that the results can be compared between different countries and time periods (Litman, 2008). Extra care should be given to forecasting the value of a price in a future year as it is commonly assumed that all travel prices will increase in the future at the same rate of inflation. Moreover, it is extremely difficult to extrapolate results from other parts of the world to particular environments as it depends on several variables such as congestion levels, quality of alternative modes, political climate, level of public engagement in transportation planning and pricing levels (Washbrook et al., 2006).

B.3.8 Large and cumulative price changes

Extra care should be used when calculating the impacts of large price changes or when summing the effects of multiple changes, because each subsequent change impacts a different base (Litman, 2008).

B.4 Literature review

As there exists no single elasticity of policy measures, the price elasticity is often disaggregated into elasticities with respect to several price components such as vehicle operational costs, parking charges, fuel costs, tolls fees, emission charges, travel time costs etc. This literature overview will consider those disaggregated elasticities and will give an overview of resulting changes in travel demand ranging from changes in travel modes, destination, travel routes, departure times and trip patterns to changes of residence and employment location (USEPA, 1998; Burris, 2003).

B.4.1 Vehicle operating costs

This elasticity measures the effect of **vehicle operating costs** such as fuel costs, parking charges etc. on travel demand. De Borger et al. (1997) estimated elasticities for urban peak travel in Belgium to be – 0,384 for vehicles and – 0, 35 for public transit. As a 10% increase in price will result in a decreasing demand of 3,8% for vehicle travel, and 3,5% for public transit, we may conclude that the Belgian consumer is on average more sensitive for its vehicle expenses than for its public transport expenses. As to Small and Winston (1999), the price sensitivity of a particular vehicle's use increases over time depending on whether it is the only vehicle in the household or not. This may be important when analyzing the impact policy measures can have on the use of vehicles that have desirable attributes such as increased fuel efficiency or reduced emissions (Litman, 2008). Table 8 illustrates the impact of out-of-pocket expenses on travel demand. Leisure activities display the largest elasticities because of the availability of various alternatives.

Table 8: Elasticities with respect to out-of-pocket expenses

Type of trip	Elasticity of road travel w.r.t. out of pocket expenses
Urban shopping	-2.7 to -3.2
Urban commuting	-0.3 to -2.9
Inter-urban business	-0.7 to -2.9
Inter-urban leisure	-0.6 to -2.1

Source: Button (1993) in: Litman (2008)

B.4.2 Parking price

Vehicle drivers tend to be very sensitive to parking prices as they have to be paid immediately (Litman, 2008). Parking prices are found to have a larger effect on vehicle trips, 1.5 to 2 times larger, than other out-of-pocket expenses (USEPA, 1998). Table 9 displays the impact parking prices may have on various types of travel. The displayed elasticities are **European long-term elasticities** for vehicle-oriented urban areas and they refer to increasing parking rates in areas where parking charges already exist.

Table 9: European parking price elasticities

Purpose	Car Driver	Car Passenger	Public Transport	Slow Modes
Trips				(Walking or cycling)
Commuting	-0.08	+0.02	+0.02	+0.02
Business	-0.02	+0.01	+0.01	+0.01
Education	-0.10	+0.00	+0.00	+0.00
Other	-0.30	+0.04	+0.04	+0.05
Total	***-0.16***	***+0.03***	***+0.02***	***+0.03***
Kilometres				
Commuting	-0.04	+0.01	+0.01	+0.02
Business	-0.03	+0.01	+0.00	+0.01
Education	-0.02	+0.00	+0.00	+0.00
Other	-0.15	+0.03	+0.02	+0.05
Total	***-0.07***	***+0.02***	***+0.01***	***+0.03***

Source: TRACE (1999) in: Litman (2008)

A 10% increase in parking charges will decrease car drivers' trips with - 1,6% and car drivers' kilometres with - 0,7%. Increasing parking prices will in contrast stimulate carpooling: + 0,3% for trips and + 0,2% for kilometres. Alternative transportation modes such as public transport and slow modes will also become more attractive. According to TRACE (1999), parking price elasticities can also be used to predict the impact of an area or cordon- based road pricing or to predict the impact of a change in supply of parking spaces as the price is more or less a fixed amount per trip. With respect to **parking supply**, Mildner, Stratman and Bianco (1997) discovered that increased supply tends to increase vehicle use, while reducing the use of public transport and carpooling. A higher parking charge will also have a negative impact on the use of **parking facilities** within a certain area. A decrease in use of parking facilities in one area can result in an increase of the use of parking facilities in other areas without higher parking fees. Another possible effect of higher parking charges in one area is illegitimate "spillover" parking.

Total vehicle travel can be affected by increasing parking charges on the condition that there is an effective enforcement of **parking regulations** and an availability of good travel alternatives. However, Mayeres and Proost (2004) discovered that one could obtain only 30% of welfare gain (with respect to the optimal policy) by imposing parking charges in Belgium. This low amount of welfare gain is due to the fact that parking charges cannot be differentiated according to off-peak and peak periods.

As most parking is free outside the commercial areas of Belgium, it is interesting to have a look at the effect from **free to priced parking** on mode shifts (drive alone, carpool, transit and other). Feeney (1989) (in: Litman, 2008) found out that shifting from free to priced parking reduces drive alone commuting by 10-30%, especially in combination with improvements in transit service. A last interesting result comes from Washbrook, Haider and Jaccard (2006) where it was determined how commuters respond to various pricing measures such as a road toll and a parking charge and how it would affect their drive alone rates. Table 10 shows that free parking, combined with unpriced roads results into 83% commuters driving alone. A parking fee of $3, together with a daily road toll of $3 results in 56% of the commuters driving alone. A parking fee of $9 and a road toll of $9 will reduce the commuters driving alone to 17%, which is a reduction of 66% in drive alone demand compared to the first "free" scenario.

Table 10: Impact of various pricing measures on commuting

Road Toll	Free Parking	$1 Parking	$3 Parking	$6 Parking	$9 Parking
$0	83%	80%	74%	62%	49%
$1	78%	75%	68%	55%	42%
$3	68%	65%	56%	43%	30%
$6	56%	52%	43%	31%	21%
$9	50%	46%	37%	26%	17%

Source: Washbrook, Haider and Jaccard (2006) in: Litman (2008)

B.4.3 Fuel consumption with respect to fuel price

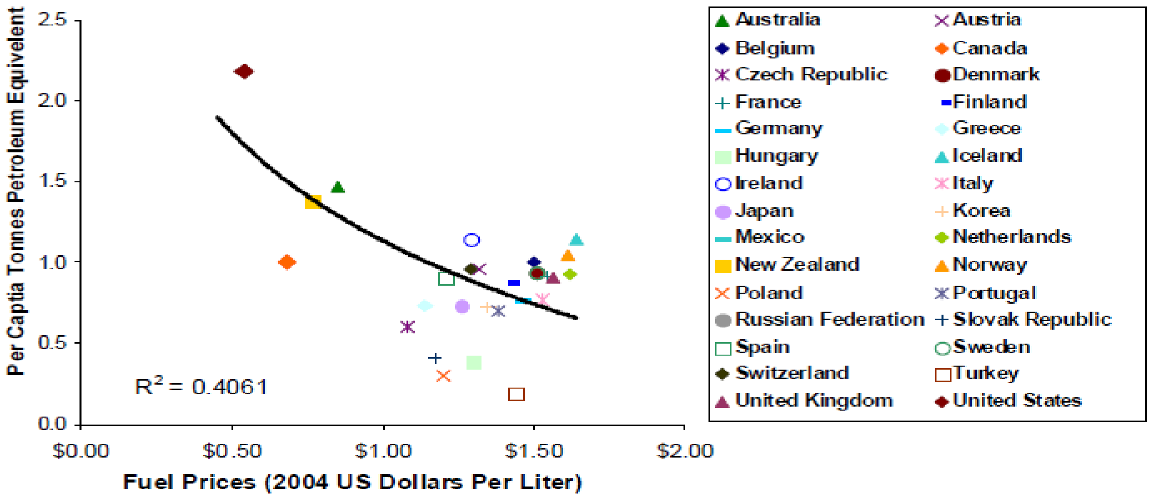
Fuel price elasticities are one of the most widely studied elasticities. A review of **fuel price elasticities**, elaborated by Goodwin (1992) resulted in a short-run fuel price elasticity of – 0, 27 and a long-run fuel price elasticity of – 0,71. In the short run, a 10% increase in fuel prices will reduce fuel consumption with 2,7% as total vehicle travel and traffic speeds will decrease. The reduction in total vehicle travel is estimated to be – 1,5%. In the longer run, a 10% increase in fuel prices will reduce fuel consumption by 7% as people will switch to the purchase of more fuel-efficient vehicles and to more accessible land use patterns. Moreover, total vehicle travel tends to decrease with 3 to 5%. Short term as well as long term elasticities are higher for fuel consumption than for vehicle traffic as the rapid behavioural responses such as changes in driving speed or style, or modifying the least energy-inefficient trips will affect fuel consumption more than traffic. Manipulation of fuel prices will in this respect be more effective in reducing fuel consumption than in reducing road congestion (Graham and Glaiser, 2002). In addition, fuel taxes will reduce the overall long-term fuel consumption much more than an increase in other vehicle related taxes such as ownership taxes (Johansson and Schipper, 1997).

In the **short run**, fuel prices will affect **traffic speed**. Traffic speed is dependent on the height of fuel price change, the potential fuel savings and the drivers'value of time. CBO (2008) discovered that if the value of potential fuel savings is small compared to the value of time, the likely effect of fuel prices on traffic speed will be rather small. Car drivers will reduce their speed up to the level at which the value of the fuel savings equals the value of time lost to slower driving. It has to be noticed that the preferred speed is of course also a function of other variables such as the local speed limit and its enforcement, time of the day, time of the year, traffic density, and physical characteristics of the road and location. The effect of fuel prices on traffic speed has been estimated to be around -0,05 indicating that a 10% increase in the price of fuel would cause the median speed to decrease by about 0,5%.

The longer fuel prices remain, the more it will affect the consumers' expectations about future prices. These expectations will influence the consumers **long-term** decisions such as the purchase of a new car. CBO (2008) warns for the fact that a smaller fuel price effect may be expected as automakers are giving incentives in times of higher fuel prices for cars with a higher fuel consumption such as SUVs and light trucks. As a result, consumers will be stimulated to purchase a fuel-inefficient car in times of high fuel prices.

Figure 13 shows that countries with higher fuel prices tend to drive with more fuel-efficient vehicles (**long-term effect**), driving fewer annual kilometres and rely more on alternative modes (**short-term effects**). The United States, Canada, Australia and New Zealand are for example experiencing low fuel prices which results into a high transport energy consumption. Other countries with higher fuel prices consume about half as much transport energy. Moreover, Lutsey and Sperling (2005) found out that countries with low fuel prices use vehicle energy efficiency improvements to increase the vehicle performance rather than improving the fuel economy.

Figure 13: Fuel price versus per capita Transport Energy Consumption



Source: Litman (2007)

A very interesting result comes from Small and Van Dender (2007) and CBO (2008) pointing out that household **income** appears to have a larger impact on fuel consumption than fuel prices. In addition, the impact of fuel prices on driving and on the demand for fuel appears to decline as income rises. A consequence is that the impact of fuel prices on fuel demand works increasingly through economy improvements rather than through reductions in the amount of driving. As a result, fuel taxes should rise more than income to keep fuel consumption at a constant rate. High fuel taxes are however not politically attractive. That is why Small and Van Dender (2007) advise to combine fuel taxes with **fuel-efficiency regulations**. Improved fuel-efficiency may in contrast produce a “rebound effect”, as a better fuel economy will result in lower fuel costs and in increased driving. This rebound effect is expected to be rather small thanks to two reasons. The first one is that rising incomes will diminish the rebound effect as the share of fuel expenditures within the total expenditures will decline, which might lead to lower elasticities. The second one is that higher incomes lead to higher values of time so that time costs become relatively more important than fuel costs. Taking into account this small rebound effect, Small and Dender (2007) are in favour of combining fuel taxes with fuel-efficiency regulations as it would promote technological improvements whilst evoking vehicle-mix shifts towards more fuel-efficient vehicles. Another motivation for fuel-efficiency regulations is that there are **imperfections** in the market for vehicles that are not sufficiently dealt with by fuel taxes alone. There are several indications that consumers tend to underinvest in fuel economy (Joint Transport Research Centre, 2008). Reasons for these market imperfections are the insufficient information at the point of purchase on the trade-off between more expensive technologies and lower fuel costs, frictions in markets for used cars, the fact that drivers pay little attention to fuel economy as there care more about other attributes and the share of fuel costs in the total purchase and use costs is small, inappropriate incentives in company car markets, and uncertainty for manufacturers about the reactions of car buyers and competing manufacturers to produce more efficient, but more expensive vehicles. These frictions may justify interventions such as providing better information and regulating fuel economy.

Goodwin, Dargay and Hanly (2004) define the **elasticity of fuel efficiency** a combination of the elasticity of fuel consumption and the elasticity of vehicle-kilometres (Formula 6).

Formula 6: Elasticity of fuel efficiency

Elasticity of fuel efficiency = - elasticity of fuel consumption + elasticity of vehicle-km

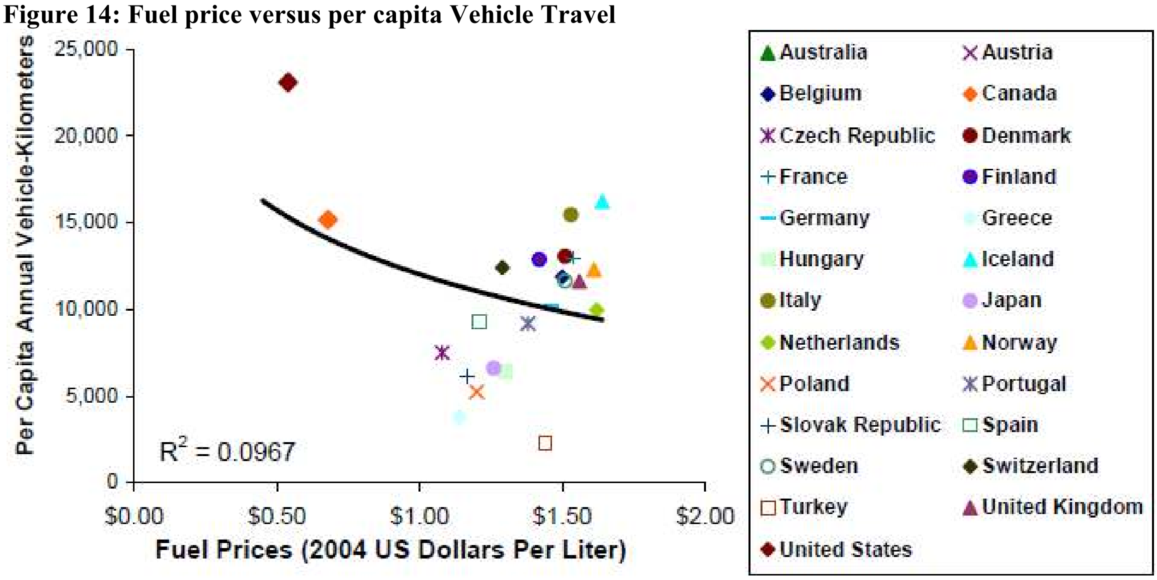
Source: Goodwin, Dargay and Hanly (2004)

Early research (Baltagi and Griffin, 1983) found out that the elasticity of fuel efficiency with respect to fuel price is situated between – 0,6 and -0,9, meaning that a 10% increase in fuel price will reduce the fuel inefficiency by 6 to 9%. As said by Espey (1996), one needs to take the pure technological improvements in fuel economy into account when estimating short and long run impacts. She assumed an annual increase in fuel efficiency of 2,8%, independent from changes in fuel prices and income. Moreover, this author believes that changes in the **registration and circulation taxes** of vehicles may have important effects on fuel efficiency.

B.4.4 Vehicle travel with respect to fuel price

About a third of fuel savings resulting from an increase in fuel prices consist of reductions in **vehicle mileage**. Figure 14 demonstrates how changes in fuel prices affect the per capita annual vehicle-kilometres. One can see that the per capita vehicle-kilometres decrease in countries with high fuel prices.

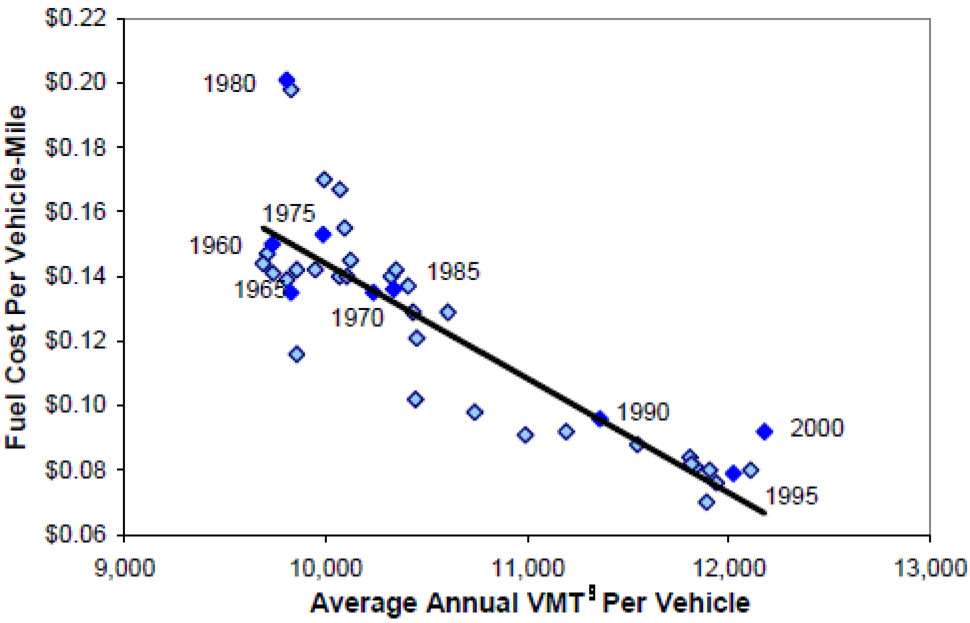
Figure 14: Fuel price versus per capita Vehicle Travel



Source: Litman (2007)

Figure 15 demonstrates how changes in real fuel prices affect the per capita annual vehicle mileage. The annual vehicle mileage increases at declining real fuel costs per kilometre. Schimek (1997) estimated the elasticity of vehicle travel with respect to the fuel price to be -0,26, indicating that a 10% increase in fuel prices will decrease vehicle travel with 2,6%. Goodwin, Dargay and Hanly (2004) compared the effect of a fuel price increase on **fuel consumption** and **vehicle travel**. They observed higher elasticities for fuel consumption than for vehicle travel. A fuel price increase will thus rather stimulate car drivers to reduce their fuel consumption than to reduce their vehicle mileage. Fuel consumption can be reduced by changing the driving style, shifting the pattern of journeys so that more of them are in a fuel – efficient context and finally by changing to more fuel-efficient vehicles (see previous section).

Figure 15: Fuel price versus Annual Vehicle Mileage



Source: BTS (2001) in Litman (2008

Table 11: European elasticities with respect to fuel price

Purpose	Car Driver	Car Passenger	Public Transport	Slow Modes
Trips				
Commuting	-0.11	+0.19	+0.20	+0.18
Business	-0.04	+0.21	+0.24	+0.19
Education	-0.18	+0.00	+0.01	+0.01
Other	-0.25	+0.15	+0.15	+0.14
Total	***-0.19***	***+0.16***	***+0.13***	***+0.13***
Kilometres				
Commuting	-0.20	+0.20	+0.22	+0.19
Business	-0.22	+0.05	+0.05	+0.04
Education	-0.32	+0.00	+0.00	+0.01
Other	-0.44	+0.15	+0.18	+0.16
Total	***-0.29***	***+0.15***	***+0.14***	***+0.13***

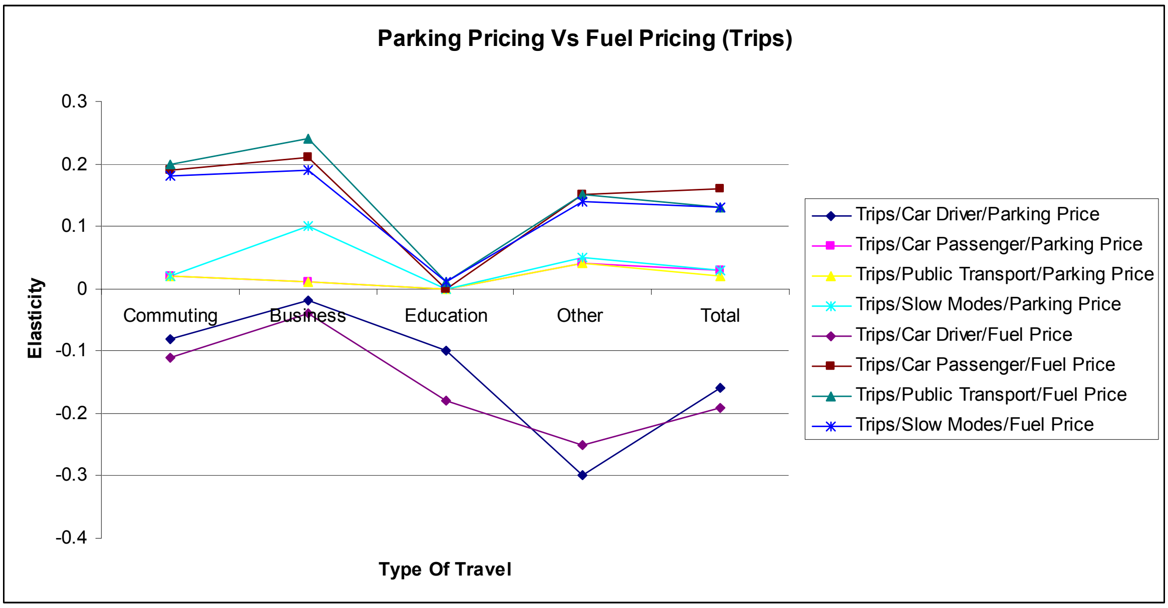
Source: TRACE (1999) in Litman (2008)

Table 11 provides estimates of **European long-term elasticities** of urban travel in response to fuel costs. A fuel price increase of 10% will affect **car drivers**' **trips** with -1.9% (first column, at the top). Commuting and business trips seem to be less sensitive to changes in fuel prices than travel for other purposes. TRACE (1999) estimated some specific elasticities for **Brussels** assuming a fixed car occupancy rate. The elasticities for car drivers were assumed identical to the elasticities for car drivers and car passengers together. The elasticities from the Brussels model, which is a morning peak model, can be interpreted as *commuting elasticities* (De Jong and Gunn, 2001). These commuting elasticities with respect to car drivers' trips are estimated to be -0.16 on the short run and -0.24 on the longer term, which is in line with the European elasticity (-0,19). Changes in fuel prices appear to have a larger effect on **vehicle-kilometres** than on vehicle trips (first column, at the bottom). Several researchers agree on the fact that the fuel price elasticity of vehicle kilometres should be around -0.15 in the short-term and -0.30 in the long term. The long-term effect is bigger than the short-term effect as destinations further away will become less attractive (De Jong and Gunn, 2001). Here, commuting as well as business travel appear to have a lower than average elasticity. With respect to the *commuting elasticities*, vehicle-kilometres elasticities are estimated to be -0,22 in the short run and 0,31 in the longer term, which is in line with the European elasticity (-0,29).

Trips and kilometres of **car passengers** will be affected too by fuel price changes as cost increases stimulate carpooling (Table 11, second column). **Public transport** is also positively affected by an increase in fuel costs of cars (Table 11, third column). The *commuting elasticities* are estimated to be around + 0.38 in the short term and + 0.37 in the long run. These elasticities are higher than the European elasticities as Brussels is a predominantly urban area where there are a lot of substitution possibilities (De Jong and Gunn, 2001). Even **slow modes** such as walking and cycling are positively influenced by fuel prices and produce elasticities of about +0.13 for trips and kilometres (Table 11, fourth column). According to TRACE (1999), these fuel price elasticities can be also used to predict the impact of **fuel taxes**. If for example fuel prices consist for 60% of fuel taxes, than a fuel tax increase of 10% could be evaluated as a 6% increase in fuel prices. Even **distance-based road pricing** could be simulated using these fuel price elasticities as the amount is dependent on the distance driven, like fuel prices.

