DIFFERENTIATED SALES AND VEHICLE TAXES

An Assessment of Instruments for the Internalisation of External Costs of Transport

E. SCHOL
Framework of the study

This study has been carried out in the framework of the second phase of the EU Environment Programme, Area III: Research on Economic and Social Aspects of Environmental Issues (EU contract nr: EV5V-CT94-0365; ECN project number 7168). The title of the whole project is 'External Costs of Transport and Internalisation'. The results of this project are reported separately in the form of a Synthesis Report on Topic A: External Cost of Transport (ECN Policy Studies report number ECN-C--95-080) and a Synthesis Report on Topic B: Internalisation of External Costs of Transport published by ECOPLAN. Besides a description of the theory of internalisation and an overview of possible internalisation instruments, the Synthesis Report on Topic B is based on three Sub Reports in which three possible internalisation instruments have been analysed in detail, namely:

- Mileage Tax for European Road Freight Transport carried out by ECOPLAN (Switzerland),
- Variable Track Charge for Railway Noise carried out by COWIconsult (Denmark),
- Differentiated Sales and Vehicle Taxes carried out by ECN Policy Studies (The Netherlands).

The results of the last study are presented in this report.

Abstract

In this report an assessment is carried out on the differentiated sales and annual vehicle taxes as instruments for the internalisation of external costs of transport. The level of differentiation of the sales and annual vehicle taxes is based on the avoidance costs of noise and air pollution caused by transportation. The assessment is made on economic, ecological, technical and political criteria.

The basic assumption of this report is that a system of differentiated sales and annual vehicle taxes for passenger cars will be an additional instrument to an energy/CO₂ tax. The reason is that due to the far reaching characteristics, the incentives for innovation and the fact that fuel taxes are relatively easy to implement, the core of any internalisation strategy at an international level should consist of a taxation on fuel. In this report the discussion of instruments is at the European Community level.

On the base of this preliminary research it can be concluded that differentiated sales and annual vehicle taxes have no strong negative impacts, but also have not many strong positive impacts. The instruments will not lead to strong positive impacts on the environment. One of the reasons is that both tax systems are related to vehicle ownership and not to vehicle use. There is a stronger relationship between vehicle use and emissions than between vehicle ownership and emissions. However, the instruments probably are technically as well as politically feasible and will give an incentive for the development and sale of cleaner and more quiet vehicles within the European Union.
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EXECUTIVE SUMMARY

Our current transport system contributes to a large extent to our welfare in the sense of giving us a feeling of freedom, create the possibility to carry out a lot of diverse activities at different locations with a minimum loss of time for travel and to consume goods produced in different parts of the world. However, our role as active ‘globetrotters’ is debatable because we do not pay the full price for our transport activities: the costs of effects like air pollution, noise and accidents are not fully paid for. Nowadays market prices only reflect private costs and not the marginal external costs of transport. As a consequence, activities with negative external effects, such as driving passenger cars, take place on a too large scale. This leads to distortions in the economy in the sense of a misallocation of resources and non-optimized social welfare. In their effort to correct this market failure, economists estimate the external costs of transport and try to internalise these costs in the price of transport. There are several fiscal instruments available to internalise the environmental costs of transport. Examples of price instruments for road transport are: fuel taxes, sales taxes on new motor vehicles, recurrent annual vehicle charges, tax treatment of commuting expenses and road-user charges. The selection of instruments that is most appropriate for internalisation depends on criteria like effectiveness, efficiency, technical feasibility and acceptability.

The objective of this sub report is to evaluate a system of differentiated sales and annual vehicle taxes for passenger cars on their suitability to internalise the external costs of transport. The basic assumption of this sub report is that the system of differentiated sales and annual vehicle taxes for passenger cars would be an additional instrument to an energy/CO\(_2\) tax. The reason is that due to the far-reaching characteristics of an energy/CO\(_2\) tax, the incentives for innovation and the fact that fuel taxes are relatively easy to implement, the core of any internalisation strategy at an international level should consist of a taxation on fuel. The introduction of an energy/CO\(_2\) tax at EU level has been suggested by the EU in May 1992 and also within the discussion of possibilities and limits of an ecological tax reform taxation of energy has been a major element.

The differentiated sales tax and the differentiated annual vehicle tax can be defined as follows: The *differentiated sales tax* is a tax on the sale of new passenger cars. Up to now this instrument is more used to obtain revenues than to influence the purchase decision in the direction of more environmentally friendly types of passenger cars in the EU. The modification of this tax in order to internalise the external costs of transport requires the definition of different categories of vehicles based on differences in specific emissions of air pollutants, noise and fuel consumption. The *differentiated annual vehicle tax* is a recurrent annual tax for vehicle registration. In some countries the revenues are used for the finance of road infrastructure. Historically, the goal of this instrument is to receive revenues. However, many countries have based the level of the tax on vehicle parameters like weight,

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1 The European countries levy taxes on private cars but these taxes are rarely based on environmental costs.
cylinder capacity and/or kind of fuel, which all can be considered to be a sort of environmental performance indicator.

In order to internalise the external costs of transport the level of the external costs has to be determined first. In this report the avoidance costs are used as a shadow price for the external cost of transport. In this report only the avoidance cost for passenger cars, based on [1], will be discussed, as this report focuses on measures for passenger transport.

For the estimation of the avoidance cost for noise for passenger cars a target reduction level has to be determined. The existing 1990 EU noise emission limit for passenger cars is 77 dB(A). A new proposal for a further tightening of the noise emission limit, the so-called 1996 limit, will reduce the noise limit by 3 dB(A) to 74 dB(A) per passenger car. This will require an approximately 3% increase in vehicle production cost. At an average vehicle production cost of 6700 ECU per passenger car\(^2\) the marginal avoidance cost for noise is about 200 ECU per passenger car. This means about 22 ECU per year under the assumption of a lifetime of passenger cars of 12.5 years and an interest rate of 5%. Based on these avoidance costs for noise, a differentiation of the sales tax and annual vehicle tax can be made as presented in table S.1.

<table>
<thead>
<tr>
<th>Noise level of a passenger car</th>
<th>Sales tax [ECU per vehicle]</th>
<th>Vehicle tax [ECU/y per vehicle]</th>
</tr>
</thead>
<tbody>
<tr>
<td>74 dB (A)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>75 dB (A)</td>
<td>67</td>
<td>7</td>
</tr>
<tr>
<td>76 dB (A)</td>
<td>134</td>
<td>15</td>
</tr>
<tr>
<td>77 dB (A)</td>
<td>201</td>
<td>22</td>
</tr>
</tbody>
</table>

In this case the additional tax which car owners have to pay per type of vehicle is equal to the additional cost of investment in noise