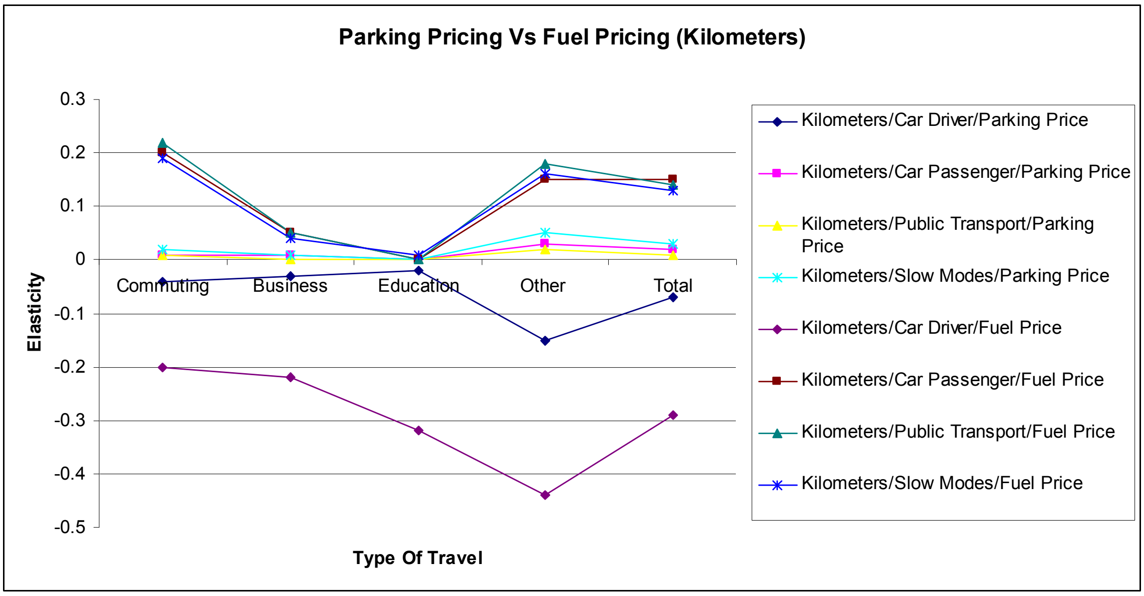
In Figures 16 and 17, the results from Table 9 (Parking elasticities) and Table 11 (Fuel price elasticities) are combined with respect to **trips** and **kilometres**. When comparing the impact of parking prices and fuel prices on trips and kilometers, it appears that fuel prices generally have a larger impact on trips and kilometers than parking prices. Figure 16 also reveals that business trips are quite sensitive to price changes, except for business trips made by car. Educational trips made by carpooling, public transport and slow modes are in contrast almost price insensitive. With respect to kilometers (Figure 17), commuting kilometers appear to be quite sensitive to price changes, whereas educational trips are again highly price insensitive expect for the educational trips made by car.

Figure 16: Parking prices versus fuel pricing with respect to trips



Source: David Zimmer (2008)

Figure 17: Parking prices versus fuel pricing with respect to kilometres



Source: David Zimmer (2008)

B.4.5 Road Pricing and Tolls

Road pricing is defined as a toll paid by people using a particular road or driving in a particular area (VTPI, 2005). A particular case of road pricing is **congestion pricing** where tolls are higher during peak periods and lower during off-peak periods aiming at reducing traffic congestion. In some cases, congestion charging has been producing considerable behavioural effects. The **London congestion charge** for example reduced private automobile traffic by 38% and total vehicle traffic by 18% while affecting the vehicle stock as older cars have been replaced and the amount of diesel cars has increased. The price elasticity was higher than expected, resulting in less generated revenues. Possible explanations for this success is the fact that the city centre was extremely congested, vehicle mode share was only 12% before the introduction of the charges, parking prices were already extremely high and a large variety of efficient transit, subway, rail and taxi services were/are available to and within the centre (Washbrook et al., 2006). Hirschman et al. (1995) used twelve years of monthly time series to derive **bridge and tunnel elasticities** for vehicles in the **New York area**. The median toll elasticity for passenger cars was found to be -0,10, indicating a high inelasticity of vehicle traffic with respect to tolls. A possible explanation for this low elasticity is that it consists of relative low fees as the aim is to collect revenues for transportation system improvement, rather than to reduce vehicle congestion (Washbrook et al., 2006). Another explanation lays in the fact that tolls are common sense in New York and that traffic volume will not be sensitive to such a small, gradual toll increase. A final reservation is that tolls are in fact only a small part of the total vehicle costs. The total price elasticity of vehicle travel will be much larger than the partial elasticity with respect to tolls alone. As the daily total vehicle costs consist for example of tolls, parking fees, fuel costs, vehicle depreciation etc., a multi-faceted price strategy would have a large impact on travel behaviour (Hirschman et al., 1995). Arentze, Hofman and Timmermans (2004) made use of a public survey to investigate the behavioural responses relative to **congestion pricing policies**. For *commuting trips*, travellers will most likely change their route and departure time, whereas a shift to public transport or working at home seems to be a less suitable option. For *non-commuting trips*, shifts to cycling also occur. This confirms the results of Schuitema et al. (2007) saying that changing travel times seems to be perceived as a more feasible option than changing the transportation mode. According to Arentze et al. (2004), the price elasticity of overall vehicle travel is found to be -0.13 to -0.19 (short run) and -0.35 to -0.39 (long run) if a particular congested road is priced, taking into account the shifts to other routes and departure times. **In Singapore**, the electronic kilometre charge resulted into toll elasticities of -0.19 to -0.58, with an unweighted average of -0,34. The toll resulted in an increased traffic before peak hours and a decreased traffic during the peak hours (Luk, 1999). Odeck and Brathan (2008) found out that elasticities vary along -0.45 in the short run and -0.82 in the long run for **Norwegian toll roads**. They also state that policy measures seem to be more accepted if there is a clear communication of how the revenues will be used (see also section B.3.2). Moreover, they discovered that in general, transport demand with respect to tolls is seen as quite inelastic. Out of an overview of studies, toll elasticities were found to vary along -0,5 implying that a 10% increase in tolls results in a 5% reduction of traffic, or less. The variation in the observed elasticities can be explained by several factors such as trip purpose, frequency of trips, toll level, and the existence of toll-free alternatives. In this respect, travel demand seems to be more elastic in case where there are good untolled alternatives. **A reduction in tolls fee** seems to have a larger effect on vehicle travel. In case of the Dulles **Greenway in Washington**, a reduction in toll of 43% has been found to produce an increase in vehicle traffic of 80%, resulting in a price elasticity of -1,9 (UTM, 2000). Glaister and Graham (2003) evaluated the effect of environmental charges and congestion charges on the busiest roads during peak periods in **England**. Environmental charges were defined as additional charges per vehicle kilometre, matching the environmental damage it causes based on vehicle type and location. It has been found that a combination of environmental charges and congestion charges, while keeping fuel taxes at the current rate, would evoke a reduction in overall traffic by about 9%, whilst environmental charges alone would reduce it by 6%. Although environmental charges were found to have relatively small effects compared with congestion charges in highly congested areas, congestion charges only apply to high congested areas whereas environmental charges are universal. Glaister and Graham (2003) also investigated whether it is better to implement **nation-wide charging** or to stick to **location-specific**

charging, bearing in mind the costs of introducing and administrating new charging systems. As new charging schemes are confronted with large capital and operating costs, very large schemes also incorporating wide and less affected areas will produce higher costs than location-specific charging. As a result, Glaister and Graham (2003) advise to research the impact on revenues and benefits of several scenarios with different scales of implementation. Expending the capacity will depend on whether the charges, covering the full cost of capital plus the environmental damage caused to others, exceed the capacity costs.

Overall, the impact of road pricing seems to depend on the **price structure**. Ubbels and Verhoef (2006) report that road pricing in the Netherlands would reduce car trips by 6% to 15%. A **flat** fee tends to affect social trips and evokes a shift towards non-motorized modes, whereas a peak-period fee mainly affects commute trips, and evokes shifts in travel time and mode, and working at home. Also Burris (2003) investigated whether flat-rate tolls or tolls that vary by time or congestion level have a higher impact on travel demand. The flat-rate toll was found to produce an elasticity from -0,03 to -0,35 whereas the variable toll elasticities varied from -0,16 to -1.0. Elasticities of a flat toll are found to be less elastic than the elasticities of a variable toll as this last one offers the drivers the additional flexibility in travel decisions. May and Milne (2000) used an urban traffic model to compare the effects of cordon tolls, distance-based pricing, time-based pricing and congestion pricing. They found out that time-based pricing has the greatest overall benefits, followed by distance-based pricing, congestion pricing and cordon pricing (Table 12).

Table 12: Types of road pricing

Type of road pricing	Fee required to reduce trips by 10%
Cordon pricing (pence per crossing)	45
Distance-based pricing (pence per kilometre)	20
Time-based pricing (pence per minute)	11
Congestion pricing (pence per minute delay)	200

Source: May and Milne (2000)

This result is confirmed by Mayeres and Proost (2004) who estimated the impact of a potential cordon toll around Brussels. They discovered that a cordon toll leads to a positive result, but that it is less efficient than other forms of road pricing. The reason is that a cordon toll limits inbound traffic and that traffic inside the cordon remains and partly increases when inbound traffic falls. Compared to the optimal policy, they found a relative efficiency for the cordoll toll of 52% indicating that the toll needs to be complemented with other supplementary policy measures such as higher parking charges etc.

B.4.6 Kilometre and emissions charges

As seen in previous section, **kilometre charges**, also called **distance-based road pricing**, seem to produce one of the greatest overall benefits. INFRAS (2000) reveals elasticities ranging from -0,1 to -0,8, depending on trip purpose, mode and price level. Schuitema et al. (2007) are in contrast not convinced that the effectiveness depends on the price level, as they found out that even a small kilometre charge can already have a large impact on car use. According to them, small price changes are already effective whereas for other pricing measures stronger price increases are needed to induce the right behavioural changes.

Kilometre charges can take two forms. The first type of kilometre charge is a distance-based charge (in kilometres), based on the average emissions of the vehicle model (**type 1)**. The second type is a charge based on the actual emissions measured during the use of the vehicle (**type 2)**. Table 13 gives an insight in the effectiveness of these two types of kilometre charges.

Table 13: Comparison of two types of emission charges

Region	Fee basis	VMT	Trips	Delay	Fuel	ROG	Revenue
Bay area	Vehicle model	-2,2%	-1,9%	-3,5%	-3,9%	-5,4%	$384
	Vehicle Use	-1,6%	-1,4%	-2,5%	-6,6%	-17,7%	$341
Sacramento	Vehicle Model	-2,6%	-2,3%	-4,5%	-4,0%	-5,7%	$116
	Vehicle Use	-2,3%	-2,1%	-5,0%	-7,4%	-20,2%	$102
San Diego	Vehicle Model	-2,5%	-2,2%	-3,5%	-4,1%	-5,5%	$211
	Vehicle Use	-1,9%	-1,7%	-3,5%	-7,1%	-19,5%	$186
South Coast	Vehicle Model	-2,5%	-2,3%	-5,5%	-3,9%	-5,5%	$1,106
	Vehicle Use	-2,1%	-1,9%	-6,0%	-7,2%	-18,9%	$980

The Fee basis is based on Vehicle-Model or on Vehicle-Use. **VMT** = the change in total Vehicle Mileage. **Trips** = the change in total vehicle trips. **Delay** = the change in congestion delay. **Fuel** = change in fuel consumption. **ROG** = a criteria air pollutant. **Revenue** = annual revenue in millions of 1991 US Dollars.
Source: Harvey and Deaking (1998) in: Litman (2008)

It appears that both have similar effects on the total vehicle mileage, total vehicle trips and congestion delay. However, type 2 has a larger impact on fuel consumption and the resulting air pollutants. It can be concluded that policy measures based upon the produced emissions in **real traffic situations** have a larger impact on fuel consumption and emissions than policy measures based upon emissions, measured by **test cycles**. In that case, people will switch to more fuel efficient vehicles, rather than reducing their total amount of vehicle mileage or vehicle trips. Peters et al. (2008) think however that people will only make the switch to more environmental friendly vehicles if there exist governmental incentives to make these vehicles more affordable. According to them, policy measures need to find the balance between reaching underlying targets such as lowering energy consumption and stimulating the purchase of fuel efficient vehicles. Environmental friendly vehicles may not become too cheap too as there exists a risk in stimulating people to purchase vehicles while they do not necessarily need one.

Ubbels et al. (2001) investigated the effect of a kilometre charge on **car ownership** and found some contradictory results. First results indicated that variabilisation will evoke an increase in car ownership as fixed costs will decrease while variable costs will increase. This effect will probably not lead to a rise in vehicle kilometres as the stimulating effect on car ownership is only expected in groups that are covering relatively few kilometres. Moreover, an increase in car ownership often means the purchase of a second car. As the first car will be used less, these extra cars will probably not lead to many extra kilometres. Other results indicate that variabilisation will lead to a decrease in car ownership as the increase in car ownership will be less than the decrease caused by the higher variable costs.

A final result relates to research performed by Mayeres and Proost (2004) investigating the effect of kilometre charges on **trucks** driving through Belgium. A kilometre charge for trucks can be an interesting way to let transit traffic pay taxes, as they currently pay no fuel taxes in Belgium but cause meanwhile important congestion, accident and environmental costs. The current Eurovignette is only covering the infrastructure costs, no external costs. It has been observed that a kilometre charge on trucks would only have a small effect on congestion levels as latent car demand will take part of the freed road space. In the longer run, an electronic toll differentiated by time and location seems to be a more efficient option as it will charge prices that are more closely related to the marginal social costs. Another option on the long run is letting the transit traffic pay for the use of the infrastructure equal to the marginal operating costs.

B.4.7 Travel Time

A widely used concept with respect to travel time is the **Travel Time Budget (TTB) hypothesis**, referring to the idea that the average daily travel time (70 to 90 minutes) and money budget tend to be relatively constant. People have a certain amount willing to spend on travel and will make adaptations to minimize departures from that amount in either direction (Mokhtarian and Chen, 2004). In this respect, increasing travel speeds and reduced delays tend to increase the travel distance so as to keep travel times approximately constant. Improvements in technology or additions of capacity of the system will result in an increasing traffic volume as people will take advantage of the reduced travel time. Increasing traffic speed with 20% is estimated to increase the traffic volume by 10% in the short term and by 20% in the long run (SACTRA, 1994). As this concept is clashing with the aim of decision makers to minimize travel time, it is important to take this into account. It is however notable that this TTB concept is valid on a aggregate level. At the disaggregate level, there seems to be a high degree of variation between travel time and money expenditures depending on individual and household characteristics, attributes of activities at the destination and characteristics of residential areas. Table 14 summarizes the effects in car travel time on travel demand for other modes and for various types of trips.

Table 14: Long Run Travel elasticities with respect to Car Travel Time

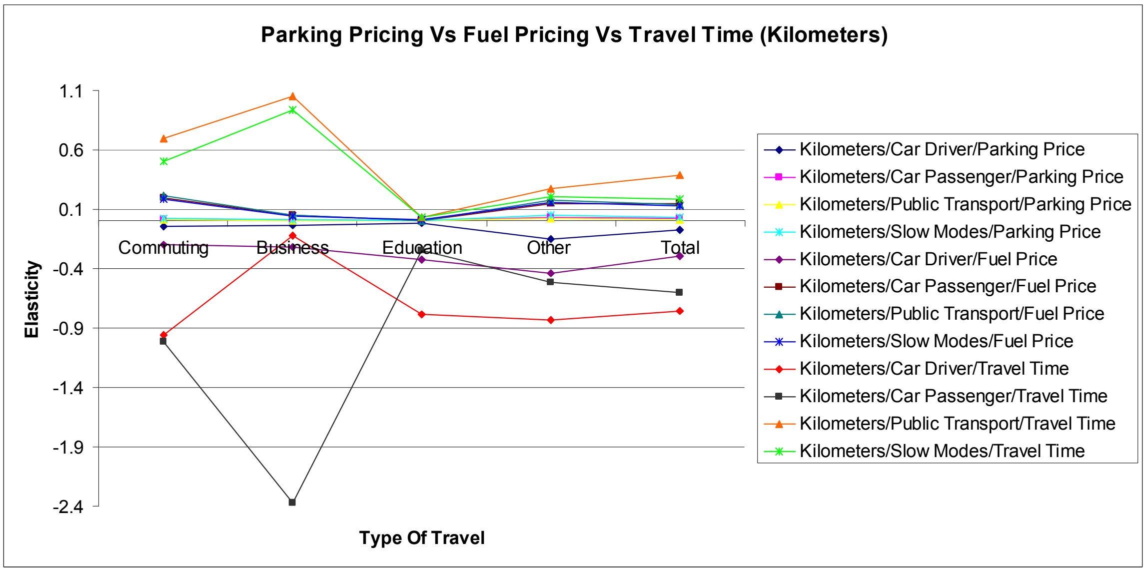
Purpose	Car Driver	Car Passenger	Public Transport	Slow Modes
Commuting	-0,96	-1,02	+0,70	+0,50
Business	-0,12	-2,37	+1,05	+0,94
Education	-0,78	-0,25	+0,03	+0,03
Other	-0,83	-0,52	+0,27	+0,21
Total	*-0,76*	*-0,60*	*+0,39*	*+0,19*

Source: TRACE (1999) in: Litman (2008)

According to De Jong and Gunn (2001), the effect of a percentage change in **car travel time** is greater than the effect of a change in **car cost** by the same percentage. Reviewers of SACTRA (1999) even stipulate that the long-run travel time elasticity of traffic is a factor of two or more times the fuel price elasticity (De Jong and Gunn, 2001). The impact of car travel time on **vehicle kilometres** is also estimated to be greater in the long run than in the short run as in the long-run destination effects are taken into account. A change in car travel time will reduce **vehicle traffic** in the long-run (-0.76) (Table 14, first column). TRACE (1999) estimated *commuter elasticities* for **Brussels** around -0.31 on the short term and about -0.49 on the long term. Changes in travel time will also affect **carpooling** (-0.60) (Table 14, second column). Contrary to the impact of fuel prices on carpooling, this elasticity is negative as an increase in travel time applies to each of the occupants. A car travel time change has a positive impact on **public transportation** (+0.39) (Table 14, third column). As with the direct elasticities, the cross-elasticities for changes in time exceed the cross-elasticities for changes in fuel prices. In the Brussels model, the cross-elasticities for public transportation are estimated to be + 0,60 in the short-run and + 0,50 in the longer term. The total number of trips will decrease in the longer run because of relocation. Travel time increases affect also **slow modes** such as walking and cycling (+0.19) (Table 14, last column). According to TRACE (1999) travel time elasticities can also be used to predict the impact of **congestion on mode choice and distribution/generation**.

In Figure 18, the results from Table 9 (Parking elasticities), Table 11 (Fuel price elasticities) and Table 14 (Travel time elasticities) are combined with respect to kilometres.

Figure 18: Parking pricing versus fuel pricing versus travel time with respect to kilometres



Source: David Zimmer (2008)

Figure 18 reveals that a 10% change in car travel time has a bigger impact on vehicle kilometres than a 10% increase in fuel prices or a 10% increase in parking charges. One exception is the business trips of car drivers, as a 10% increase in fuel prices is found to have a bigger impact than a 10% increase in travel time.

B.4.8 Vehicle price and income

Vehicle ownership and use are affected by price and income. With respect to the **vehicle price**, Goodwin, Dargay and Hanly (2004) report an elasticity of vehicle ownership of -0.4 to -1.0, indicating that a 10% increase in total vehicle costs will reduce vehicle ownership by 4 to 10%. De Borger and Mayeres (2004) researched the impact of money prices and fixed costs on vehicle ownership (Table 15). An increase in costs of a particular car is found to have limited effects on the overall stock, but with larger effects on the composition of the stock.
As fuel costs represent about 25% of the total vehicle costs, an increase in fuel costs of a diesel car for example will decrease diesel car ownership in favour of petrol car ownership. Diesel car ownership is found quite more elastic than petrol car ownership.

The impact of vehicle prices on vehicle ownership also depends on whether it is the **first** vehicle or the **second** or **third vehicle** in the household. The purchase of the first vehicle is primarily dependent on socio-economic factors such as an increase in income, whereas the purchase of a second or third vehicle rather depends on the quality of alternative transportation modes in the community. Here, it is important to make a distinction between **rural** and **urban communities**. Car ownership in urban areas appears to be twice as sensitive to car purchase costs as in rural areas as rural households are more dependent on car use and have little alternative transportation possibilities. In addition, while car ownership is in urban areas mildly sensitive to fuel costs, rural and other households appear to be totally price insensitive to fuel costs. It is important to take these differences into account when introducing policy measures, especially with respect to the distributional aspects. General increases in costs of car transport could pose a considerable economic burden on rural households (Karlaftis and Golias, 2002; Dargay, 2002). Vehicle prices seem to produce considerable effects on **vehicle use** too. Dargay (2004) even stipulates that vehicle prices might have a larger impact on vehicle use than on vehicle ownership. A possible explanation is that as vehicles become less expensive, fixed costs per kilometre will decrease, so there will be a tendency to use the vehicle more. As a result, it will be easier to influence vehicle use than vehicle ownership as the former responds more quickly to prices and is less related with resistance to change.

Table 15: Calibrated elasticity of car ownership probabilities with respect to money car prices and fixed car costs

	Money price				**Fixed costs**	
	Peak petrol car	**Off-peak petrol car**	**Peak diesel car**	**Off-peak diesel car**	**Petrol car**	**Diesel car**
Probability						
No car	0.02	0.03	0.02	0.03	0.07	0.07
Petrol car	-0.12	-0.17	0.15	0.22	-0.37	0.48
Diesel car	0.16	0.23	-0.24	-0.33	0.49	-0.74

Source: De Borger and Mayeres, 2004

Vehicle ownership and fuel consumption are also associated with **income**. The long-run elasticity of vehicle fuel consumption with respect to income is 1,1 to 1,3 and the long-run elasticity of vehicle travel with respect to income is 1,1 to 1,8 (Glaister and Graham, 2000). When comparing the absolute elasticity of fuel consumption with respect to fuel prices to the absolute elasticity of fuel consumption with respect to the income, the last one seems to have the largest impact (see also B.4.3). This means that fuel prices should rise faster than income in order to keep fuel consumption at a constant rate (Glaister and Graham, 2000). The relationship between the growth of **vehicle ownership** and per capita-income is found to be highly non-linear. Vehicle ownership tends to grow relatively slow at the lowest levels of per capita income, then about twice as fast as income at the middle-income levels and finally about fast as income at higher income levels, before reaching a saturation level at the highest levels of income, following a S-shaped curve. Dargay et al. (2007) inventoried historical data on income, vehicle ownership and population during 1960-2002. Historical data for the Belgium case are presented in Table 16.

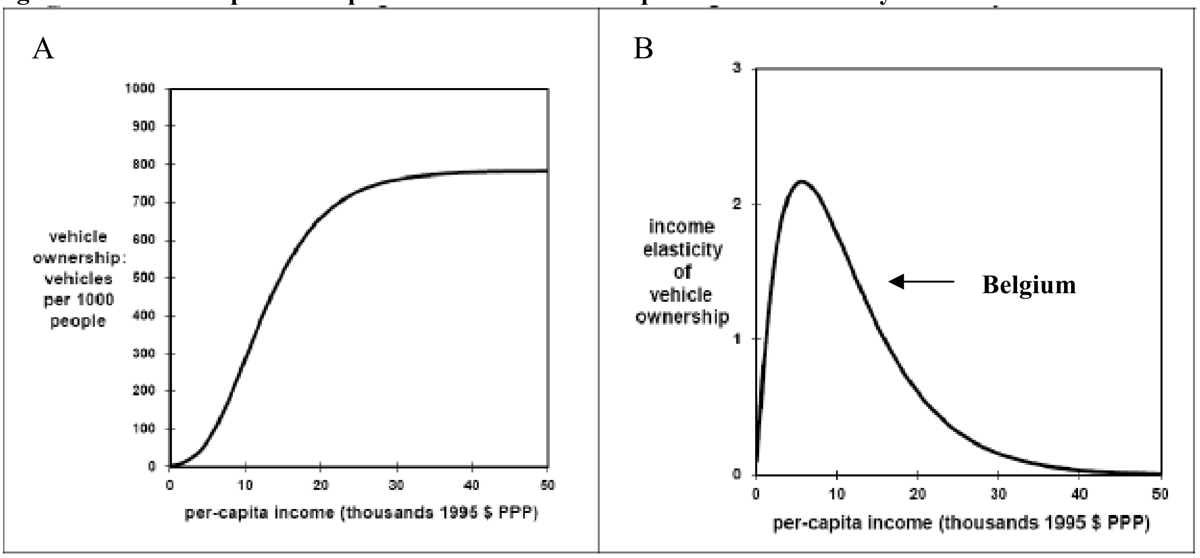
Table 16: Historical data on income, vehicle ownership and population, 1960-2002

Country	Per capita-income (thousands, 1995 $ PPP)			Vehicles per 1000 Population			Total Vehicles (millions)			Ratio of growth rates
	1960	2002	Average annual growth rate	1960	2002	Average annual growth rate	1960	2002	Average annual growth rate	
Belgium	8.2	24.7	2.7%	102	520	4.0%	0.9	5.3	4.3%	1.48

Source: Dargay et al. (2007)

As people getting wealthier vehicle ownership increases, but at a decreasing rate towards a saturation level (Schafer and Victor, 2000). Figure 19A shows the S-shaped curve and the saturation level. The saturation level of Belgium is situated at 647 vehicles per 1000 people. The maximum saturation level is situated at 852 vehicles per 1000 people. This is the saturation level for the USA and for those countries which are less urbanized en less densely populated such as Finland, Norway and South Africa. Saturation levels appear to decline with rising population density and with increasing urbanization (Dargay et al., 2007). Next, the implied long-term income elasticity of vehicle ownership can be derived, based on the ratio of vehicle ownership growth to the per-capita income growth. The long-run income elasticity of vehicle ownership can be found in Figure 19B and it is a country-specific income elasticity.

Figure 19: The S-shaped "Gompertz" function and its implied income elasticity



Source: Dargay et al. (2007)

However, Dargay et al. (2007) found an **asymmetry in vehicle ownership** which might lead to biased estimates of income elasticities. Household vehicle ownership increases as households become wealthier or have more adult workers, but they are less likely to reduce their vehicle ownership at a declining income or with declining adult workers. As a result, an increase or decrease in income will produce different elasticities with respect to vehicle ownership. A falling income will probably encourage households to keep their vehicles, but reducing their vehicle mileage. Vehicle use decreases more when income falls than it increases when income rises. At a higher income, more vehicles are purchased and vehicle use increases. As the number of vehicles does not decline at a falling income to the same extent as it does when income rises, the reduction in vehicle use resulting from a falling income will be larger than the increase in vehicle use resulting from a rise in income.

Dargay et al. (2007) made several projections regarding future trends in income, populations and urbanization to estimate **vehicle ownership to 2030**. The projected growth in vehicle ownership within OECD countries is estimated to be relatively slow, about 0.6% annually, as many of these countries are approaching the saturation level. The annual OECD growth rate for total vehicles is somewhat higher, about 1.4%, due to population growth. The projections of vehicle ownership for Belgium can be found in Table 17.

Table 17: Projections of vehicle ownership to 2030

Country	Per capita-income (thousands, 1995 $ PPP)			Vehicles per 1000 Population			Total Vehicles (millions)			Ratio of growth rates
	2002	2030	Average annual growth rate	2002	2030	Average annual growth rate	2002	2030	Average annual growth rate	
Belgium	24.7	45.3	2.2%	520	636	0.7%	5.3	6.7	0.8%	0.33

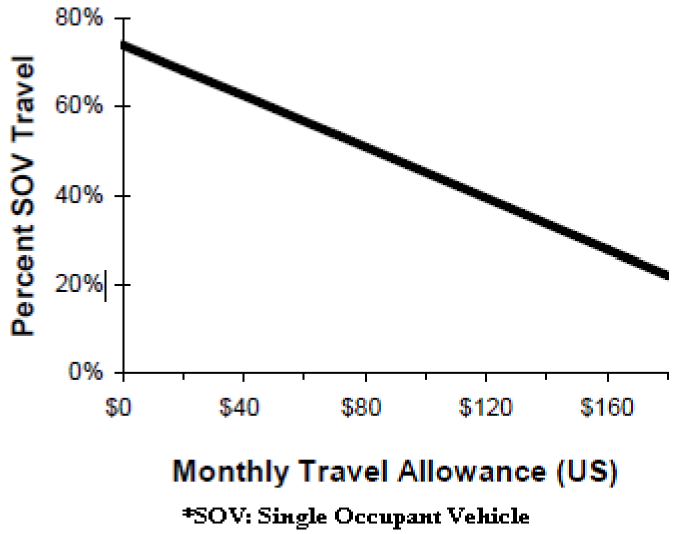
Source: Dargay et al. (2007)

Based on these projections, Dargay et al. (2007) suggest that policy makers should be able to slow down the expansion of the vehicle stock through tax policies, promotion of public transport, and appropriate urban planning.

B.4.9 Commute trips and Financial initiatives

Washbrook et al. (2006) estimated the **commuter response** of 548 commuters to various policy oriented combinations of **charges and incentives**. It has been found that increases in drive alone costs will have a larger impact on travel demand than increases in drive alone travel time or improvements in times and costs of alternative transportation modes. Road pricing was found more effective in reducing vehicle demand than parking charges. Fiscal disincentives should however be accompanied with an improved supply of alternative travel modes in order to effectively reduce vehicle demand. Financial disincentives could also have a larger impact on lower income households. Lower income respondents are more likely to be a member of one-vehicle households and have less opportunity to carpool. Also, they may be unable to avoid paying charges if the improved supply of alternative transportation modes is not available. Overall, commute travel tend to decline as companies provide financial incentives (Figure 20).

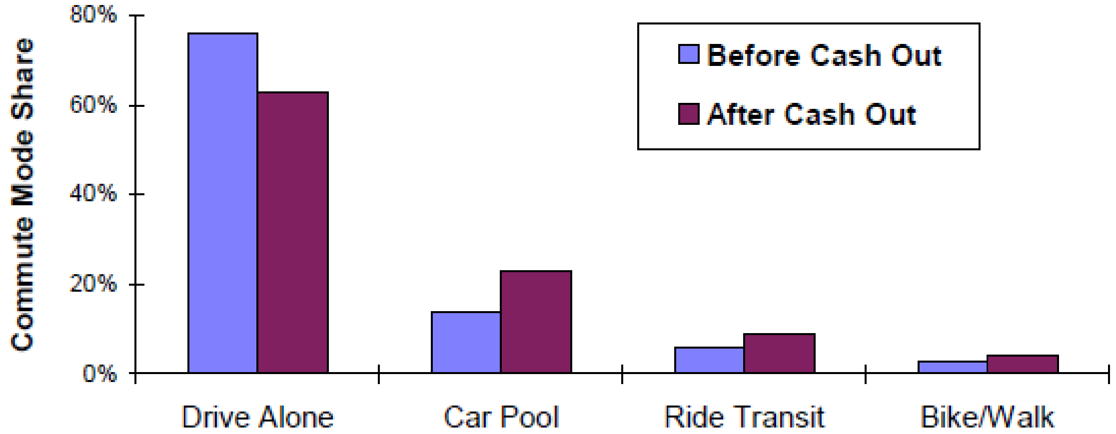
Figure 20: Effect of financial incentives on Single Occupant Vehicle (SOV) commuting



Source: Rutherford (1995) in Litman (2008)

The effects of financial incentives even increase over time. Schoup (1997) demonstrates that solo commuting declined with 17% after cashing out parking fees (Figure 21). There was still an effect three years after the introduction of cashing out as the commuters found more possibilities to reduce their driving.

Figure 21: Impact of cashing out on commuting mode



Source: Schoup (1997)

B.4.10 Mode shifts

As already mentioned, vehicle use tends to decrease at increases in vehicle operational costs such as fuel costs, parking fees etc. Some of this travel will disappear as people will make fewer and shorter trips or by working at home. Another part of the reduced vehicle use will be replaced by an alternative transportation mode. Which changes occur depends on the type of trip, route, quality of the available substitutes and type of traveller. In general, people will switch to cycling or walking for shorter distances, whereas public transportation (urban areas) and carpooling (rural areas) will be used for longer distances. Policy measures aiming at reducing vehicle use generally cause 20 to 60% of vehicle trips to shift to public transportation. Other trips will be replaced by cycling, carpooling or will disappear. Improving the quality of public transportation will attract 10 to 50% out of the vehicle trips. Research performed by Volusia County Public Transit (in: Litman, 2008) discovered that 25 to 58% of the users of public transportation would switch to vehicle trips in case of unavailability of public transit (Table 18) . This substitution is found to be higher in more vehicle dependent areas, and lower in multi-modal areas where consumers have a larger variability of other transportation modes available.

Table 18: Alternatives to transit travel

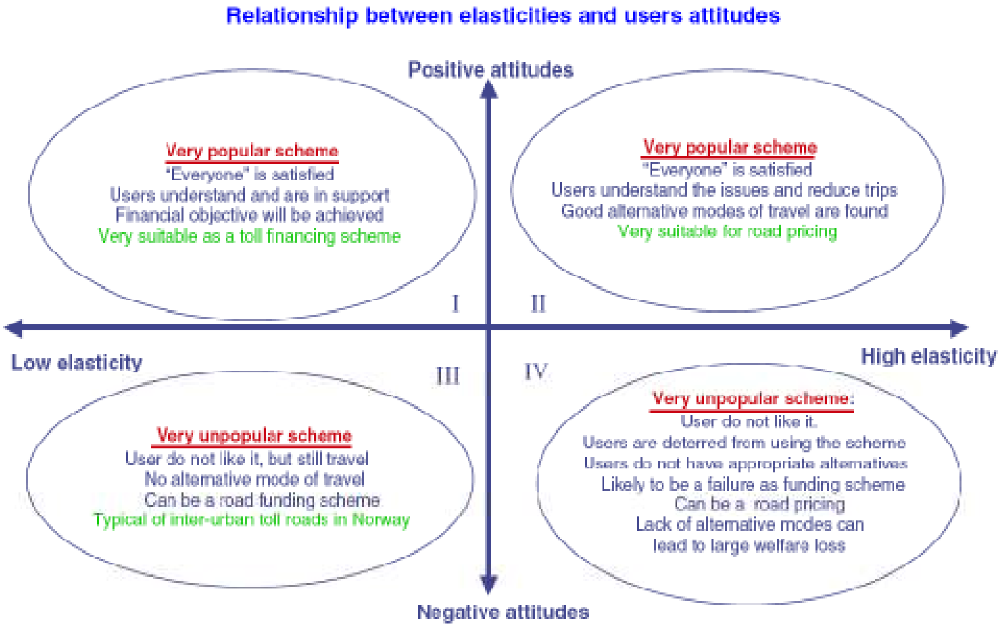
How would you make this trip if not by bus?	**Frequency**
Ride with someone*	626 (33%)
Walk	369 (19%)
Would not make the trip	262 (14%)
Taxi*	245 (13%)
Drive*	147 (8%)
Bicycle	161 (8%)
Paratransit service*	57 (3%)
Other	56 (3%)
Total	*1.923 (100%)*

Source: Volusia County Public Transit in: Litman (2008), *Increases vehicle trips

B.5 Evaluation of policy measures

When it comes to the evaluation of policy measures, on should take not only the **travelers'attitudes** (see section B.3) into account, but also the **elasticities** (see section B.4). Travelers'attitudes only do not necessarily result into actions because of several reasons (principles of users, availability of alternatives, accessibility, ...). So one should link it to the elasticities in order to get an insight in the effectiveness of policy proposals. For this purpose, the taxonomy, developed by Odeck and Brathan (2008) can be used. They set up a preliminary taxonomy for the link between demand elasticities and travelers'attitudes with respect to tolls (Figure 22).

Figure 22: Concept for the evaluation of policy measures



Source: Odeck and Brathan (2008)

Figure 22 shows four possible combinations with respect to elasticities and users attitudes. In **Quadrant IV**, users have a negative attitude towards the policy measure and the elasticity is high. This is an unfavourable situation for the implementation of a policy measure. First of all because there is a negative attitude towards the policy measure. As seen in previous sections, the acceptability of the policy measure by the people is a crucial factor for an effective policy. Secondly because of the high elasticities. High elasticities may refer here to the fact that users are deterred from using the scheme or that they have no other possibilities of alternative transportation modes or changing destinations leading to large welfare losses. **Quadrant III** refers to a negative attitude and a low elasticity. A possible reason for the low elasticity is the non-understanding or non-acceptance of the policy. Another explanation may be the that the change in price is relatively low resulting in a situation where they still continue to travel. These elasticities can however increase on the longer term as people will adjust their travel patterns. Policy measures situated in Quadrants III and IV seems thus not advisable as they suffer from a lack of information and a low understanding. An increasing understanding of the policy measure has been reached in Quadrants II and I. In **Quadrant II,** travellers show positive attitudes. The elasticity is high indicating that they will probably not travel by road as they have other travel options. This scheme is advisable for introducing **congestion pricing or road pricing**. In **Quadrant I,** travellers have favourable attitudes towards the policy measure and the elasticity is low indicating that they are still travelling by road. This situation can happen when the price change is low and people support the purpose of the policy measure as they are well informed. This situation is advisable for a **road financing scheme**. So policy measures should be preferable situated in Quadrants I and II as the majority of the involved stakeholders will accept it. It has to be noted that this scheme does not take account of distributional impacts. In this respect, elasticities could be low as travellers are rich and will not take their travel costs into account. In this scheme, the average traveller has been represented.

B.6 Conclusion

Policy measures are seen as an effective tool to let drivers base their travel decision upon the marginal external costs instead of the private consumer costs. In theory, the optimal flow in traffic would occur if vehicle users are charged an optimal tax closing the gap between the private and marginal social cost. In practice, there is a strong preference for second-best reasoning due to technological challenges and political objections. To evaluate the effectiveness of a policy measure, one should take the travellers' attitudes, as well as price elasticities into account. In a first part, several factors affecting price sensitivity have been identified such as type of price change, characteristics of the pricing policy, type of trip and traveller, quality and price of alternative routes and destinations, scale and scope of pricing and time period. In a second part, a literature review of price elasticities has been performed. The price elasticity of travel demand measures the reactivity of a change in price on travel demand, both measured in percentage changes. An overview of disaggregated elasticities has been performed with respect to several price components such as vehicle operational costs, parking costs, fuel costs, tolls fees, emissions charges, travel time costs, vehicle price and income, commute trips and financial incentives and their resulting changes in travel demand ranging from changes in travel modes, destination, travel routes, departure times and trip patterns to changes of residence and employment location. Out of this review, the following conclusions can be drawn. Belgian consumers are on average more sensitive for their vehicle expenses than for their public transport expenses. Household **income** has the largest impact on fuel consumption, followed by fuel prices. This means that fuel prices should rise faster than income to keep fuel consumption at a constant rate. Increasing **fuel prices** are found to have a larger effect on fuel consumption than on vehicle traffic as the rapid behavioural responses such as changes in driving speed or style, or modifying to the least energy-inefficient trips will affect fuel consumption more than traffic. As a result, **fuel taxes** will be more effective in reducing fuel consumption than in reducing road congestion. Moreover, they are found to affect vehicle trips and kilometres more than **parking charges.** Fuel taxes alone are however not politically attractive. That is why Small and Van Dender (2007) advise to introduce **fuel-efficiency regulations** too as it would promote technological improvements whilst evoking vehicle-mix shifts towards more fuel-efficient vehicles. Such a system will on the other hand hardly affect safety, congestion and noise. From these perspectives, it may be desirable to make the tax system more variable. **Time-based pricing** is found to produce the greatest overall benefits, followed by distance-based (kilometre) charging, congestion pricing and cordon pricing**. Kilometre charging** based on real traffic emissions will have a larger impact on fuel consumption and emissions compared to kilometre charges based on measured emissions from drive cycles. Kilometre charges are seen as a very effective tool as it makes it possible to differentiate according to energy-use, emissions, noise, road safety, driving style and congestion. As a result, people will switch to more fuel-efficient vehicles, rather than reducing their total amount of vehicle mileage or vehicle trips. These findings are in line with the results obtained from the face-to-face and web-based surveys. The surveys also revealed that an **extra pollution tax**, based on the environmental performance of cars, would be effective in discouraging the use of fuel-inefficient cars. Out of the price elasticity review, it appears that policy measures affecting purchase prices and fixed costs would indeed evoke a shift in the composition of the stock towards the most fuel-efficient car, but with a limited affect on the overall stock. Finally, a scheme for the evaluation of policy measures has been presented, in which the travelers'attitudes are linked to the price elasticities in order to get an insight in the effectiveness of policy proposals. **Congestion pricing** or **road pricing** will be effective if travellers have a favourable attitude towards the policy measure and if the elasticity is high indicating that they will probably not travel by road as they have other travel options. **Road financing schemes** will be effective when travellers have favourable attitudes and when the elasticity is low indicating that people support the purpose of the policy measure and that they are still travelling by road.

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CLEVER
Clean Vehicle Research

Addendum to Task 3.1

Update September 2010

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Preface

The original task 3.1 has been finished in May 2008. Meanwhile, cost figures have been changed and additional calculations have been performed. This addendum presents some additional insights in the LCC methodology and applies this methodology to investigate whether a reformed taxation system, based on the Ecoscore, could provide an incentive to enhance the LCC of clean vehicles and hence further stimulate their adoption. This addendum is entirely based on the paper: "Promoting environmentally friendlier cars with fiscal measures: general methodology and application to Belgium", submitted for Journal of Transportation Research Part C by Laurence Turcksin, Olivier Mairesse, Cathy Macharis and Joeri Van Mierlo.

1. Introduction

In 2005, the European Commission presented a proposal for a Council Directive that requires Member States to restructure their passenger car taxation systems. The aim of this proposal is twofold. First, to improve the functioning of the internal market by eliminating existing tax obstacles. Second, to promote sustainability by restructuring the vehicle registration tax (VRT) and annual circulation tax (ACT) linked to carbon dioxide (CO_2) emissions (European Commission, 2005a). The proposal does not intend to harmonize tax rates, but only to restructure existing systems, without obliging Member States to introduce new taxes. The European Commission sees fiscal measures as a strong incentive to steer consumer's behaviour towards more fuel-efficient vehicles and as a way to meet the Community' strategy to reduce CO_2 emissions from passenger cars (European Commission, 2007).

So far, 15 European countries have already applied taxation systems, correlated with the CO_2 emissions and fuel consumption of the car (ACEA, 2009). In Belgium however, taxes are still based on the performance of the vehicle. To be in line with European Union policy, the Belgian government should introduce a reformation of the vehicle taxation system. However, orienting taxes on CO_2 emissions alone will give diesel vehicles an advantage as a result of their higher fuel efficiency, whereas they release more particulate matter (PM) and nitrogen oxide (NO_x) emissions than comparable petrol vehicles. Yet, the European Commission (2005a) states that the tax reformation should not discriminate between specific types, classes or segments of cars and be technologically neutral. That is why CO_2 emissions should not be the only basis for taxation (Kunert and Kuhfeld, 2007).

The present paper introduces an innovative methodology, the Ecoscore, as a potential taxation base. The Ecoscore is based on a well-to-wheel (WTW) framework and enables a comparison of the environmental burden caused by vehicles with different drive trains and using different fuels (Timmermans et al., 2005; 2006). Compared to a tax orientation on CO_2 emissions, it enables a technology neutral reform of the fiscal system. To analyze the extent in which this fiscal measure can provide an incentive to promote a sustainable vehicle choice, a life cycle cost (LCC) analysis is elaborated to assess the cost-efficiency of alternative and conventional vehicles in the existing and new fiscal system. A LCC takes all costs related to the purchase and the use of the car for the end-user into consideration. The advantage of using a LCC is that, besides taxation, it covers the three most important financial aspects of the car purchase decision, namely purchase price, fuel consumption and maintenance costs (Mairesse et al., 2008).

The remainder of the paper is as follows. Section 2 develops the LCC tool and highlights the current fiscal incentives and disincentives with respect to the stimulation of sustainable vehicles in Belgium. Section 3 introduces the Ecoscore methodology as a potentially new assessment base for a vehicle tax reformation. Section 4 elaborates the tax restructuring and investigates whether it enables a better conformity between the LCC and the environmental performance of vehicles. Section 5 summarizes the main conclusions.

2. Life Cycle Cost analysis

2.1 Methodology

LCC analyses have been widely applied to calculate the retail and LCC of hybrid electric vehicles (Lipman and Delucchi, 2006), to assess the cost-efficiency of alternative fuels and drive trains in Thailand (Goedecke et al., 2007), to examine the economical feasibility of hydrogen as an alternative fuel (Lee et al., 2009), to calculate the cost-efficiency of an electric car versus a gasoline-powered car (Werber et al., 2009) and to make a techno-economic comparison of series hybrid, plug-in hybrid, fuel cell and regular cars (van Vliet et al., 2010).

A detailed vehicle LCC spreadsheet model is elaborated to analyze the cost-efficiency of conventional vehicles, electric-drive vehicles and other alternative-fuel vehicles that are currently commercially available. This model integrates all anticipated costs associated with the car throughout its life and includes all user expenses to own and use vehicles. A vehicle useful lifetime of 7 years is assumed, with an annual vehicle mileage of 15,000 kilometers (NIS, 2008). Only the first owner is considered, and not the total vehicle lifespan which is on average 13,5 years (NIS, 2008). The used method within the LCC analysis is the net present value method (equation 1) as one has to accurately combine the initial expenses related to the purchase of the car with future expenses related to the use of the car.

$$PV = A_t * \frac{1}{(1+i)^T} \quad (1)$$

PV is present value, A_t is the cost at time t, T is the depreciation time (expressed in number of years) and i is the interest rate of 4%. This interest rate is the average rate of return for investments and represents the consumer opportunity cost of purchasing a vehicle relative to alternative uses of the same money (EPA, 2000; Pearce et al., 2006; European Commission, 2005b; LNE, 2008). It is also the standard discount rate as applied in social cost-benefit analyses.

The LCC of each vehicle is calculated in three steps. First every stream of costs is analyzed. Then, the discounted present value of future costs is calculated and finally, an annuity factor is applied to convert total costs to annual costs, with a commercial lifespan of 7 years (Van Hulle, 2006; LNE, 2008). As such, the cost-efficiency of several vehicle types (supermini, small city car, small family car, big family car, exclusive car, SUV) and vehicle technologies (internal combustion engine (ICE), EV, HEV) can be compared.

The chosen vehicle technologies are so-called “near-term” technologies as they are (or will be) nearly available on the market. That is why fuel cell and hydrogen vehicles are not considered. Within each vehicle type, the analyzed vehicles are compared to a reference diesel or petrol vehicle as they are very similar in terms of performance (cc, kW and acceleration time from 0 till 100 km/h) and standard equipment. The LCC is based on several cost parameters (depreciation, insurance, maintenance, vehicle taxation and fuel) and is applied for the case of Belgium. An overview of the cost parameters is given in table 2.

Depreciation costs

Purchase costs of the reference vehicles (and additional equipment such as a particulate matter filter (PM-filter)) are based on automobile retail websites (Autogids, 2010). Vehicles on alternative fuels (LPG, CNG, biofuels) require additional conversion costs to make them fuel compatible. A LPG and CNG retrofit to the reference vehicle amounts up to respectively 2,000 and 2,500 Euros. Vehicles driving on low blends of biofuels (E5, E10, B5, B10) are still compatible to all existing vehicle engines and require no additional costs. Vehicles driving on high blends of biodiesel (B30, B100) and ethanol (E20, E85) need dedicated vehicles with surplus costs of respectively 200 and 1,000 Euros (flexi-fuel vehicles). EVs, like Citroën C-Zero and Nissan Leaf, consist of a lithium-ion battery package with a limited driving range of 130 km. Lithium-ion batteries currently have a life expectancy of 240,000 km so at a yearly coverage of 15,000 km, no battery replacements will take place. At a higher yearly mileage, the replacement cost of the battery is expected to be 85% of the cost of a new battery pack, which amounts to approximately 11,200 Euros for the Citroën C-Zero (Lipman and Delucchi, 2006; ecodrivemagazine, 2010). Other producers of EVs, such as Renault Fluence, offer battery leasing at 100 Euros/month. For HEVs, a 7,5 battery life is taken into consideration, as warranty periods for the battery are typically 7 to 8 years (Lipman and Delucchi, 2006).

Vehicles depreciate over time. Loss of value due to depreciation is in the first few years of a vehicle’s life a very critical cost parameter. Depreciation rates vary not only along the used fuel or drive train, but also according to the brand image, new model pricing, mileage range, comfort and convenience features and vehicle class (Spitzley et al., 2005). In this analysis, the deprecation cost is only based upon the used fuel and/or drive train and excludes other sources of variation amongst makes and types. As a result, depreciation costs of makes with a high resale value, such as German makes, might be overestimated. The applied depreciation rate after 7 years time is 79% for petrol and biofuels, 74% for diesel, 82% for LPG, 83% for CNG and 84% for EV (Van Mierlo et al., 2001).

Insurance

Legally, the civil liability premium is obliged in Belgium. This premium is based on three parameters: living area, age, and bonus-malus which reflects the driving experience and accident rate of the main driver. Here, this premium is calculated for a 37-year-old man, living in Brussels with a bonus-malus of 14 (Ethias, 2007). Additionally, the civil liability premium can be complemented with an omnium insurance, which fully depends on the actual value of the car. This is not included in the analysis as it already covers a part of the depreciation, so as to avoid double counting (Keppens, 2006).

Vehicle taxes

The LCC of a car also depends on the vehicle taxation system. Here, the Belgian taxation system is used as an example. In Belgium, three forms of taxes apply:

1) Acquisition taxes, comprising a value-added tax (VAT) of 21 % on the net purchase price and a vehicle registration tax (VRT), which is currently based on the power of the vehicle (kW). This VRT is levied once-only upon the registration of the vehicle and is further reduced for LPG and CNG vehicles (minus 298 Euros). EVs get the minimum VRT (61,5 Euros). At the acquisition of a new car, vehicles with low CO_2 levels (respectively lower than 105 g/km; and between 105-115 g/km) receive a reduction of their purchase price (respectively 15%; 3%). EVs even get a special reduction of 30% up to 2012. A reduction of 210 Euros (indexed amount 2010) can be obtained when purchasing a diesel vehicle, standard equipped with a PM-filter and with a CO_2 level lower than 130 g/km (FPS Finance, 2010a).
2) Ownership taxes, consisting of an annual circulation tax (ACT), currently based on the power of the vehicle (CC). LPG and CNG vehicles pay a compensating ACT, whereas for EVs the ACT is reduced to the minimum (69,7 Euros/year).
3) User taxes, referring to the VAT (21%) and excises applied on fuels.

Maintenance costs

Maintenance costs include tire costs, costs for small and large maintenance and costs for annual car inspection (Testaankoop, 2007; GOCA, 2010). Tires are assumed to be replaced when a car has driven 50,000 km. Tire costs depend on the vehicle type and annual mileage. Table 1 presents the cost of replacing a full set of tires according to vehicle type and supposing an annual coverage of 15,000 km.

Table 1: Tire costs

Car type	**Tire price (Euro)**
Supermini	265
Small city car	265
Small family car	312
Big family car	337
Exclusive car	400
SUV	400

Source: Testaankoop (2007).
Note: Figures are adjusted to 2010 figures using the consumer price index (FPS Finance, 2010b).

Costs for small and large maintenance are viewed as costs to keep the vehicle operational including oil replacement, revision of brakes etc. These costs depend on the type and make of the vehicle and drive train. Compared to an ICE, maintenance costs for EVs are low because electric motors contain less moving components and face less temperature stress (Van Vliet et al., 2010; Werber et al., 2009; van den Bulk, 2009). Moreover, regular maintenance such as oil and filter replacements are not necessary. Assuming a yearly coverage of 15,000 kms, the maintenance costs of EVs are expected to be 180 Euros/year (van den Bulk, 2009). Estimations of maintenance costs for HEVs vary from 15% higher to 25% lower than the reference ICE vehicle (Stadsregio Amsterdam, 2009; Whisper hybrid bus, 2009). In this analysis, it is assumed that maintenance costs for HEVs will be of equal amount as for the reference ICE (Goedecke et al., 2007).

Annual car inspection is obliged for all vehicles aged four years or older. Annual car inspection costs comprise a base price of 27,5 Euros, complemented with an environmental inspection (+ 10,5 Euros for ICE, 3,5 Euros for electric propulsion systems) and an additional inspection for LPG and CNG installations (15 Euros) (GOCA, 2010).

Fuel costs

Fuel prices for reference diesel and petrol vehicles are based on maximum fuel prices in Belgium: 1,24 Euros/l for diesel and 1,50 Euros/l for petrol (Petrolfed, 2010). This includes a VAT of 21% and excise duties (0,39 Euros/l for diesel and 0,61 Euros/l for petrol). Untaxed prices are 0,63 Euros/l for both diesel and petrol. LPG and CNG are exempted from excises. Their fuel prices, including VAT, amount up to 0,54 Euros/l LPG and 0,90 Euros/kg CNG (Petrolfed, 2010). Petrol and diesel blended with an amount of biofuels originating from Belgian biofuel plants get a small excise reduction (0,37 Euros/l for bio-diesel blends and 0,57 Euros/l for ethanol blends) (FPS Finance, 2006). Untaxed prices of biofuels depend on many factors (raw materials, capital cost, intermediary processing and logistics). In this analysis, production prices of 0,55 Euros/l for ethanol and 0,90 Euros/l for bio-diesel are assumed, based on the ethanol price on the Rotterdam market and bio-diesel prices on the German market (Lievens and Jossart, 2009). The higher the percentage of biofuel in the blend, the higher total fuel costs/l will be (see figure 1). Electricity from the grid is not taxed a transport fuel. The exact electricity price depends on many factors, such as separate day and night prices. Here, a variable home-use tariff is used which is 0,15 €/kWh (including VAT) (Stroomtarieven, 2010).

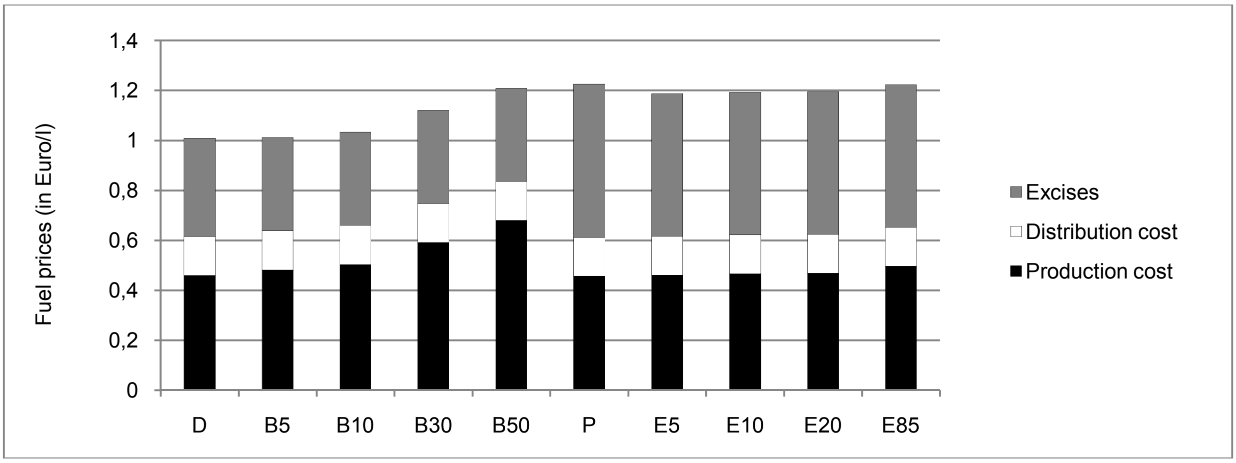

Figure 1: Breakdown of biofuel prices

Sources: Lievens and Jossart (2009), Petrolfed (2010)
Note: An overview of abbreviations is given on page 27.

Total fuel costs also depend on fuel consumption. Where available, the officially reported fuel consumption, based on the new European driving cycle (NEDC) is used. For other vehicles (e.g. biofuels, EVs), no official figures on energy consumption exists as they are not released on the market yet. Here, fuel consumption of biofuel vehicles is based on the energy density of the fuel and the percentage of biofuel in the blend (Goedecke et al., 2007; H2moves.eu, 2007). Vehicles on E20 and E85 consume respectively 8 and 35% more than the baseline petrol vehicle, whereas B30 and B100 have a smaller surplus consumption (respectively 3 and 10%) with respect to the baseline diesel vehicle as a result of the higher energy density of biodiesel as compared to ethanol (Chiarimonti and Tondi, 2003). For EVs, energy consumption is based on prototypes, communicated by vehicle manufacturers.

Table 2: Key cost parameters

Vehicle type	Make/model	Fuel	Purchase price (€)	VRT (€)	ACT (€/year)	Fuel consumption (l/100 km; m^3/km; kWh/km)	Insurance (€/year)	Maintenance (€/year)
Supermini	Citroën C1	P	9446	62	126	4,5	793	1067
Supermini	Citroën C1	D	11896	62	204	4,1	680	1067
Supermini	Citroën C1	LPG	11446	0	215	5,7	793	1127
Supermini	Citroën C-Zero	EV	35756	62	70	0,12	793	846
Small City Car	Fiat Punto	P	14720	62	204	5,8	804	1074
Small City Car	Fiat Punto	D	14300	62	165	4,5	804	1084
Small City Car	Fiat Punto	LPG	14560	0	254	7,4	804	1144
Small City Car	Fiat Punto	CNG	16810	62	254	6,5	725	1144
Small family car	Nissan Leaf	EV	32829	62	70	0,15	881	941
Small family car	Citroën C4	P	16586	62	204	6,4	881	1162
Small family car	Citroën C4	D PM	18286	123	243	4,7	881	1162
Small family car	Citroën C4	B5	18286	123	243	4,7	881	1162
Small family car	Citroën C4	B10	18286	123	243	4,8	881	1162
Small family car	Citroën C4	B30	18486	123	243	4,8	881	1162
Small family car	Citroën C4	B100	18486	123	243	5,2	881	1162
Small family car	Honda Civic	HEV	22390	62	165	4,6	878	1097
Big family car	Renault Fluence	EV	20000	62	70	0,15	1021	1036
Big family car	Toyota Prius	HEV	26830	62	204	4,3	833	1170
Big family car	Volvo V50	D PM	33050	495	373	5,7	1021	1275
Big family car	Volvo V50	P	30600	495	281	7,3	1021	1275
Big family car	Volvo V50	E5	30600	495	281	7,5	1021	1275
Big family car	Volvo V50	E10	30600	495	281	7,6	1021	1275
Big family car	Volvo V50	E20	31600	495	281	7,9	1021	1275
Big family car	Volvo V50	E85	31600	495	281	9,9	1021	1275
Exclusive car	Mercedes S	P	106722	4957	2368	11,7	1272	1422
Exclusive car	Mercedes S	D PM	98978	4957	1784	9,4	1272	1422
Exclusive car	Mercedes S	LPG	107722	4659	2576	14,8	1272	1482
Exclusive car	Lexus LS	HEV	113750	4957	2173	9,2	1272	1304
SUV	Mercedes M	P	57354	4957	1351	11,1	1272	1422
SUV	Mercedes M	D	55055	4957	700	9,4	1206	1422
SUV	Mercedes M	D PM	55781	4957	700	9,4	1206	1422
SUV	Mercedes M	LPG	58354	4659	1567	14,1	1272	1482
SUV	Lexus RX	HEV	61180	4957	1351	8,1	1172	1304

Notes: Insurances and maintenance costs are 2007 figures, adjusted to 2010 figures using the consumer price index (FPS Finance, 2010a). Purchase prices include standard offered equipment. An overview of the abbreviations is given on page 27.

2.2 Results

Figure 2 displays the LCCs for the alternative fuel- and drive train vehicles and the comparison baseline vehicles. At first sight, it seems that there is a large dispersal of the results over different vehicle types. Vehicles can have a yearly cost of 3,000 (supermini) to more than 17,000 Euros (exclusive car), with a cost per person kilometres travelled that varies from 0,18 Euros (supermini) up to 1,16 Euros (exclusive car).

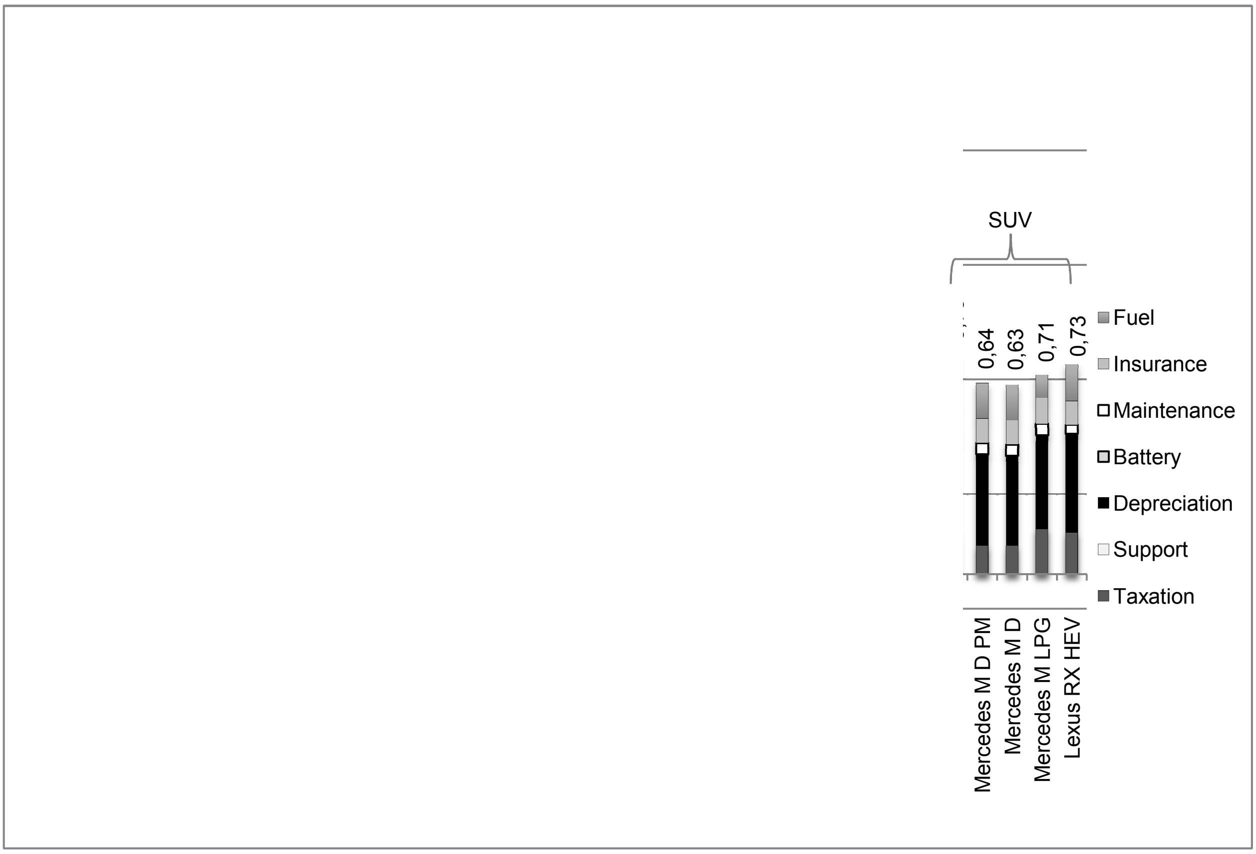

Figure 2: Life cycle cost in current vehicle taxation system

Notes: The cost per km (€/km) is indicated above each bar

Figure 2 discloses that the diesel vehicle is more cost-efficient than its petroleum equivalent. Although these vehicles often face a higher purchase price and as a result a higher VAT on the purchase price, they benefit from better resale values (less depreciation over time) and lower taxation rates. Because of the higher excise duties on petrol (more than twice as high) and their lower fuel efficiency (20 to 30% less efficient), fuel taxes will always be higher for petrol than for diesel vehicles. This tax advantage for diesel vehicles is not compensated by an appropriate vehicle taxation system. As table 2 illustrates, diesel and petrol vehicles are very differently taxed, based on their performance.

Accordingly, due to high cost-effectiveness of diesel vehicles as compared to petrol engines, there has been a so-called "dieselification" of the Belgian vehicle fleet over time. Over the period 1970-2007, the amount of diesel cars duplicated whilst the number of petrol cars decreased with 15%. In 2009, petrol cars represented only 25% of new vehicle registrations, compared to 75% diesel vehicles (Febiac, 2010). An important drawback of this evolution is the increasing amount of PM and NO_x in the air. Today, some vehicles are already standard equipped with PM-filters (like Citroën C4 D PM, Volvo V50 D PM, Mercedes S D PM), whereas for others it comes at the expense of an additional premium (like Mercedes M PM). Besides the Belgian subsidy for PM-filters, which requires a CO_2 level less than 130 g/km, no differentiation is made in the vehicle taxation system for these more ecologically friendly vehicles.

Apart from the Citroën C1 LPG, vehicles on LPG and CNG are currently not financially beneficial as compared to vehicles with diesel engines. Despite their lower fuel costs (low production costs combined with exemption of excise duties), these vehicles encounter additional conversion costs, a higher depreciation rate, higher annual inspection costs and even an additional ACT. Only with respect to the heavily taxed petrol vehicles, they provide a financially attractive alternative.

The existing generation of HEVs cannot compete on cost-efficiency with conventional (diesel) vehicles without additional support. They still face higher purchase prices, lower resale values and encounter more fuel taxes than diesel vehicles, despite their greater fuel efficiency. The Belgian support for vehicles with low CO_2-emissions makes the Toyota Prius very cost-efficient for the end-user. Real sales data show indeed that this subsidy is vital for its encouragement. With more than 6,500 units sold in 2008, the Toyota Prius is ranked at the 22nd position of best selling cars in Belgium (Autoworld, 2009). However, other HEVs (such as Honda Civic IMA, Lexus LS and Lexus RX) with higher CO_2 levels cannot profit from this support, which makes them financially less attractive for the consumer. Moreover, in some cases (Lexus LS and Lexus RX), the ACT is higher than for comparable diesel engines, whereas they release less polluting emissions.

EVs (like C1 EV) are at present more expensive than the baseline vehicles (C1 P, D). This high cost is particularly the result of its high purchase price (small-scale production) which includes an expensive lithium-ion battery, combined with a higher depreciation rate. The lower maintenance costs and fuel costs (low untaxed electricity prices) and the minimum vehicle taxation tariffs cannot compensate the vehicle purchase price premium. Without the 30% governmental support, the amortized cost per kilometer would be even higher (+ 0,08 Euro/km). The financial attractiveness of EVs can nevertheless increase with battery leasing (see for example Renault Fluence).

Vehicles with blends of biofuels are also confronted with higher LCC than the reference vehicles. This is caused by several factors, namely the higher initial conversion costs, higher fuel production costs (see figure 1), additional fuel consumption and as a consequence higher fuel taxes (excises and VAT). The higher the % in the blend, the higher total fuel costs will be. Unless the imposed excises would be adapted proportional to the amount of biofuels in the blend, biofuel vehicles will not become financially advantageous for end-users.

Overall, the LCC analysis demonstrates that (more) sustainable vehicles are at present not financially attractive for the Belgian end-user. The fiscal system discourages them (by an additional ACT for LPG and CNG vehicles; by high excise duties for biofuel vehicles), whilst favouring polluting vehicles (e.g. diesel cars). The existing incentives (exemption of excises for LPG, CNG, EVs; governmental support for vehicles with low CO_2-emissions and PM-filters), should be complemented with other policy measures to enhance their attractiveness. The European Commission (2005a) sees a restructuring of the vehicle taxation system as a strong signal to steer consumers towards the purchase of more sustainable vehicles. Next section introduces a new methodology, the Ecoscore, which may serve as a basis for such a tax reformation.

3. Ecoscore

3.1 Methodology

To make a judgment of the environmental friendliness of vehicles with different drive trains and fuels, an environmental rating tool for vehicles, called "Ecoscore", has been developed (Timmermans et al., 2005; 2006). Ecoscore takes several damage categories into account: climate change, air quality depletion (health impairing effects and effects on ecosystems) and noise pollution (figure 3).

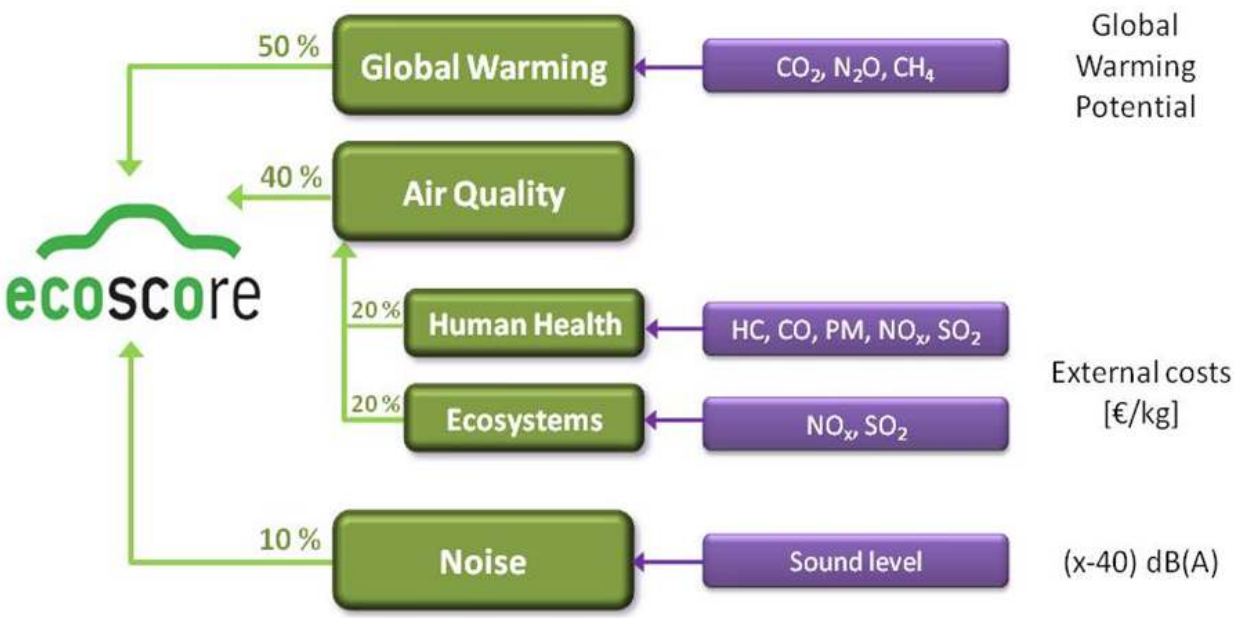

Figure 3: Overview of the Ecoscore methodology

Source: Timmermans et al. (2006)

The Ecoscore is based on a WTW analysis, which means that besides direct tailpipe (tank-to-wheel (TTW)) emissions, the indirect (or well-to-tank (WTT)) emissions due to the production and distribution of the fuel are taken into account. Emissions resulting from the vehicle assembly and from the production of its constituting elements are not considered, nor are the maintenance phase and recycling phase of end-of-life vehicles. However, analyses have shown that the emissions due to the using phase of the car are decisive compared to those of the production and end-of-life phases of the car (Timmermans et al., 2005). Moreover, the differences in emissions when comparing different drive trains are expected to be small. The use of large secondary batteries in the case of HEVs and EVs is expected to have a limited environmental impact as a result of the high recycling rate of this type of batteries (Van den Bossche et al., 2006; Matheys et al., 2009).

The environmental evaluation of a vehicle is done according to a sequence of five steps, similar to those used in a standardized life cycle assessment (LCA): inventory, classification, characterization, normalization and weighting (see figure 3). In the inventory step, direct emissions related to the use of the vehicle (CO, HC, NO_x, PM, CO_2, SO_2, N_2O, CH_4) and indirect emissions related to the production and distribution of the fuel (CO, NMHC, NO_x, PM, CO_2, SO_2, N_2O, CH_4) are collected. Once the total environmental impact (TI) of these emissions is calculated, their contribution to the different damage categories (global warming - air quality – noise) is analyzed in the classification and characterization step. The contribution of greenhouse gases is calculated using global warming potentials, whereas the contribution of air pollution is expressed in Euros per kilogram and noise pollution in dB(A), a decibel scale with A-weighting to take the sensitivity of human hearing into account. In the normalization step, the relative severity of the evaluated damages of each damage category is quantified based on a specific reference value. The reference point is the damage associated with a theoretical passenger vehicle with target emission values. The emission levels correspond with the EURO 4 emission limits for passenger cars, introduced by Directive 98/69/EC. Moreover, a reference CO_2 emission level of 120 g/km is taken into consideration as this is the CO_2 target value of the European Union by 2012 (European Commission, 2007). The noise emission reference has been set to 70 dB(A). In the final step, the normalized damages are weighted before they can be added into the TI. These weighting factors reflect policy priorities and decision makers' opinions and were determined by a stakeholder group consultation, including representatives from governmental administrations, political parties, the automotive sector, environmental NGOs and consumer organizations (Timmermans et al., 2006).

For communication purposes, the TI is rescaled into the Ecoscore ranging from 0 to 100, where 100 represents a perfectly clean and totally silent vehicle. The reference value for an environmental friendly vehicle corresponds with an Ecoscore of 70. The transformation is based on an exponential function (see figure 4) to avoid negative scores. Due to this exponential function, the differentiation of Ecoscores is larger for vehicles with a low environmental impact compared to those with a high environmental impact.

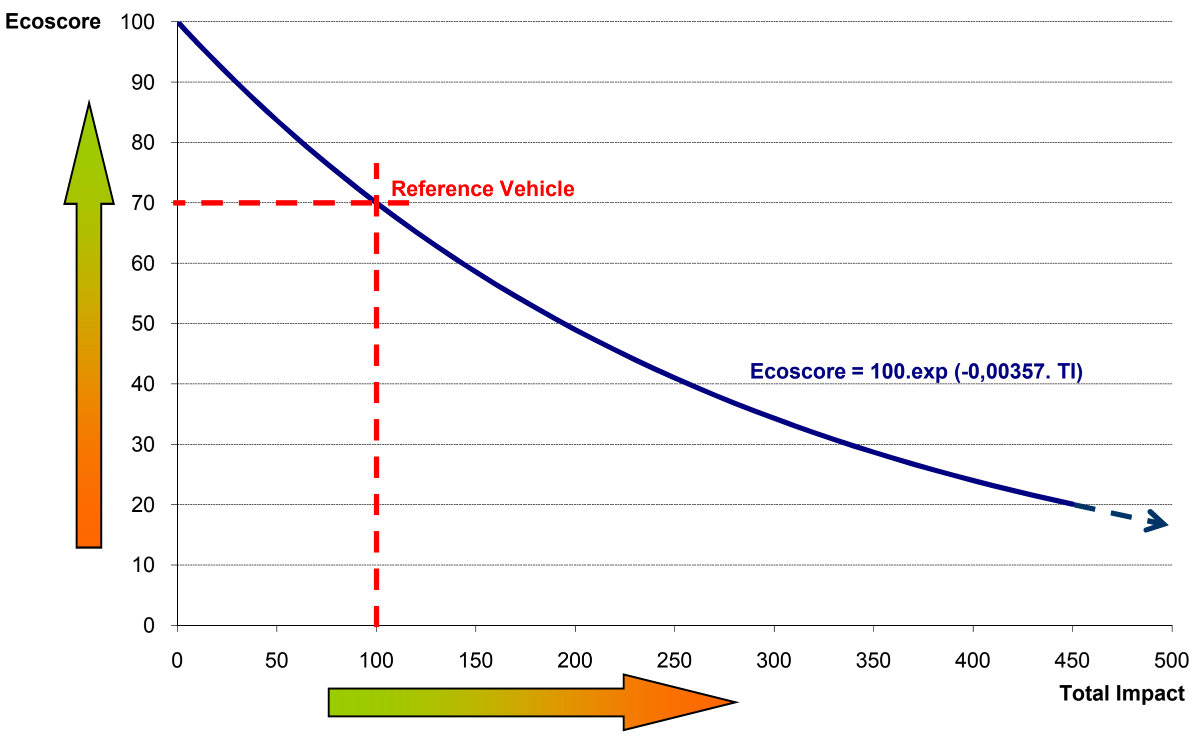

Figure 4: Transformation of total impact to Ecoscore

Source: Timmermans et al. (2006)

3.2 Results

Figure 5 displays the TI (split up per damage category) and the Ecoscore for each EURO 4 vehicle, included in the LCC analysis. One can conclude that EVs are very environmentally friendly on a WTW basis. HEVs also contribute less to global warming (higher fuel efficiency), human health emissions and noise pollution and are in this respect more ecologically friendly than their conventional counterparts. In spite of the somewhat lower energy efficiency, LPG and CNG vehicles remain more sustainable than petrol and diesel cars. This is mainly because of lower indirect emissions combined with lower air quality depleting emissions. The main advantage of diesel vehicles is the high energy efficiency which adds to a lower impact on global warming. On the other hand, the high PM and NO_x emissions make them less environmentally friendly at the moment (e.g. C1 D, Fiat Punto D). Their environmental performance can nevertheless increase with a PM-filter, as illustrated by C4 D PM, V50 D PM, etc. Within a certain vehicle type, large differences in the Ecoscore are possible. Hence, the results may not be generalised on the basis of technology. A small diesel vehicle (e.g. Citroën C1 D) produces for example lower emissions than a large petrol SUV vehicle (e.g. Mercedes M P). A database of vehicles can be found on www.ecoscore.be.

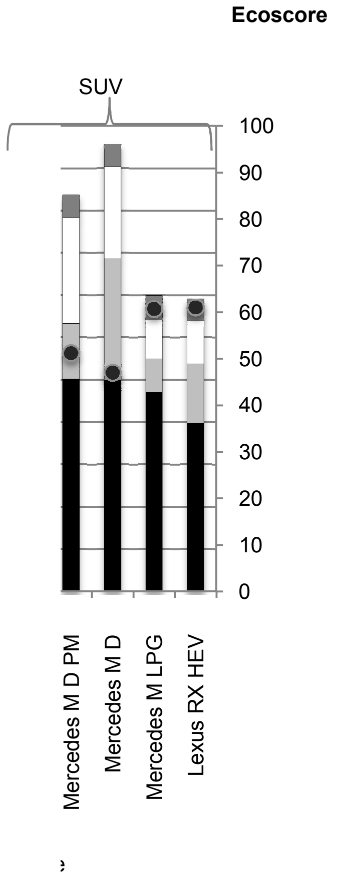

Figure 5: Total impact of the vehicle, split up per damage category

Source: Ecoscore (2010)

Notes: Input data are based on official homologation data (CO, NO_x, PM, HC). Other pollutants are correlated with fuel consumption, based on the NEDC (CO_2, N_2O, CH_4, SO_2). Emissions related to production of the fuel (or electricity) are derived from fuel consumption data. Since 2002, homologation data are available for all vehicles brought on the Belgian market. However, up to now, no homologation data exist for biofuel vehicles as they are not commercially available yet. Moreover, indirect emissions (WTT) will highly depend on the origin of the biofuel. Due to these data constraints, no Ecoscores currently exist for biofuel vehicles. For EVs, the Ecoscores have been calculated, based on data of prototypes, as reported by vehicle manufacturers.

4. Tax reform

4.1 Methodology

The European Commission (2005a) encourages a vehicle taxation system, correlated with the CO_2 emissions of the car. Several studies researched the impact of a tax reformation on CO_2 emissions and reported that CO_2 emission reductions can only be achieved if accompanied with the vehicles' sizes being reduced and the share of diesel vehicles being increased (COWI, 2002; European Commission, 2005a, Kunert and Kuhfeld, 2007; Giblin and McNabola, 2009; Caulfield, 2010).

As a result, orienting Belgian taxes on CO_2 emissions will give diesel vehicles an additional tax advantage, whereas their cost-efficiency has already contributed to a increased market share in Belgium (see also section 2.2). Taking into account that a tax reformation should not discriminate between specific types, classes or segments of cars, CO_2-emissions should not be the sole basis of taxation (European Commission, 2005a, Kunert and Kuhfeld, 2007). Instead, the Ecoscore methodology can be used. In Belgium, the Flemish, Walloon and Brussel Capital region are in charge of the vehicle taxation system related to passenger cars. Vehicle taxes are collected on a federal level, after which they are distributed to the three regions. The Flemish and Brussels region are presently considering a tax reformation, based on the Ecoscore (Chamber of Belgian representatives, 2008).

The tax restructuring covers both to the VRT and ACT. According to COWI (2002), the replacement of both taxes performs better than the individual cases. As the demand for company cars in Belgium is dependent on specific (federal) taxation schemes, the tax reform only focuses on vehicles bought by private households. It is still important to integrate them in a later stage as they make up a significant proportion of the vehicles sold in Belgium. The tax reform applies to new as well as second-hand vehicles. For the latter, correction factors need to be introduced, based on the depreciation of the car, as used vehicles are mainly owned by people that cannot easily access the new vehicle market (Kunert and Kuhfeld, 2007). The new VRT will be introduced immediately, while the new ACT will be gradually introduced in order to let people get used to prices and enhance the acceptability (Rouwendal and Verhoef, 2006).

The boundary conditions of the tax reform are budget neutrality, technological neutrality and fleet composition neutrality. The tax reform should be budget neutral implying that no changes occur in the revenues obtained from the VRT and ACT. If it would affect the governmental budget, then compensating measures (such as decreasing other existing distortionary taxes) could be initiated. Technological neutrality refers to the fact that no specific vehicle technology should be favoured (e.g. like diesel vehicles today). Here, the use of the Ecoscore as taxation base has a clear advantage to the use of for instance the EURO standards or the CO_2 emissions of the vehicle as it does not discriminate on the basis of technology (see section 3.2). Moreover, the Ecoscore helps to preserve fleet composition neutrality. Figure 5 demonstrated that there is a range of Ecoscores for vehicles within the same vehicle segment. As a result, a tax reform based on the Ecoscore will rather evoke a shift to vehicles with a better environmental performance in the same vehicle segment, than a shift to smaller vehicles.

For the elaboration of the functional form, it is important to mention that for the calculation of the Ecoscore, there has been a transformation of the TI based on an exponential function (see figure 4). The new tax reform is calculated as (one or more) linear functions, based on the Ecoscore of the vehicle (see equation 2).

$$TAX = a * TI + b \qquad (2)$$

TAX represents the VRT or the ACT, TI is the total environmental impact of the vehicle (LN (Ecoscore/100)/-0,00357) and "a" and "b" are parameters defined in a way that polluting cars (Ecoscore < 70) pay more taxes and environmentally friendly vehicles (Ecoscore > 70) pay less taxes compared to existing taxation levels. In this application, the Brussels tax proposal is taken as an example (Macharis et al., 2007).

4.2 Results

Figures 6 and 7 show a comparison of the VRT and ACT in the old and new vehicle taxation system for the EURO 4 vehicles, included in the LCC analysis.

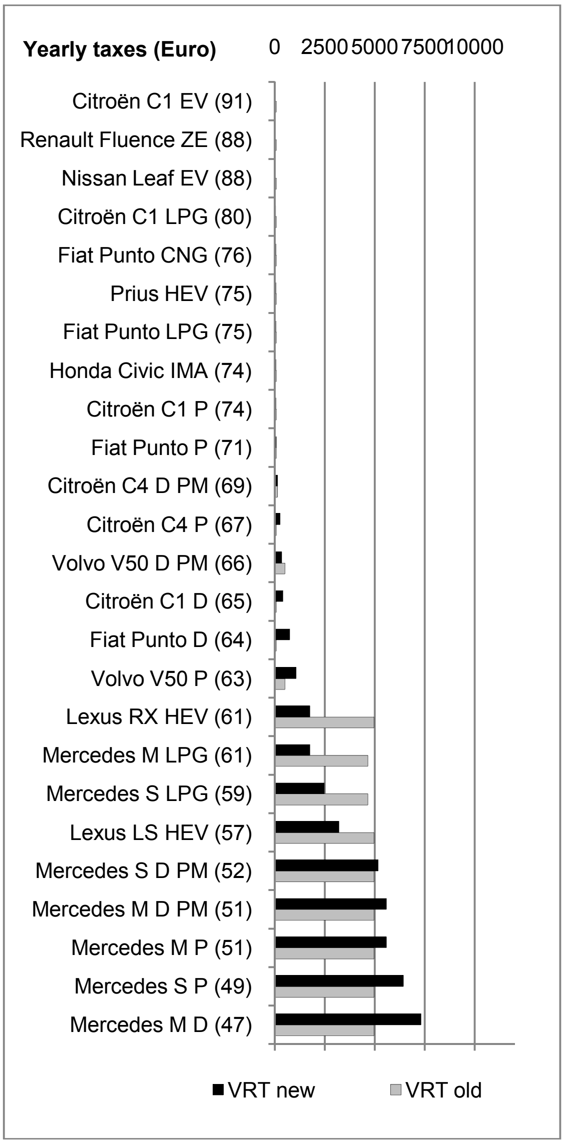

Figure 6: Old and new VRT

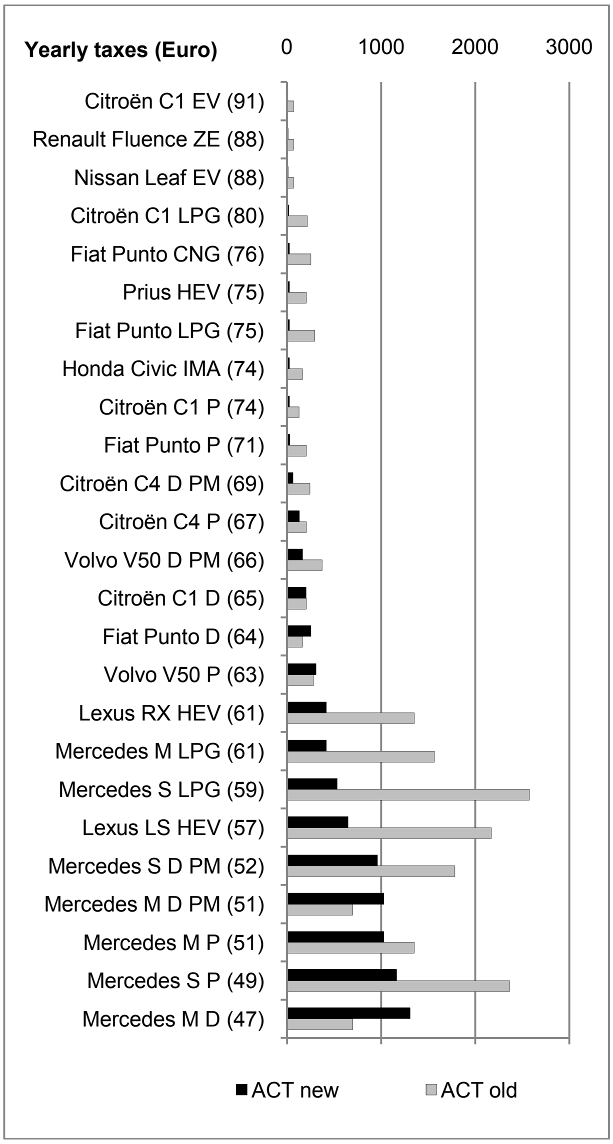

Figure 7 : Old and new ACT

Note: The number between brackets represents the Ecoscore

In general, a discrepancy between current taxes and the environmental performance of vehicles can be noticed. In the new taxation system, sustainable vehicles (Ecoscore > 70) are favoured, whereas for other vehicles, taxes increase along their environmental damage. As a result, diesel and petrol vehicles are more equally taxed in the new system (e.g. Mercedes M P & D). There is also a clear differentiation between diesel vehicles with and without PM-filter (e.g. Mercedes M D & D PM). Vehicles on alternative fuels (LPG, CNG) and drive trains (EV, HEV) are more encouraged by a lower tax burden on an annual basis (like Renault Fluence; Lexus LS & Lexus RX, Mercedes M & S LPG).

The overall decrease in taxation levels is explained by the fact that only new (EURO 4) vehicles (and no second-hand vehicles) are covered in this analysis. Figure 8 illustrates whether these new taxes are reflected in the LCC of the vehicle and hence might provide an incentive to promote a more sustainable vehicle choice.

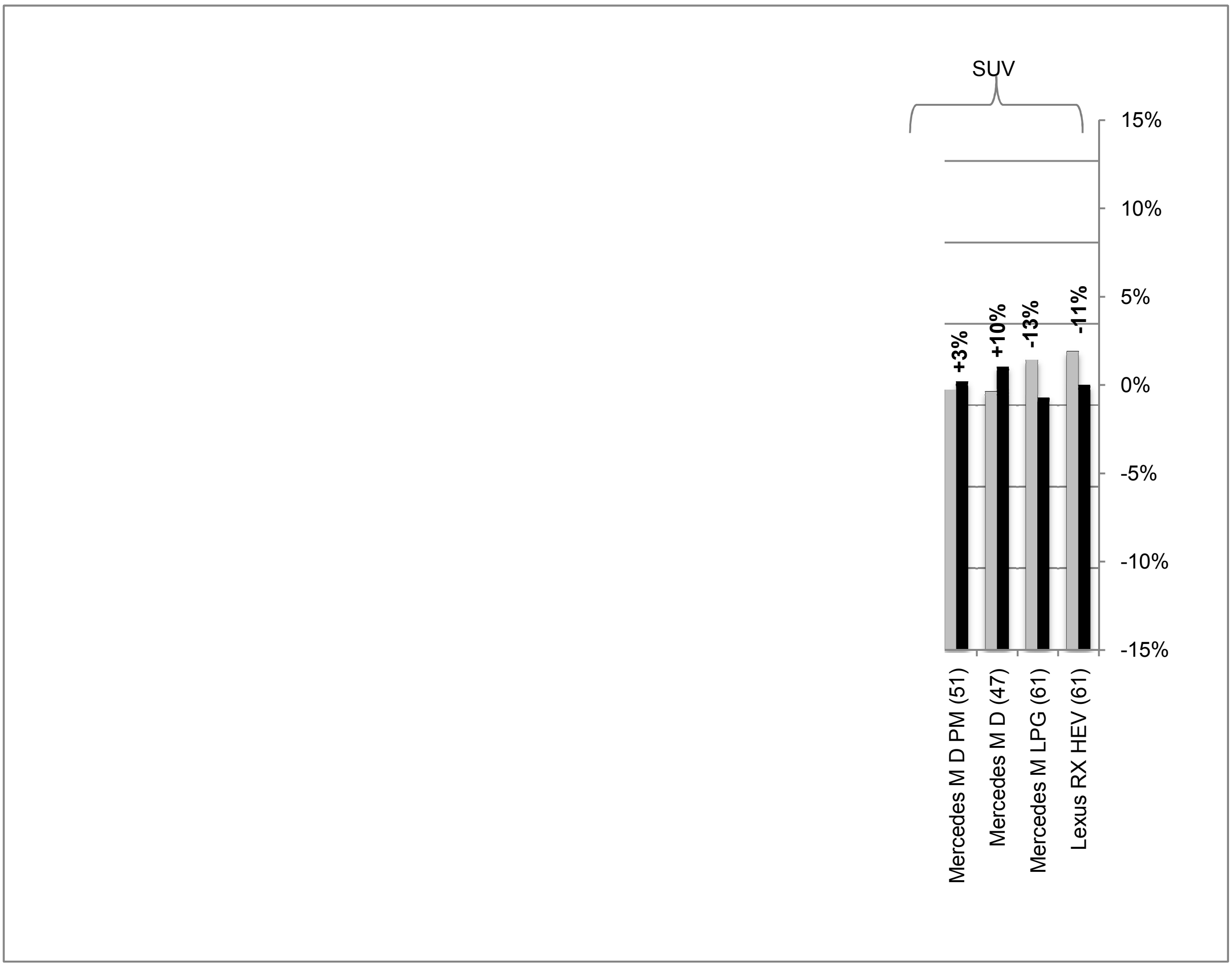

Figure 8: Life cycle cost in new vehicle taxation system

Notes: The percentage change between the old and new LCC (in Euro/km) is denoted above each bar.

In the new taxation system, petrol vehicles become 1 to 4% less expensive on a cost per kilometer basis, whereas the LCC of diesel vehicles without PM-filter increases up to 10%. Yet diesel vehicles remain more cost-efficient than petrol vehicles, which is the result of their great fuel tax advantage. In the ideal situation, excise duties for diesel and petrol cars should be brought in line with one another. This proposal was also brought forward by the European Commission in 2002, where they suggested a tax convergence of taxes on diesel and petrol fuels with special tax arrangements for diesel used for commercial or private purposes. This proposal was however rejected by the European Parliament (Kunert and Kuhfeld, 2007; European Commission, 2002).

Diesel vehicles, equipped with a PM-filter are more incentivized in the new taxation system. The LCC for the Mercedes M with PM-filter increases with 3%, whereas the Mercedes M without PM-filter faces an increase of 10%. Thanks to the tax reformation which also includes the abolishment of the additional ACT, retrofitted LPG and CNG vehicles encounter LCC reductions from 5% (Fiat Punto CNG) to 13% (Mercedes M LPG). In most cases, they now provide a cost-competitive alternative with respect to petrol as well as diesel vehicles. The better environmental performance of HEVs results in LCC reductions from 3 to 11% which considerably enhances their cost-competitiveness. The financial attractiveness of EVs only increases with 1 to 2% as these vehicles already get minimum taxation tariffs in the existing taxation scheme. Additional governmental support remains very important to encourage these vehicles for the end-user. Overall, the new taxation system based on the Ecoscore appears to be a useful means to differentiate the taxation system along the environmental performance of vehicles and eliminate existing tax distortions. In this way, the new system is more fair and it will better reflect the cost that each vehicle imposes on society. However, the steering effect of such a tax reform should not be overestimated. Belgian vehicle taxes (ACT and especially VRT) are amongst the lowest throughout Europe and only represent a fraction of total vehicle costs (COWI, 2002). Moreover, car purchasers consider the most important financial factors to be purchase price, fuel consumption and maintenance costs (Mairesse et al., 2008). According to Lehman et al. (2003), road taxes are the least important running cost at the purchase of a new vehicle in the UK. So a tax reformation will only indirectly affect consumers' purchase decisions, unless extremely high taxation levels would be raised, which is less acceptable from a social point of view.

5. Conclusions

This paper proposed a Belgian tax reformation to respond to the EU proposal, which stipulates that vehicle taxes should be rebalanced, and by preference partially or totally based on CO_2 emissions (European Commission, 2005a). Instead of focusing on CO_2 emissions alone, the Ecoscore was introduced as a new tax assessment base. A tax reform based on the Ecoscore has some clear advantages as compared to a tax orientation on CO_2-emissions: it takes not only the WTW emissions of the vehicles into account, but also enables a budget-neutral tax reform, while preserving the neutrality of technology and the fleet composition. The LCC methodology was used to investigate whether a tax reform can promote a sustainable vehicle choice. The tax reform was found to be an ideal means to eliminate current tax distortions and bring the costs of the vehicle more in line with their environmental performance. As such, the vehicle taxation system might become more fair (in an ecological sense) and will better reflect the cost that a vehicle has on society. To enhance acceptance of a tax reform, Jagers and Hammer (2009) advise governments to present taxes in terms of their intended effects and their actual costs to the individual. In this respect, the LCC can be used as a communication tool to inform consumers about the actual cost of a vehicle in the new system. However, the steering effect of such a tax reform should be put into perspective. Taxes only represent a fraction of total vehicle costs, and have a smaller weight in the purchase decision than other financial aspects, such as purchase price and fuel costs. Moreover, consumers might not fully investigate the costs and benefits associated with a more sustainable vehicle choice (Turrentine and Kurani, 2007). Policy measures that directly address the important (financial) purchase factors might be more effective in targeting car purchase decisions. A measure that is often proposed in literature is a feebate system, where fees are charged at the purchase of vehicles with low fuel efficiency and rebates are offered to vehicles with high fuel efficiency (Greene et al., 1995; de Haan et al., 2009). Feebates might not only induce consumer shifts in the vehicle fleet mix, but also provide an incentive to accelerate technology improvements (Greene et al., 1995; Johnson, 2006; de Haan et al., 2009). Feebates could thus be used, supplementary to the vehicle tax reformation, to enhance the adoption of sustainable vehicles and diminish the environmental impact of passenger cars.

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CLEVER
Clean Vehicle Research

Price elasticity
Task 3.2
Part 2

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1 Introduction

In task 3.2: Price elasticities, part 1, a literature review of price elasticities was performed to investigate the impact of several policy measures with respect to the purchase and use of vehicles. In this report (part 2), a contingent valuation (CV) survey has been set up to examine the impact that single pricing measures might have on the purchase of environmentally friendlier vehicles. Moreover, a new multidisciplinary model has been elaborated by adopting principles of psychological theory (Information Integration Theory, IIT) into the CV method in order to circumvent potential cognitive difficulties that may arise when presenting information of several pricing measures to the respondents. With this model, the impact of the identified CLEVER scenarios (of task 5.3) on the demand for environmentally friendlier vehicles can be derived. Section 2 introduces the applied methodology for the survey. Section 3 presents the results and section 4 formulates the conclusion.

2 Methodology

In the last decade, economists have been increasingly using stated preference surveys to unveil true preferences for environmental goods presented in a hypothetical scenario (Hanly et al., 1998; Bateman et al., 2002; Veisten, 2007). The most common stated preference techniques are the choice modeling (CM) method and the contingent valuation (CV) method. CM originates from conjoint analysis and uses a choice experiment to indirectly elicit attribute values based on either ranking or rating of products described by a number of attributes in several choice sets (Green and Srinivasan, 1990). In CV, value elicitation is whole-product based by asking respondents to express their maximum willingness to pay (WTP) for a given improvement of a public good provision level (e.g. cleaning up a lake) or for public good aspects of a market good (e.g. eco-labeled goods) (Mitchell and Carson, 1989; Hanly et al., 2001; Veisten, 2007). CV and CM offer rather different merits and their use entirely depends on the purpose of the study under investigation. CM is particularly suited to measure the marginal value of changes in various characteristics of environmental programs, whereas CV is a better technique than CM when the main objective of the study is to value an overall policy package and for assisting in policy evaluations (Hanly et al., 1998; Hanly et al., 2001; Carson, 2000). The CV method (Mitchell and Carson, 1989) is the most frequently used method for environmental-friendly policy evaluation. It has been used for setting eco-taxes in the UK to justify the tax and for determining its level (Hanly et al., 2001). Past research has also investigated consumers' WTP for air quality improvement (Wang et al., 2006; Brouwer et al., 2008; MacKerron et al., 2009; Bento et al., 2010), market potential for alternative fuels and drive trains (Sperling et al., 1995; Mourato et al., 2004; Solomon and Johnson, 2009) and eco-labeled goods (Ozanne and Vlosky, 1997; Veisten, 2007)

In this task, the CV approach is used to evaluate whether separate pricing measures, based on the environmental performance of vehicles, will bring along a substantial change in purchase behavior towards green vehicles and subsequently a decrease in vehicle emissions. However, recent literature suggest that one single policy measure is unlikely to change behavior and that a range of policy measures is required to encourage the adoption rate of green vehicles into the market (Hickman et al., 2010). Consequently, it can be assumed that the total shift to environmentally friendlier vehicles would be much higher when applying a multi-faceted price strategy. A potential drawback of CV might arise with the cognitive difficulty associated with expressing a WTP given information on multiple pricing measures (Harris et al., 1989). People only have a "bounded or limited rationality" indicating that too much information adversely affects the ability to solve complex decision problems (Simon, 1955). Moreover, Nisbett and Ross (1980) present considerable evidence that people tend to weight the relevance of the information when making judgments. Given these limitations of human information processing and judgement abilities, the accurate measurement of contingent values might be affected and hence the reliability and validity of the CV results (Harris et al., 1989). That is why Harris et al. (1989) advise to perform more multidisciplinary studies by incorporating psychological theory into CV studies. Here, a new multidisciplinary approach has been elaborated by applying the CV method according to the principles of Information Integration Theory (IIT), a theoretical and methodological framework to algebraically describe the sequence from the presentation of multiple information carriers to an actual behavioural response. This combination results in "a policy based model to predict green vehicle purchase" and enables the decision maker to estimate the population distribution willing to switch to an environmentally friendlier car based on different pricing levels of combined policy measures. Section 2.1 first describes the CV survey which has been designed to unveil the effectiveness of individual pricing measures on the willingness of the Belgian respondents to switch to a greener vehicle. Then, in section 2.2, the principles of IIT are explained and a new methodological design is proposed that allows measuring the change in purchase behavior as a result of combined pricing measures.

2.1 Contingent valuation

2.1.1 Survey design

The main objective of the CV study was to evaluate the effectiveness of pricing measures on the willingness to change to an environmentally friendlier car. Participants for the online survey were recruited in June 2010 through a marketing research institute (iVOX). 1186 respondents completed the survey, for which they received an incentive. The survey consisted of 4 parts. Part 1 contained several web pages eliciting information about transportation choices and motives (main transportation mode, private or professional trips), travel profiles (yearly mileage, proportion of trips during peak traffic), purchase profiles (importance of financial - performance-environmental attributes in the car purchase decision, number of vehicles in household, average replacement rate, future purchase intentions) and vehicle-related information on current and future vehicles in the household (brand, make, fuel type, engine power, etc.). In Part 2, general background information was provided on climate change and about the prospect of the implementation of policy measures to encourage sustainable transportation. Meanwhile, it was emphasized that each policy measure should be considered separately in the survey question, all other fiscal instruments remaining unchanged. Part 3 showed separate pages with the respondents' preferred car and an estimation of its current level of taxation for existing and hypothetical pricing measures: vehicle taxation (registration tax, annual circulation tax), urban congestion charge, kilometre charge, parking tariffs and fuel prices.

Current taxation levels are based on the vehicle-related input provided in part 1. When a taxation system is not yet installed (urban congestion charge, road pricing), a charging level based on reference values from neighbouring countries is presented. For example, in case of road pricing, a yearly charge is approximated by using proposed reference values from the Netherlands (0,11 Euro in peak traffic and 0,03 Euro otherwise) and the respondents self-reported travel profiles. Respondents are then informed that a new level of taxation will be based upon the vehicle's environmental performance. For this purpose, 4 environmental categories have been identified and visually shown to the respondents (see Figure 1). These categories have been determined in accordance with the definition of clean vehicles in the identified CLEVER scenarios (see tasks 5.2 and 5.3). Additionally, an environmental label (A, B, C or D) is attached to the respondent's preferred car. Under each governmental action, C and D-labeled vehicles will be discouraged with a higher financial burden, whereas B-labeled vehicles (low CO_2 emitting vehicles, corresponding to the definition of a clean vehicle in the realistic scenario) receive a more advantageous tariff and A-labeled vehicles (alternative fuels and drive trains, corresponding to the definition of a clean vehicle in the progressive scenario) enjoy minimum tariffs (in case of vehicle taxation) or even exemptions (in case of urban congestion charge, road pricing, parking tariff, excises). Given this information, the respondents could indicate whether and at which (new) taxation level, they would find their preferred car so expensive that they would consider a switch to a B-labeled or an A-labeled vehicle. In part 4, demographic questions were asked (gender, age, education, income) and the possibility for providing comments was given. An overview of the entire survey is given in Annex A.

Figure 1: Environmental categories

2.1.2 Elicitation format

To elicit the contingent values, the survey combines open-ended questions with discrete choice questions. Open-ended questions, which include payment cards and bidding games, provide a point estimate of the respondent's maximum WTP and works well in situations where respondents are familiar with the good in question (Carson, 2000; Mitchell and Carson, 1989). Close-ended questions asks the WTP for a stated amount and provides intervals in which the respondent's WTP lies (Worldbank, 2002). The payment vehicles used in the survey included vehicle taxes, charges and tariffs which are likely to be familiar to most respondents and are realistic modes of payment in the context of the study in question (Wiser, 2007; Yoo and Kwak, 2009). For the open-ended question, the payment card method was used, in which individuals could indicate the maximum pricing level at which they would find their preferred car so expensive that they would consider a switch to an environmentally friendlier car (A or B-labeled vehicle). Although the payment card method has some advantages like the direct elicitation of the maximum WTP, it also suffers from the production of a large amount of zero WTPs. The survey at Autosalon (January 2008; see task 3.2, part 1) by face-to-face administration revealed that these zero WTPs can be classified into two categories: in the first case, a zero WTP might indicate that one is not willing to pay anything for a more environmentally friendlier car. In the second case, a zero WTP can also be interpreted in a way that one is immediately willing to switch. That is why in this final survey, two additional discrete choice options (besides the open-ended question) were added to make a clear distinction with respect to these answers. The final question in the survey reads as follows:

"At which level would you find the taxation/charging/tariff level so high that you would consider a switch to a more environmentally friendly car (of respectively category A and B)?"

Three possible answers were offered:

- *I would only switch to a more environmentally friendly car if the taxation/charging/tariff level would be more than X Euro.* Respondents could indicate the level (X Euro) by means of a slider. Based on these responses, one can elicit the mean WTP at which the consumer would find its conventionally fuelled car so expensive that he would consider a switch to a low CO_2 emitting vehicle (category B) or a vehicle on alternative fuels and drive trains (category A).

- *I cannot or will not switch to a more environmentally friendly car, independent from the level of expensiveness.* This answer means that these people have no willingness to pay for a more environmentally friendly vehicle.

- *I would switch immediately to a more environmentally friendly car.* This option captures all the social desirable answers. As these answers do not represent a real WTP, these observations are not take as reliable estimates in the study (Carson et al., 2000; Nunes and Schokkaert, 2003).

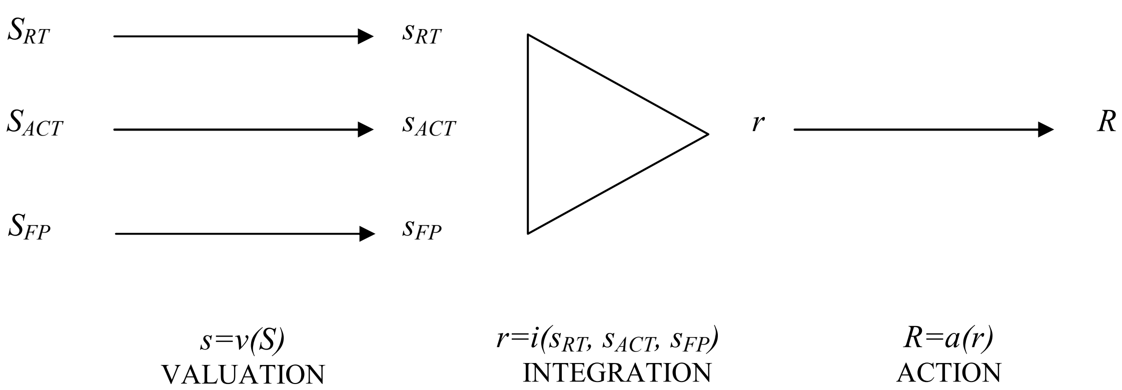
2.2. Information Integration Theory (IIT)

In order to assess how combined pricing policies have impact on purchase behaviour, we adopt the principles of Anderson's Information Integration Theory (Anderson, 1981, 1982, 1996, 2001, 2009). Information Integration Theory (IIT) unifies theoretical frameworks from personal cognition to decision making. Its foundation rests on two major axioms: (1) the axiom of purposiveness and (2) the axiom of multiple determination. The first axiom states that perception, thought and action are directed towards goals. The second states that nearly all perceptions, thoughts and actions depend on the joint effect of multiple determinants (Anderson, 1996, 2001). Uncovering the combinatory mechanisms of these determinants is of primary interest as it allows for a proper understanding and prediction of behaviour (Anderson, 2001).

2.2.1 Functional Measurement

IIT's operational counterpart, Functional Measurement (FM), provides a means to study these mechanisms. The process describing the sequence from the presentation of multiple information carriers (stimuli) to the actual response is illustrated in the Functional Measurement paradigm below (*Figure 2*). An example relevant to the current study, will further explain this sequence.

Figure 2: Functional Measurement paradigm (Anderson, 1981; Weiss, 2006) *S_n: Observable stimuli (pricing measures), s_n: subjective impressions, r: implicit response, R: observable response (reported purchase intention), v: valuation function, i: integration function, a: response function*



Observable physical stimuli (S_n) are transformed into subjective impressions (s_n) through the valuation function (v). Then, the integration function (i) combines these subjective impressions of individual stimuli into a single subjective response (r). In the last stage, the subjective response is converted into an overt response by means of the response function (a) (Anderson, 1981, 1996). Purposiveness appears essentially in the valuation operation, multiple determination appears essentially in the integration operation (Anderson, 2009).

Central in FM is the study of integration operation (i), which directly addresses the question how stimuli combine into a single overt response. Typically, integration functions are exposed by presenting participants with a set of different stimulus-combinations in a factorial judgment task. In our example, registration taxes (S_{RT}), annual circulation taxes (S_{ACT}) and fuel prices (S_{FP}) can be manipulated according to an $n \times p \times q$ full-factorial design with n levels for the registration tax attribute, p levels for the annual circulation tax attribute and q levels for the fuel price attribute. Attribute levels are chosen to elicit high, medium and low responses on the dependent variable (here: purchase price probability). Participants are required to indicate the probability of buying a hypothetical car characterized by information on registration tax, annual circulation tax and fuel price (i.e. the observable stimuli) for as many times as required by the repeated measures factorial design. These judgments provide the observable responses (R) from which the integration function (i) can be inferred by means of Analysis of Variance. Extended empirical research over the last four decades (for an overview, see Anderson (1996, 2009) showed that three algebraic integration rules approximate the internal integration functions for most judgment tasks: an addition rule (Eq.1), a multiplication rule (Eq. 2) and an averaging rule (Eq. 3). Formally:

$$[r_{ijk} = w_0 s_0 + w_{RT} s_{RT_i} + w_{ACT} s_{ACT_j} + w_{FP} s_{FP_k}] \tag{1}$$

$$[r_{ijk} = w_0 s_0 \times w_{RT} s_{RT_i} \times w_{ACT} s_{ACT_j} \times w_{FP} s_{FP_k}] \tag{2}$$

$$[r_{ijk} = \frac{w_0 s_0 + w_{RT} s_{RT_i} + w_{ACT} s_{ACT_j} + w_{FP} s_{FP_k}}{w_0 + w_{RT} + w_{ACT} + w_{FP}}] \tag{3}$$

Note: RT = "Vehicle registration tax", ACT = "Annual Circulation Tax", FP = "Fuel Prices"

In each of these integration models, the integrated response is a function of weight and scale values. Each piece of information is considered to have its own importance (=weight) and its own location (=scale value) with respect to the dependent variable (here: purchase probability). w_0 and s_0 are parameterizations of the internal stimuli or the initial state of the respondent (Anderson, 1982). However, the question remains which integration function to use. If an additive model is used, one assumes that the rating for a combination of stimuli always exceeds the rating for one of these two stimuli (Anderson, 2009). In an averaging model, this is not the case. Adding a mild stimulus to an intense stimulus will cause this rating to be lower than the rating for the intense stimulus alone. Previous empirical research has repeatedly shown that consumers do not add information on attributes, but rather apply an averaging rule (Troutman and Shanteau, 1976; Gaeth et al., 1990; Johar et al., 1997; Adaval, 2003). So in this case, equation 3 will be applied.

2.2.2 Design issues

Even though weight and scale parameters of the averaging model serve as a theoretical validity standard (Wang and Yang, 1998), the experimental procedure required to estimate these parameters suffers from some drawbacks. First, when a large set of attributes is under investigation, the design size may become very large as the number of trials to be evaluated increases exponentially. In this task, combining 7 pricing policies with each 2 levels (high and low) according to a full factorial design and all its subdesigns would generate an unmanageable 2186 trials to be evaluated. Secondly, experimental designs and the choice of stimulus levels may influence the main effect of a factor and eventually its importance with respect to other factors included in the design (Anderson, 1982; Bliemer and Rose, 2011). As a consequence, poorly chosen stimulus levels (e.g. not sufficiently spaced or too extreme) may cause effects to remain undetected or to be overestimated. In order to circumvent these issues, while respecting as closely as possible the principles of IIT, the following methodological choices were made:

- *Integration rule.* As shown by previous research, pricing policies are integrated according to an averaging rule. Therefore, we assume that the probability of switching to an environmentally friendlier car as a result of combined pricing policies can be formalized as the following equal weights averaging model (EAM) (Anderson, 1981, 1982; Wang and Yang, 1998):

$$r_{ijk} = \left[\frac{w_{RT}s_{RT_h}+w_{ACT}s_{ACT_i}+w_{UCC}s_{UCC_j}+w_{RP}s_{RP_k}+w_{PT}s_{PT_l}+w_{SP}s_{SP_m}+w_{FP}s_{FP_n}}{w_{RT}+w_{ACT}+w_{UCC}+w_{RP}+w_{PT}+w_{SP}+w_{FP}}\right] \quad (4)$$

Note: RT = "Vehicle registration tax", ACT = "Annual Circulation Tax", UCC = "Urban Congestion Charge", KC = "Km Charge", PT = "Parking Tariff", SP = "Scrapping Premium", FP = "Fuel Prices"

- *Scale values.* Assuming that $w_0 = 0$ (Wang and Yang, 1998), scale values are estimated from responses to uncombined stimuli (one-way subdesigns). Therefore, it was emphasized that respondents should consider each policy measure separately, all other fiscal instruments remaining unchanged. Consequently, the model scale values are based on the WTP values of each individual pricing measure. The single policy-based switch to environmentally friendlier vehicles is then estimated from frequency distributions of point estimates of the respondent's maximum WTP (see section 2.1 on contingent valuation).

- *Weights.* Weight estimation requires the averaging model to be true and the inclusion of subdesigns along with a full factorial design to ensure parameter uniqueness (Norman, 1976). However, using the EAM as a benchmark, theoretically valid weights can be approximated by using either direct rating on a 0-10 scale (Zhu and Anderson, 1991), SMART or AHP (Wang and Yang, 1998). For efficiency purposes, weight values for our model were elicited through direct rating (see *Figure 3*).

Figure 3: Weight elicitation

"Which of the following governmental measures would have the largest influence on your purchase behaviour?"

Welke van deze overheidsmaatregelen zou op uw **aankoopgedrag** het meeste effect hebben?

	helemaal geen effect										extreem veel effect
Aangepaste registratiebelasting											
Aangepaste verkeersbelasting											
Stadstolheffing											
Rekeningrijden (in plaats van verkeersbelasting)											
Aangepast parkeertarief											
Schrootpremie											
Brandstofprijzen											

Summarizing, this integrative model allows for the estimation of the population distribution willing to switch to an environmentally friendlier car based on different weighted pricing levels of combined policy measures.

3 Results

3.1 Sample

The data have been collected by use of a web-based survey, hosted by the Market Research Institution IVOX in June 2010. The survey is representative for the Belgian population. Table 1 shows the distribution of respondents according to living area (Brussels, Flanders, Wallonia) and when comparing these survey figures with NIS figures on the distribution of inhabitants in the three regions (Table 2), only a slight overrepresentation of Flemish people is noticed.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**Brussels**	106	9,0	**9,0**	9,0
	Flanders	770	65,1	**65,6**	74,7
	Wallonia	297	25,1	**25,3**	100,0
	Total	1173	99,2	**100,0**	
Missing	System	10	,8		
Total		1183	100,0		

Table 1: Distribution of regions (survey)

Region	**Valid % (survey)**	**NIS 2008**
Brussels	9,0	9.83
Wallonia	25,3	32.41
Flanders	65,6	57.76

Table 2: Distribution of regions (survey versus NIS figures (2008))

The distribution of gender of the respondents in the survey (Table 3) shows a great conformity with the distribution of gender in the Belgian population (Table 4).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	**men**	613	51,8	**52,0**	52,0
	female	566	47,8	**48,0**	100,0
	Total	1179	99,7	100,0	
Missing	System	4	,3		
Total		1183	100,0		

Table 3: Distribution of gender (survey)

Gender	Valid % (survey)	NIS 2008a
M	52	49
F	48	51

Table 4: Distribution of gender (survey versus NIS figures (2008))

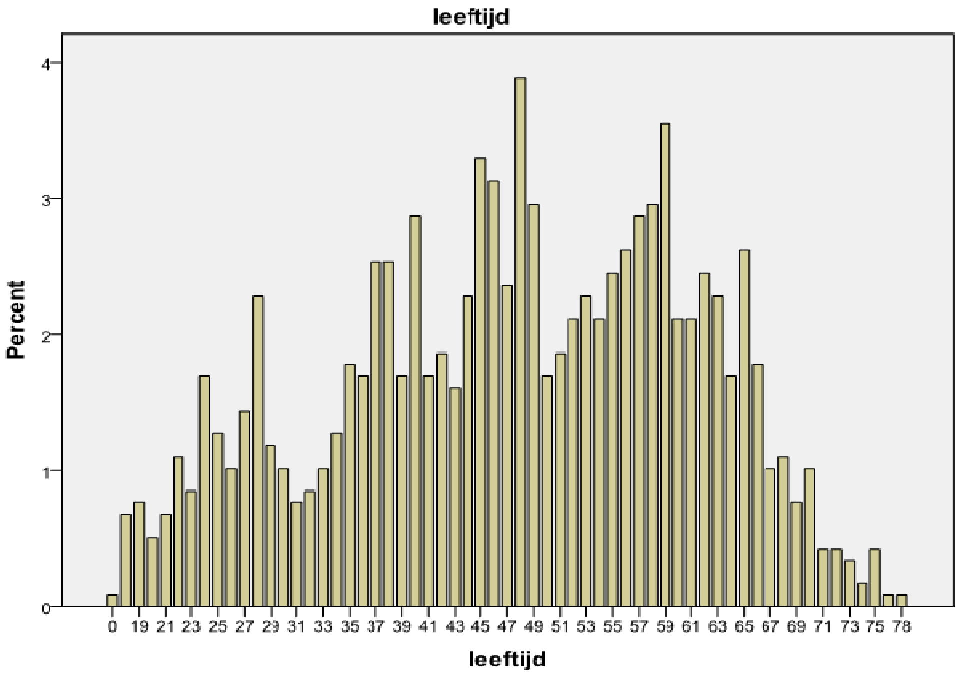
The distribution of ages (Table 5) also shows a nice bell-shaped curve (

Figure 4).

		Age
N	Valid	1183
	Missing	0
Mean		47,40
Median		48,00
Std. Deviation		13,553

Table 5: Distribution of age (survey)

Figure 4: Distribution of age (survey)



3.2 WTP results of individual policy measures

Table 6 shows an indication of each individual policy measure in the realistic and progressive scenario, with an indication of the number of respondents, the amount of respondents that provided a "zero WTP" (cannot or will not change), the mean WTP and the amount at which the greatest shift will be realised (measured by means of the arc elasticities, for a definition and formulation of this elasticity, see task 3.2, part 1).

Policy measure	Scenario	N	Zero WTP	Mean WTP	Arc elasticity
Registration tax (RT)	Realistic	428	193 (45%)	1107 €	950 - 1000 €
Registration tax (RT)	Progressive	535	302 (56%)	1185 €	900 - 1000 €
Circulation tax (ACT)	Realistic	461	217 (47%)	858 €/year	450 - 500 €/year
Circulation tax (ACT)	Progressive	545	319 (59%)	925 €/year	450 - 500 €/year
Congestion charge (UCC)	Realistic	456	256 (56%)	5 €/time	4-5 €/each time

Congestion charge (UCC)	Progressive	535	337 (63%)	6 €/time	4-5 €/each time
Km-charge (KC)	Realistic	446	238 (53%)	740 €/year	200 - 400 €/year
Km-charge (KC)	Progressive	523	319 (61%)	779 €/year	250 – 400 €/year
Parking tariff (PT)	Realistic	452	238 (59%)	3,3 €/hour	2,5 – 3 €/hour
Parking tariff (PT)	Progressive	531	342 (64%)	3,5 €/hour	4,5 – 5 €/hour
Scrapping PR (SP)	Progressive	643	360 (56%)	3207 €	4750 – 5000 €
Fuel prices (FP)	Realistic	476	240 (50%)	1,8 €/L	1,9 – 2 €/L
Fuel prices (FP)	Progressive	561	325 (58%)	1,9 €/L	1,9 – 2 €/L

Table 6: WTP of individual measures

Note: The realistic and progressif scenario measure the shift to respectively a vehicle of category B and A.

3.3 Results of the weight distribution

Table 7 displays the results of the weight distribution and shows that excises carry the greatest weight in the purchase decision of a car, followed by the annual circulation tax and a km charge. This is also confirmed by literature (EPA, 1998; Mairesse et al., 2008). Policy measures aiming at reforming excises or annual vehicle taxes or introducing a km charge will thus evoke the greatest effects with respect to the purchase of a more environmentally friendly car. Reformed parking tariffs will have a minor impact on the purchase decision.

	RT	ACT	UCC	KC	PT	SP	FP
Purchase	4,63	5,03	4,24	4,73	3,90	4,48	5,94

Table 7: Weight distribution in the purchase decision

Note: RT = "Vehicle registration tax", ACT = "Annual Circulation Tax", UCC = "Urban Congestion Charge", KC = "Km Charge", PT = "Parking Tariff", SP = "Scrapping Premium", FP = "Fuel Prices"

3.4 WTP results of combined policy measures

By integrating the abovementioned results, a "policy based green vehicle demand" model can be constructed with the aim of estimating the distribution of respondents willing to switch to either a lower CO_2 emitting car (category B) or an AFV (category A) based on different weighted pricing levels of combined policy measures. The green vehicle demand model can be formalized as follows:

$$r_{ijk} = [\frac{w_{RT}s_{RT_h} + w_{ACT}s_{ACT_i} + w_{UCC}s_{UCC_j} + w_{RP}s_{RP_k} + w_{PT}s_{PT_l} + w_{SP}s_{SP_m} + w_{FP}s_{FP_n}}{w_{RT} + w_{ACT} + w_{UCC} + w_{RP} + w_{PT} + w_{SP} + w_{FP}}] \quad (5)$$

Where the model scale values (S_{RT}, S_{ACT}, S_{UCC}, S_{KC}, S_{PT}, S_{SP} S_{FP}) are based on the WTP values of each individual pricing measure (see 3.2) and the weight values are based on the direct rating procedure (see 3.3). Hereunder, several case studies are worked out to illustrate the applicability of the model for assisting in complex decision making problems. These case-studies are in line with the different scenarios elaborated in tasks 5.2 and 5.3 of the CLEVER project.

3.5 Case-studies

Case 1: Realistic short term scenario

Task 5.3 elaborated a realistic short term scenario including pricing measures which might affect new vehicle sales and induce a shift from vehicles of category C (vehicles emitting 105-115 g CO_2/km) or D (vehicles emitting > 115 g CO_2/km) to vehicles of category B (vehicles emitting less than 105 g CO_2/km). The definition of a clean vehicle in this scenario is based on the CO_2 emissions and EURO standard of the vehicle. The realistic scenario comprises amongst others a reformed registration tax, based on the CO_2 emissions and EURO standard of the car and a change in excise duties. Regarding these pricing measures, the following assumptions have been made (of which the pricing levels are based on the reported WTP values of table 6):

(1) Category C vehicles will be faced with a RT of 500 Euro and an ACT of 500 Euro/year (see table 8)

(2) Category D vehicles will be faced with a RT of 1000 Euro and an ACT of 1000 Euro/year (see table 9)

(3) Excise duties of diesel rise up to the level up petrol excises, i.e. 61,36 Eurocent/L implying a diesel price of 1,50 Euro/L (see tables 8 and 9)

As a result, the shift from respectively category C vehicles (table 8) and category D vehicles (table 9) to category B vehicles can be predicted. No switches to vehicles of category A (vehicles emitting less than 105 g CO_2/km and using alternative fuels or propulsion technologies) will occur in this realistic scenario. These switches are reserved for the progressive scenario.

Policy based green vehicle demand model
Realistic scenario

Policy measure	Level	Switch	Weight
Registration tax	500	30,61	4,63
Annual circulation tax	500	31,02	5,03
Urban congestion charge	-1	0	0

Kilometre charge	-1	0	0
Parking tariffs	-1	0	0
Fuel prices	1,5	18,07	5,94
Total switch	**25,967353**		

Table 8. *Realistic short term scenario (shift from category C vehicles to category B vehicles)*

Policy based green vehicle demand model Realistic scenario			
Policy measure	**Level**	**Switch**	**Weight**
Registration tax	1000	42,52	4,63
Annual circulation tax	1000	44,25	5,03
Urban congestion charge	-1	0	0
Kilometre charge	-1	0	0
Parking tariffs	-1	0	0
Fuel prices	1,5	18,07	5,94
Total switch	**33,768006**		

Table 9. *Realistic short term scenario (shift from category D vehicles to category B vehicles)*

It is found that approximately **26%** of total new vehicle purchases of category C vehicles in the baseline will switch to category B vehicles and that approximately **34%** of total new vehicle purchases of category D vehicles in the baseline will switch to category B vehicles in this realistic scenario.

<u>*Case 2: Progressive long-term scenario*</u>

Task 5.3 also elaborated a progressive long-term including pricing measures which might affect new vehicle sales and induce a shift from vehicles of category B (vehicles emitting less than 105 g CO_2/km), C (vehicles emitting 105-115 g CO_2/km) or D (vehicles emitting > 115 g CO_2/km) to vehicles of category A (vehicles emitting less than 105 g CO_2/km and using alternative fuels or propulsion technologies). The definition of a clean vehicle in this scenario is based on the Ecoscore of the vehicle. This progressive scenario comprises amongst others a reformed RT, an abolishment of the ACT in favour of a kilometre charge, limited access zones and a scrapping premium. Regarding these pricing measures, the following assumptions have been made (of which the pricing levels are based on the reported WTP values of table 6):

(1) Vehicles of category A correspond to vehicles with Ecoscores > 75. As a result, these vehicles will be exempted from paying a RT.

(2) Vehicles of category B correspond to vehicles with an Ecoscore between 73 and 75. As a result, they get a minimum RT of 50 Euro.

(3) Vehicles of category C correspond to vehicles with an Ecoscore between 70 and 72. As a result, they will be faced with a RT of 500 Euro.

(4) Vehicles of category D correspond to vehicles with an Ecoscore lower than 70. As a result, they will be faced with a RT of 1000 Euro.

(5) Besides a RT, based on the Ecoscore of the vehicle, an abolishment of the ACT will happen in favour of a kilometre charge, dependent on location, time and individual Ecoscore of the vehicle. Table 10 gives an overview of the assumed kilometre charging levels (on a yearly basis) for the different vehicle categories, which each correspond to the Ecoscores as specified above.

Average annual km charge (€)	ecoscore category			
Year	A	B	C	D
2010	268	268	268	268
2015	200	200	400	400
2020	200	200	400	400
2025	200	400	600	600
2030	200	400	600	600

Table 10. *Simulated kilometre charge on a yearly basis (source: CLEVER task 5.3)*

(6) Moreover, a limited access zone is established. From 2015, vehicles from category D (Ecoscore < 70) will be banned from city centers. From 2020, vehicles from category C (Ecoscore 70-72) will be banned and from 2030, vehicles from category B (Ecoscore 73-75) will be prohibited to enter the limited access zone. Here, an infinite toll level (30 Euro per entrance) is considered as a ban.

(7) Lastly, a scrapping scheme is introduced. For switches from vehicles of categories B, C and D to vehicles of category A in the period 2015-2019, a premium of 2000 Euro will be given. Switches to vehicles of category B are not rewarded in this scenario.

Based on the abovementioned assumptions, switches to vehicles of category A (from vehicles of categories B, C, D) can be predicted for several years (2015, 2020, 2025, 2030) as a result of the introduction of the progressive scenario. Here, in accordance with the time frame applied in task 7 (MCA of policy scenarios), the impact of the progressive scenario on the switch to category A vehicles from categories B, C and D is predicted for 2020 and 2030. Tables 11 to 16 show these results.

Policy based green vehicle demand model
Progressive scenario

Policy measure	Level	Switch	Weight
Registration tax	50	8,6	4,63

Annual circulation tax	-1	0	0
Urban Congestion Charge	-1	0	0
Kilometre charge	200	14,53	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Total switch	**12,49091**		

Table 11. *Progressive scenario in **2020**: shift from category B to category A vehicles*

Policy based green vehicle demand model Progressive scenario			
Policy measure	**Level**	**Switch**	**Weight**
Registration tax	50	8,6	4,63
Annual circulation tax	-1	0	0
Urban Congestion Charge	30	37,01	4,24
Kilometre charge	400	22,37	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Total switch	**19,70914**		

Table 12. *Progressive scenario in **2030**: shift from category B to category A vehicles*

Policy based green vehicle demand model Progressive scenario			
Policy measure	**Niveau**	**Switch**	**Gewicht**
Registration tax	500	25,79	4,63
Annual circulation tax	-1	0	0
Urban Congestion Charge	30	37,01	4,24
Kilometre charge	400	22,37	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Totale switch	**23,7823**		

Table 13. *Progressive scenario in **2020**: shift from category C to category A vehicles*

Policy based green vehicle demand model Progressive scenario			
Policy measure	**Niveau**	**Switch**	**Gewicht**
Registration tax	500	25,79	4,63
Annual circulation tax	-1	0	0
Urban Congestion Charge	30	37,01	4,24
Kilometre charge	600	26,2	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Totale switch	**24,70942**		

Table 14: *Progressive scenario in **2030**: shift from category C to category A vehicles*

Policy based green vehicle demand model Progressive scenario			
Policy measure	**Niveau**	**Switch**	**Gewicht**
Registration tax	1000	33,08	4,63
Annual circulation tax	-1	0	0
Urban Congestion Charge	30	37,01	4,24
Kilometre charge	400	22,37	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Totale switch	**25,50967**		

Table 15: *Progressive scenario in **2020**: shift from category D to category A vehicles*

Policy based green vehicle demand model Progressive scenario			
Policy measure	**Niveau**	**Switch**	**Gewicht**
Registration tax	1000	33,08	4,63
Annual circulation tax	-1	0	0
Urban Congestion Charge	30	37,01	4,24
Kilometre charge	600	26,2	4,73
Parking Tariffs	-1	0	0
Fuel prices	1,5	13,9	5,94
Scrapping premium	-1	0	0
Totale switch	**26,43679**		

Table 16: *Progressive scenario in **2030**: shift from category D to category A vehicles*

Overall, the case-studies show that consumers are more likely to switch vehicles of category B (vehicles emitting less than 105 g CO_2/km) in comparison to vehicles of category A (vehicles emitting less than 105 g CO_2/km and using alternative fuels or propulsion technologies), even though vehicles of category A enjoy more payment exemptions and reductions than vehicles of category B in the proposed scenarios. This means that besides pricing aspects, other attributes might considerably affect the purchase decision too.

Nowadays, most large car manufacturers offer a range of low CO_2 emitting variants of existing conventionally fueled vehicles (e.g. Volkwagen BlueMotion, Ford EcoNetic, …) for which there is virtually no trade-off for other important purchase attributes besides reduced performance. On the other hand, the current offer of AFVs is less extended, meaning that consumers still have to give up other important car attributes that determine the car purchase decision (e.g. in case of electric vehicles: range, recharging time, etc.). The transition to low CO_2 emitting vehicles thus requires less "effort" from the consumer and is therefore more likely to happen when a tax reform or new pricing measure is installed.

4 Conclusion

In this task, an entirely new multidisciplinary model has been developed that enables the decision maker to estimate the potential shift of consumers to low CO_2 emitting vehicles (category B) or vehicles on alternative fuels or drive trains (category A) based on different pricing levels of combined policy measures (registration tax, annual circulation tax, urban congestion charging, kilometre charging, parking tariffs and fuel prices). This approach is based on the adoption of psychological theory (Information Integration Theory) into the stated preference contingent valuation (CV) method. The model might be particularly useful in guiding complex decision making problems and its applicability is illustrated through several case-studies, based on the realistic and progressive scenario, elaborated in tasks 5.2 and 5.3 of the CLEVER project.

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Annex A: Survey

Vrije Universiteit Brussel

Vragenlijst prijsmaatregelen

Geachte Mevrouw, Mijnheer,

Deze enquête peilt naar de effecten van eventuele prijsmaatregelen op het milieuvriendelijk aankoop- en verplaatsingsgedrag van de Belg.

Deze studie kadert binnen de onderzoeksprojecten "Milieuvriendelijk aankoopgedrag van wagens en verplaatsingsgedrag in het Brussels Hoofdstedelijk Gewest" en "CLEVER" (Clean Vehicle Research: LCA and Policy Measures) van respectievelijk het Instituut ter bevordering van het Wetenschappelijk Onderzoek en de Innovatie van Brussel (IWOIB) en de Programmatorische Federale Overheidsdienst Wetenschapsbeleid (BELSPO).

Deze projecten worden uitgevoerd door de VUB (Vrije Universiteit Brussel), vakgroep MOSI Transport en Logistiek, in samenwerking met de onderzoeksgroep CEESE van de ULB (Université Libre de Bruxelles), vakgroep ETEC van de VUB en VITO (Vlaamse Instelling voor Technologisch Onderzoek).

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Prof. Dr. Cathy Macharis
Dr. Olivier Mairesse
Laurence Turcksin
Kenneth Lebeau
MOSI-Transport & Logistics (VUB)

Ga naar de vragenlijst!

Vrije Universiteit Brussel

Prijsmaatregelen

Pagina 1/25

Waar woont u? Gelieve uw postcode in te vullen (vb. 1785)?

Welk vervoersmiddel gebruikt u om HET MERENDEEL van uw verplaatsingen uit te voeren?
- wagen
- trein
- tram/metro
- bus
- motor/scooter
- fiets
- te voet

In het algemeen, vanaf welke afstand neemt u de wagen voor een verplaatsing? (=afstand tussen vertrek- en eindpunt)
- Vanaf 100 m
- Vanaf 300 m
- Vanaf 500 m
- Vanaf 1 km
- Vanaf 3 à 5 km
- Vanaf 6 à 10 km
- Vanaf meer dan 10 km

Verplaatst u zich in hoofdzaak met de wagen naar het werk/uw dagactiviteit?
- ja
- nee
- ik heb momenteel geen werk/dagactiviteit

Volgende

Vrije Universiteit Brussel

Prijsmaatregelen

Pagina 2/25

Waar werkt u? Gelieve uw postcode in te vullen (vb. 9000, indien niet van toepassing: NVT)?

Hoeveel km legt u gemiddeld af om uw werk/dagactiviteit te bereiken?

- Minder dan 1 km
- Tussen 1 en 4.9 km
- Tussen 5 en 9.9 km
- Tussen 10 en 19.9 km
- Tussen 20 en 39.9 km
- Tussen 40 en 59.9 km
- Tussen 60 en 79.9 km
- Tussen 80 en 100 km
- Meer dan 100 km

Hoe lang bent u gemiddeld onderweg alvorens uw werk/dagactiviteit te bereiken?

- Minder dan 10 min
- Tussen 10 min en 15 min
- Tussen 16 min en 30 min
- Tussen 31 min en 45 min
- Tussen 46 min en 1 u
- Tussen 1 u 01 en 1 u 15
- Tussen 1 u 16 en 1 u 30
- Tussen 1 u 31 en 1 u 45
- Tussen 1 u 46 en 2 u
- Tussen 2 u 01 en 2 u 30

Volgende

Vrije Universiteit Brussel

Prijsmaatregelen

Pagina 3/25

Hoe druk is het meestal wanneer u van en naar het werk/uw dagactiviteit gaat?

- Altijd vlot, zonder files
- Meestal vlot, weinig files
- Redelijk vlot, maar toch geregeld files
- Meestal moeizaam, vaak files
- Zeer moeizaam, meestal files

Beschikt u over de mogelijkheid om thuis te werken of beschikt u over flexibele uren?

- Neen
- Ja, ik heb flexibele uren
- Ja, ik kan thuiswerken (=telewerken)
- Ja, ik beschik over flexibele uren en mag thuis werken

Indien u over telewerken kan beschikken, hoe vaak maakt u daar gebruik van?

- Enkele keren per jaar
- Enkele keren per maand
- Eén keer per week
- Enkele keren per week
- Elke dag
- Niet van toepassing

Hebt u parkeergelegenheid in de buurt van uw werk/dagactiviteit?

- Ja, een parking voorbehouden voor werknemers
- Ja, gratis parkeren
- Ja, gratis parkeren met parkeerschijf
- Ja, betalend parkeren
- Neen
- Niet van toepassing

Vrije Universiteit Brussel

7

Prijsmaatregelen

Pagina 4/25

Hoe belangrijk zijn voor u de volgende factoren bij de keuze van een vervoersmiddel?

Hoewel de meeste aspecten voor iedereen belangrijk zijn, is het hier vooral de bedoeling om te onderscheiden welke aspecten echt een cruciale rol spelen in uw **keuze van vervoersmiddel** en welke minder of helemaal niet.

Gelieve eerst alle factoren te overlopen alvorens uw beoordeling op elk aspect te geven.

	weinig of niet van belang	van belang	van groot belang	van cruciaal belang
Reiskost (aankoopprijs vervoersmiddel, abonnementskosten, ...)	○	○	○	○
Betrouwbaarheid (stiptheid, zekerheid van aansluiting, ...)	○	○	○	○
Bereikbaarheid/flexibiliteit (aanbod, aantal aansluitingen, ...)	○	○	○	○
Comfort (zitcomfort, rijcomfort, zekerheid van zitplaats, ...)	○	○	○	○
Reistijd (duur van de verplaatsing inclusief wachttijden, ...)	○	○	○	○
Verkeersveiligheid (kwetsbaarheid in het verkeer, ...)	○	○	○	○
Algemene veiligheid (diefstal, aanranding, ...)	○	○	○	○
Reiservaring (reistijd nuttig kunnen gebruiken, rijplezier, ...)	○	○	○	○
Milieuaspecten (beperking uitstoot van CO2, fijn stof, lawaai, ...)	○	○	○	○
Status (imago, bepaalde uitstraling van de transportmodus, ...)	○	○	○	○
Functionaliteit (laadruimte, zitruimte, bescherming tegen het weer, ...)	○	○	○	○
Gebruiksvriendelijkheid (vinden van aansluitingen, alternatieven, ...)	○	○	○	○

Hoeveel wagens zijn er nu binnen uw gezin? ○ 0 ○ 1 ○ 2 ○ 3 ○ 4 ○ 5 ○ Meer dan 5

Volgende

Vrije Universiteit Brussel

15%

Prijsmaatregelen

Meest gebruikte wagen (indien u het merk, het model, de versie of het bouwjaar niet terugvindt, gelieve dan een wagen te kiezen die het dichtst aansluit bij uw huidige wagen)

Merk
Brandsto
Model
Variant
Versie

Bouwjaar (kan verschillen van jaar van aankoop)

Gemiddeld aantal km per jaar met deze wagen

Hoeveel % van die verplaatsingen staat u gemiddeld in de file?

Voornaamste gebruiksmotief van deze wager

Verplaatsingsprofie

Deze wagen is:
- nieuw aangekocht (privé)
- tweedehands aangekocht (privé)
- professioneel aangekocht/bedrijfswage..

In welk jaar kocht u de wagen aan?

Heeft u genoten van een overheidskorting voor de aankoop van deze wagen? (Meerdere antwoorden zijn mogelijk)
- Ja, 15% overheidskorting (CO_2 uitstoot <105 gr/km
- Ja, 3% overheidskorting (CO_2 uitstoot <115 gr/km)
- Ja, een roetfilterpremie
- Ja, een bonus-premie van het Waalse Gewest
- Neen

Beschikt u over een tankkaart voor deze wagen?
- Ja, maar enkel beperkt voor woon-werkverkeer in België
- Ja en ik mag ze gebruiken voor mijn privéverplaatsingen in België
- Ja, maar enkel beperkt voor woon-werkverkeer in België en het buitenland
- Ja en ik mag ze gebruiken voor mijn privéverplaatsingen in België en het buitenland
- Neen

Volgende

Vrije Universiteit Brussel

24%

Pagina 6/25

Prijsmaatregelen

Tweede meest gebruikte wagen (indien u het merk, het model, de versie of het bouwjaar niet terugvindt, gelieve dan een wagen te kiezen die het dichtst aansluit bij uw huidige wagen)

Merk
Brandsto
Model
Variant
Versie

Bouwjaar (kan verschillen van jaar van aankoop)

Gemiddeld aantal km per jaar met deze wagen

Hoeveel % van die verplaatsingen staat u gemiddeld in de file?

Voornaamste gebruiksmotief van deze wager

Verplaatsingsprofie

Deze wagen is:
- nieuw aangekocht (privé)
- tweedehands aangekocht (privé)
- professioneel aangekocht

In welk jaar kocht u de wagen aan?

Heeft u genoten van een overheidskorting voor de aankoop van deze wagen? (Meerdere antwoorden zijn mogelijk)
- Ja, 15% overheidskorting (CO2 uitstoot <105 gr/km
- Ja, 3% overheidskorting (CO2 uitstoot <115 gr/km)
- Ja, een roetfilterpremie
- Ja, een bonus-premie van het Waalse Gewest
- Neen

Beschikt u over een tankkaart voor deze wagen?
- Ja, maar enkel beperkt voor woon-werkverkeer in België
- Ja en ik mag ze gebruiken voor mijn privéverplaatsingen in België
- Ja, maar enkel beperkt voor woon-werkverkeer in België en het buitenland
- Ja en ik mag ze gebruiken voor mijn privéverplaatsingen in België en het buitenland
- Neen

Vrije Universiteit Brussel

33%

Prijsmaatregelen

Pagina 8/25

Hoe belangrijk zijn de volgende factoren voor u bij de aankoop van een wagen?

Hoewel de meeste aspecten voor iedereen belangrijk zijn, is het hier vooral de bedoeling om te onderscheiden welke aspecten echt een cruciale rol spelen in uw aankoopbeslissing en welke minder of helemaal niet.

Gelieve eerst alle factoren te overlopen alvorens uw beoordeling op elk aspect te geven.

	weinig of niet van belang	van belang	van groot belang	van cruciaal belang
Aankoopkost (aankoopprijs, belasting inverkeersstelling, ...)	○	○	○	○
Afkomst (land van oorsprong, garage, verdeler, ...)	○	○	○	○
Afwerking (gebruikte materialen, details, ...)	○	○	○	○
Basisuitrusting (GPS, multimedia, airco, velgen, ...)	○	○	○	○
Betrouwbaarheid (motor, elektronica, ...)	○	○	○	○
Brandstofkost (verbruik)	○	○	○	○
Comfort (zitcomfort, rijcomfort, ...)	○	○	○	○
Doorverkoopwaarde	○	○	○	○
Esthetiek (binnen- en buitendesign, kleur, ...)	○	○	○	○
Functionaliteit (bergruimte, wegklapbare achterbank, ...)	○	○	○	○
Gebruiksvriendelijkheid (plaatsing instrumenten, zicht vooraan/achteraan, ...)	○	○	○	○

Volgende

Vrije Universiteit Brussel

49%

Prijsmaatregelen

Pagina 9/25

	weinig of niet van belang	van belang	van groot belang	van cruciaal belang
Merk (reputatie, getrouwheid)	○	○	○	○
Zuivere milieuprestatie (uitstoot van CO2, fijn stof, lawaai, ...: los van financiële aspecten van lager verbruik!)	○	○	○	○
Motorprestaties (acceleratiesnelheid, topsnelheid, hernemingen, ...)	○	○	○	○
Onderhoudskosten (banden, olie, ...)	○	○	○	○
Overbrenging (voor- of achterwielaandrijving, versnellingsbak (automatisch of niet), ...)	○	○	○	○
Overnameprijs vorige wagen	○	○	○	○
Status (imago, uitstraling van de wagen, ...)	○	○	○	○
Subjectieve rijervaring (rijplezier, motorgeluid, wendbaarheid, vinnigheid, ...)	○	○	○	○
Veiligheid (ABS, ESP (in- en uitschakelbaar), airbags, ...)	○	○	○	○
Volume (aantal zitplaatsen, kofferinhoud, ...)	○	○	○	○
Waarborg (aantal jaren, inhoud, ...)	○	○	○	○

Volgende

Vrije Universiteit Brussel

57%

Prijsmaatregelen

Pagina 10/25

Gemiddeld gezien, om de hoeveel tijd vervangt u de wagen die u het meest gebruikt?

Bent u van plan om in de nabije toekomst een wagen aan te kopen? Ja Neen

Volgende

Vrije Universiteit Brussel

57%

Prijsmaatregelen

Pagina 11/25

Binnen welke termijn zal u deze wagen aankopen?
- Minder dan 6 maanden
- Tussen 6 en 12 maanden
- Tussen 12 en 18 maanden
- Meer dan 18 maanden

Zal deze wagen extra zijn of ter vervanging van een huidige?
- Extra of eerste wagen
- Ter vervanging van mijn meest gebruikte wagen
- Ter vervanging van een andere wagen

Zal deze wagen nieuw of tweedehands zijn?
- Nieuw
- Tweedehands

Welk maximaal budget voorziet u voor de aankoop van een wagen (registratietaksen en/of eventuele kortingen inbegrepen)?

Volgende

Vrije Universiteit Brussel

60%

Prijsmaatregelen

Pagina 12/25

Welke wagen zou u dan aankopen?

(indien u dit nog niet zeker weet of indien u het merk, model of versie niet terugvindt, gelieve dan een wagen te kiezen die het dichtst aansluit bij uw huidige wagen)

… naar welk merk zou uw voorkeur uitgaan?

… naar welk brandstoftype zou uw voorkeur uitgaan?

… naar welk model zou uw voorkeur uitgaan?

… naar welke variant zou uw voorkeur uitgaan?

… naar welke versie zou uw voorkeur uitgaan?

andere, namelijk:

Hoeveel km per jaar schat u met deze wagen af te leggen?

Hoeveel % hiervan schat u in de file te zullen staan?

Volgende

Vrije Universiteit Brussel

65%

Prijsmaatregelen

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Gezien de huidige klimaatproblematiek plannen de overheden om in de nabije toekomst bijkomende maatregelen in te voeren om mobiliteit duurzamer te maken. De meeste van deze maatregelen zijn bedoeld om de aankoop van milieuvriendelijke wagens aan te moedigen en/of mensen aan te sporen om alternatieve vervoersmiddelen te gebruiken (te voet, fiets, openbaar vervoer).

Met de volgende vragen willen we graag nagaan in welke mate prijsmaatregelen een invloed zullen hebben op aankoop- en/of verplaatsingsgedrag. U wordt verwacht **enkel rekening te houden met de voorgestelde maatregel/hervorming, binnen een anderzijds ongewijzigde fiscale context**.

De wagen die u daarnet hebt gekozen zal toegewezen worden aan een milieucategorie. We zullen hierbij nagaan in welke mate een maatregel u ertoe kan aanzetten een wagen van een hogere milieucategorie aan te kopen en/of een ander vervoersmiddel te kiezen.

Volgende


70%
U koos voor volgend voertuig: BMW SERIE-3, een wagen van categorie D
CAT A
ALTERNATIEVE BRANDSTOFFEN & AANDRIJFSYSTEMEN
Wagens uit deze categorie behoren tot de groep wagens met de beste milieuprestaties. Door hun lage CO2-uitstoot (< 105 g/km) komen zij bovendien in aanmerking voor een overheidskorting van 15% op de aankoopprijs en (eventuele) andere voordelen.
Citroën C1 Zero (elektrisch)
Renault Kangoo ZE (elektrisch)
Toyota Prius (hybride)
Opel Zafira (aardgas)
CAT B
LAGE CO2- UITSTOOT
Wagens uit deze categorie behoren tot de groep wagens met goede milieuprestaties. Door hun lage CO2-uitstoot (< 105 g/km) genieten ook zij van een overheidskorting van 15% op de aankoopprijs.
Smart ForTwo
Audi A3 1.6 TDI (99g)
Ford Focus Clipper Econetic² 1.6 TDCI DPF
CAT C
MATIGE CO2-UITSTOOT
Wagens uit deze categorie behoren tot de groep wagens met matige milieuprestaties. Toch krijgen zij door hun relatief lage CO2-uitstoot (< 115 g/km) een overheidskorting van 3% op de aankoopprijs.
Peugeot 107
Fiat Bravo 1.6 Mjet 66 DPF
Renault Mégane Grandtour 1.5 dci 63 DPF
CAT D
HOGE CO2- UITSTOOT
Wagens uit deze categorie kunnen geen goede milieuprestaties voorleggen en komen dan ook niet in aanmerking voor een overheidskorting.
Mini Cooper S
Honda Civic 2.2 Cdti
Volkswagen Passat Variant

Vrije Universiteit Brussel

70%

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Prijsmaatregelen

REGISTRATIETAKS

De hervormde fiscaliteit rond personenwagens houdt in dat de éénmalige registratietaks (BIV) wordt aangepast aan de milieuprestaties van het voertuig. De huidige fiscale context blijft voor de rest ongewijzigd.

Wagens met matige of hoge CO2-uitstoot (CATEGORIE C of D) zullen in het **nieuw** fiscaal systeem nog **zwaarder belast** worden.

Wagens met lage CO2-uitstoot (CATEGORIE B) zullen kunnen genieten van een gunstiger tarief.

Wagens met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) genieten van het allerlaagste tarief (maximaal 61,5 euro).

U heeft voor uw volgende aankoop voor deze wagen gekozen: BMW SERIE-3, een wagen van categorie D .

Voor deze wagen bedraagt de registratietaks in het **huidig** fiscaal systeem: **867 euro**

a) **Vanaf welk bedrag vindt u de aangepaste registratietaks van een BMW SERIE-3 zo duur dat u overschakelt op een wagen met lage CO2-uitstoot (CATEGORIE B, gunstigere registratietaks)?**

- Ik schakel pas over op een wagen met lage CO2 uitstoot vanaf dat de totale registratietaks voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een wagen met lage CO2 uitstoot, ongeacht hoe duur de registratietaks voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met lage CO2-uitstoot.

b) **Vanaf welk bedrag vindt u de aangepaste registratietaks van een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (CATEGORIE A, max. 61,5 Euro)?**

- Ik schakel pas over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat de totale registratietaks voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur de registratietaks voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) **Vanaf welk bedrag vindt u de aangepaste registratietaks van een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoersmiddel (trein, tram, bus, fiets, ...)?**

- Ik schakel pas over op een alternatief vervoersmiddel vanaf dat de totale registratietaks voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een alternatief vervoersmiddel, ongeacht hoe duur de registratietaks voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoersmiddel.

Vrije Universiteit Brussel

72%

Prijsmaatregelen

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VERKEERSBELASTING

De hervormde fiscaliteit rond personenwagens houdt in dat ook de jaarlijkse verkeersbelasting (VB) aangepast wordt aan de milieuprestaties van het voertuig. De huidige fiscale context blijft voor de rest ongewijzigd.

Wagens met matige of hoge CO2-uitstoot (CATEGORIE C of D) zullen in het **nieuw** fiscaal systeem nog **zwaarder belast** worden.

Wagens met lage CO2-uitstoot (CATEGORIE B) zullen kunnen genieten van een gunstiger tarief.

Wagens met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) genieten van het allerlaagste tarief (maximaal 69,7 euro/jaar).

U heeft voor uw volgende aankoop voor deze wagen gekozen: BMW SERIE-3, een wagen van categorie D .

Voor deze wagen bedraagt de jaarlijkse verkeersbelasting in het **huidig** fiscaal systeem: **365,11 euro.**

a) **Vanaf welk bedrag vindt u de aangepaste verkeersbelasting van een BMW SERIE-3 zo duur dat u overschakelt op een wagen met lage CO2-uitstoot (CATEGORIE B, gunstigere verkeersbelasting)?**

- Ik schakel pas over op een wagen met lage CO2 uitstoot vanaf dat de jaarlijkse verkeersbelasting voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een wagen met lage CO2 uitstoot, ongeacht hoe duur de verkeersbelasting voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met lage CO2-uitstoot.

b) **b) Vanaf welk bedrag vindt u de aangepaste verkeersbelasting van een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (CATEGORIE A, max. 69,7 Euro/jaar)?**

- Ik schakel pas over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat de jaarlijkse verkeersbelasting voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur de verkeersbelasting voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) Vanaf welk bedrag vindt u de aangepaste verkeersbelasting van een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoersmiddel (trein, tram, bus, fiets, ...)?

- Ik schakel pas over op een alternatief vervoersmiddel vanaf dat de jaarlijkse verkeersbelasting voor een BMW SERIE-3 meer bedraagt dan
  50 euro
- Ik kan of wil niet overschakelen op een alternatief vervoersmiddel , ongeacht hoe duur de verkeersbelasting voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoersmiddel.

Volgende

Vrije Universiteit Brussel

74%

Prijsmaatregelen

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STADSTOLHEFFING

Bij een stadstolheffing zal er een tol gegeven worden bij het binnen- en buitenrijden van een stad. De huidige fiscale context blijft voor de rest ongewijzigd.

Wagens met matige of hoge CO2-uitstoot (CATEGORIE C of D) zullen hierbij **de hoogste stadstol** betalen.

Wagens met lage CO2-uitstoot (CATEGORIE B) zullen kunnen genieten van een gunstiger tarief.

Wagens met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) zullen vrijgesteld worden van een stadstolheffing.

U heeft voor uw volgende aankoop voor deze wagen gekozen: **BMW SERIE-3, een wagen van categorie D** .

Ter info: in Stockholm betaalt men een stadstol van **2,2 Euro/keer**,
in Bologna wordt **5 Euro/keer** voorgesteld.

a) **Vanaf welk bedrag vindt u de stadstolheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met lage CO2-uitstoot (CATEGORIE B, gunstigere stadstol)?**

- Ik schakel pas over op een wagen met lage CO2 uitstoot vanaf dat de stadstol voor een BMW SERIE-3 meer bedraagt dan
  1 euro/keer
- Ik kan of wil niet overschakelen op een wagen met lage CO2 uitstoot, ongeacht hoe duur de stadstol voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met lage CO2-uitstoot.

b) **Vanaf welk bedrag vindt u de stadstolheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (CATEGORIE A, vrijstelling stadstol)?**

- Ik schakel pas over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat de stadstol voor een BMW SERIE-3 meer bedraagt dan
  1 euro/keer
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur de stadstol voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) **Vanaf welk bedrag vindt u de stadstolheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoersmiddel (trein, tram, bus, fiets, ...)?**

- Ik schakel pas over op een alternatief vervoersmiddel vanaf dat de stadstol voor een BMW SERIE-3 meer bedraagt dan
  1 euro/keer
- Ik kan of wil niet overschakelen op een alternatief vervoersmiddel, ongeacht hoe duur de stadstol voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoersmiddel.

Vrije Universiteit Brussel

76%

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Prijsmaatregelen

REKENINGRIJDEN

Bij rekeningrijden zal er een belasting geheven worden afhankelijk van de plaats en het tijdstip waarop u zich met de wagen bevindt.

Rekeningrijden zal de huidige jaarlijkse verkeersbelasting vervangen, terwijl de huidige registratiebelasting (BIV) onveranderd blijft.

Wagens met matige of hoge CO2-uitstoot (CATEGORIE C of D) zullen een **kilometerheffing** betalen.

Wagens met lage CO2-uitstoot (CATEGORIE B) zullen kunnen genieten van een verlaagd tarief.

Wagens met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) zullen vrijgesteld worden van een kilometerheffing.

Ter info: In Nederland is het basistarief 3 eurocent per kilometer, terwijl het spitstarief kan oplopen naar 11 eurocent per kilometer.

U hebt deze wagen gekozen: BMW SERIE-3, een wagen van categorie D .

U staat gemiddeld **30 %** van uw jaarlijks aantal kilometers in de file (11 eurocent per km), terwijl u voor de overige kilometers het basistarief aangerekend krijgt (3 eurocent per kilometer).

Op jaarbasis zou u dus gemiddeld **1350 euro** betalen.

a) **Vanaf welk bedrag vindt u de kilometerheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met lage CO2-uitstoot (CATEGORIE B, gunstigere kilometerheffing)?**

- Ik schakel pas over op een wagen met lage CO2 uitstoot vanaf dat de totale kilometerheffing voor een BMW SERIE-3 meer bedraagt dan
  300 euro/jaar
- Ik kan of wil niet overschakelen op een wagen met lage CO2 uitstoot, ongeacht hoe duur de kilometerheffing voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met lage CO2-uitstoot.

b) **Vanaf welk bedrag vindt u de kilometerheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (CATEGORIE A, vrijstelling kilometerheffing)?**

- Ik schakel pas over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat de totale kilometerheffing voor een BMW SERIE-3 meer bedraagt dan
  300 euro/jaar
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur de kilometerheffing voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) **Vanaf welk bedrag vindt u de kilometerheffing voor een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoermiddel (trein, tram, bus, fiets, ...)?**

- Ik schakel pas over op een alternatief vervoermiddel vanaf dat de totale kilometerheffing voor een BMW SERIE-3 meer bedraagt dan
  300 euro/jaar
- Ik kan of wil niet overschakelen op een alternatief vervoermiddel, ongeacht hoe duur de kilometerheffing voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoermiddel.

Vrije Universiteit Brussel

78%

Prijsmaatregelen

AANGEPAST PARKEERTARIEF

Een aanpassing van de parkeertarieven zal rekening houden met de milieuprestatie van voertuigen. De huidige fiscale context blijft voor de rest ongewijzigd.

Wagens met matige of hoge CO_2-uitstoot (CATEGORIE C of D) zullen het **hoogste parkeertarief** betalen.

Wagens met lage CO_2-uitstoot (CATEGORIE B) zullen kunnen genieten van een gunstiger tarief.

Wagens met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) zullen vrijgesteld worden van betalend parkeren.

U heeft voor uw volgende aankoop voor deze wagen gekozen: BMW SERIE-3, een wagen van categorie D .

Ter info: het parkeertarief in de grote steden bedraagt gemiddeld **2,5 Euro/uur**

a) Vanaf welk bedrag vindt u het parkeertarief voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met lage CO_2-uitstoot (CATEGORIE B, gunstiger parkeertarief)?

- Ik schakel pas over op een wagen met lage CO_2 uitstoot vanaf dat het parkeertarief voor een BMW SERIE-3 meer bedraagt dan

  0.5 euro/uur
- Ik kan of wil niet overschakelen op een wagen met lage CO_2 uitstoot, ongeacht hoe duur het parkeertarief voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met lage CO_2-uitstoot.

b) Vanaf welk bedrag vindt u het parkeertarief voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (CATEGORIE A, vrijstelling parkeertarief)?

- Ik schakel pas over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat het parkeertarief voor een BMW SERIE-3 meer bedraagt dan

  0.5 euro/uur
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur het parkeertarief voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) Vanaf welk bedrag vindt u het parkeertarief van een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoersmiddel (trein, tram, bus, fiets, ...)?

- Ik schakel pas over op een alternatief vervoersmiddel vanaf dat het parkeertarief voor een BMW SERIE-3 meer bedraagt dan

  0.5 euro/uur
- Ik kan of wil niet overschakelen op een alternatief vervoersmiddel, ongeacht hoe duur het parkeertarief voor een BMW SERIE-3 wordt.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoersmiddel.

Vrije Universiteit Brussel

Prijsmaatregelen

80%

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SCHROOTPREMIE

Bij het vervangen een wagen door een milieuvriendelijkere wagen zal u een premie kunnen ontvangen. De huidige fiscale context blijft voor de rest ongewijzigd.

Bij vervanging van een wagen op conventionele brandstoffen/aandrijfsystemen door een wagen met alternatieve brandstoffen/aandrijfsystemen (CATEGORIE A) zal u **een basispremie** kunnen ontvangen.

Wanneer u zou beslissen om een wagen met conventionele brandstoffen/aandrijfsystemen **definitief** te vervangen door een ander vervoersalternatief (trein, tram, bus, fiets, etc.) zal u kunnen genieten van een **maximale schrootpremie.**

Ter info: voorstellen voor schrootpremies variëren gemiddeld van **1200 tot 2500 euro** (basispremie) en zelfs **5000 euro** (maximale premie).

*OPM: in de volgende vragen bedoelen we met **vroegtijdig vervangen: vóór** de termijn waarop u **gewoonlijk** van wagen verandert.*

a) **Vanaf welk bedrag vindt u de schrootpremie zo aantrekkelijk dat u vroegtijdig (één of meerdere van) uw huidige wagen(s) inruilt voor een andere wagen (ander merk, model of versie) met alternatieve aandrijfsystemen/brandstoffen (bv. elektrisch of hybride, CATEGORIE A, basispremie)?**

- Ik schakel pas vroegtijdig over op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride) vanaf dat de schrootpremie voor mijn huidige wagen(s) meer bedraagt dan 250 euro
- Ik kan of wil niet vroegtijdig overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe aantrekkelijk de schrootpremie wordt.
- Ik ben sowieso bereid om vroegtijdig over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

b) **Vanaf welk bedrag vindt u de schrootpremie zo aantrekkelijk dat u vroegtijdig (één of meerdere van) uw huidige wagen(s) definitief inruilt voor een alternatief vervoersmiddel (trein, tram, bus, fiets, ...; maximale schrootpremie)?**

- Ik schakel pas **vroegtijdig** over op een alternatief vervoersmiddel vanaf dat de schrootpremie voor mijn huidige wagen(s) meer bedraagt dan 250 euro
- Ik kan of wil niet **vroegtijdig** overschakelen op een alternatief vervoersmiddel, ongeacht hoe aantrekkelijk de schrootpremie wordt.
- Ik ben sowieso bereid om **vroegtijdig** over te schakelen op een alternatief vervoersmiddel.

Vrije Universiteit Brussel

Prijsmaatregelen

82%
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BRANDSTOFPRIJZEN

De belastingen op de brandstofprijzen zullen aangepast worden aan de milieuprestatie van de brandstof. De huidige fiscale context blijft voor de rest ongewijzigd.

Brandstofinefficiënte wagens (CATEGORIE C of D) zullen geconfronteerd worden met **hogere brandstofprijzen** door een verhoging van de belasting op diesel en benzine.

Zuinigere wagens (CATEGORIE B) zullen minder getroffen worden door deze maatregel.

Wagens met alternatieve brandstoffen (LPG, aardgas, biobrandstoffen) en aandrijfsystemen (elektriciteit) (CATEGORIE A) zullen vrijgesteld worden van belastingen op brandstoffen.

U heeft voor uw volgende aankoop voor deze wagen gekozen: BMW SERIE-3, een wagen van categorie D .

Ter info: In april 2010 bedroeg de gemiddelde brandstofprijs **1,5 Euro/liter** voor benzine en **1,2 Euro/liter** voor diesel

a) **Vanaf welk bedrag vindt u de brandstofprijs per liter voor een BMW SERIE-3 zo duur dat u overschakelt op een zuinigere wagen** (CATEGORIE B)?

- Ik schakel pas over op een zuinigere wagen vanaf dat de brandstofprijs per liter voor een BMW SERIE-3 meer bedraagt dan
  0.1 euro
- Ik kan of wil niet overschakelen op zuinigere wagen, ongeacht hoe duur de brandstofprijzen voor een BMW SERIE-3 worden.
- Ik ben sowieso bereid om over te schakelen op zuinigere wagen.

b) **Vanaf welk bedrag vindt u de brandstofprijs per liter voor een BMW SERIE-3 zo duur dat u overschakelt op een wagen met alternatieve aandrijfsystemen/brandstoffen (bv. elektrisch of hybride, CATEGORIE A, vrijstelling brandstofbelastingen)?**

- Ik schakel pas over op een zuinigere wagen vanaf dat de brandstofprijs per liter voor een BMW SERIE-3 meer bedraagt dan
  0.1 euro
- Ik kan of wil niet overschakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride), ongeacht hoe duur de brandstofprijzen voor een BMW SERIE-3 worden.
- Ik ben sowieso bereid om over te schakelen op een wagen met alternatieve aandrijfsystemen/brandstoffen (vb. elektrisch of hybride).

c) **Vanaf welk bedrag vindt u de brandstofprijs per liter voor een BMW SERIE-3 zo duur dat u overschakelt op een alternatief vervoersmiddel (trein, tram, bus, fiets, ...)?**

- Ik schakel pas over op een alternatief vervoersmiddel vanaf dat de brandstofprijs per liter voor een BMW SERIE-3 meer bedraagt dan
  0.1 euro
- Ik kan of wil niet overschakelen op een alternatief vervoersmiddel, ongeacht hoe duur de brandstofprijzen voor een BMW SERIE-3 worden.
- Ik ben sowieso bereid om over te schakelen op een alternatief vervoersmiddel.

Vrije Universiteit Brussel

Prijsmaatregelen

Welke van deze overheidsmaatregelen zou op uw **aankoopgedrag** het meeste effect hebben?

	helemaal geen effect										extreem veel effect
Aangepaste registratiebelasting	○	○	○	○	○	○	○	○	○	○	○
Aangepaste verkeersbelasting	○	○	○	○	○	○	○	○	○	○	○
Stadstolheffing	○	○	○	○	○	○	○	○	○	○	○
Rekeningrijden (in plaats van verkeersbelasting)	○	○	○	○	○	○	○	○	○	○	○
Aangepast parkeertarief	○	○	○	○	○	○	○	○	○	○	○
Schrootpremie	○	○	○	○	○	○	○	○	○	○	○
Brandstofprijzen	○	○	○	○	○	○	○	○	○	○	○

Waarom?

Welke van deze overheidsmaatregelen zou op uw **verplaatsingsgedrag** het meeste effect hebben?

	helemaal geen effect										extreem veel effect
Aangepaste registratiebelasting	○	○	○	○	○	○	○	○	○	○	○
Aangepaste verkeersbelasting	○	○	○	○	○	○	○	○	○	○	○
Stadstolheffing	○	○	○	○	○	○	○	○	○	○	○
Rekeningrijden (in plaats van verkeersbelasting)	○	○	○	○	○	○	○	○	○	○	○
Aangepast parkeertarief	○	○	○	○	○	○	○	○	○	○	○
Schrootpremie	○	○	○	○	○	○	○	○	○	○	○
Brandstofprijzen	○	○	○	○	○	○	○	○	○	○	○

Waarom?

Indien u toch op basis een van de maatregelen zou overschakelen op een milieuvriendelijk voertuig uit CATEGORIE A, naar welke soort brandstof zal uw keuze dan uitgaan en waarom?

- ○ Benzine-hybride
- ○ Diesel-hybride
- ○ LPG
- ○ Aardgas
- ○ Biobrandstoffen (puur)
- ○ Brandstofcellen
- ○ Elektriciteit

Waarom?

Volgende

Vrije Universiteit Brussel

Prijsmaatregelen

90%

Geslacht: ○ man ○ vrouw

Leeftijd in jaren (vb. 26):

Met wie woont u nu samen onder één dak? Gelieve het aantal aan te geven (vul een nul in (0) wanneer niet van toepassing).

Mijn partner

Mijn kind(eren) (ook aangenomen en stiefkinderen)

< 12 jaar

Tussen 12 en 18 jaar

> 18jaar

Mijn broer(s) en/of zus(sen)

< 12 jaar

Tussen 12 en 18 jaar

> 18jaar

Mijn ouders of schoonouders

Mijn andere familie

Wat is uw hoogst genoten opleiding?
- ○ Basisonderwijs
- ○ Lager secundair
- ○ Hoger secundair
- ○ Hogeschool
- ○ Universitair
- ○ Postuniversitair

Wat is uw beroep?
- ○ Ambtenaar
- ○ Arbeider
- ○ Bediende
- ○ Gepensioneerde
- ○ Student
- ○ Zelfstandige/Vrij beroep
- ○ Werkzoekende
- ○ Andere, namelijk:

Hoeveel bedraagt uw netto-inkomen

Vrije Universiteit Brussel

Prijsmaatregelen

99%

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Indien u nog opmerkingen heeft betreffende deze vragenlijst of dit onderzoek, kunt u die hieronder kwijt.

Verzenden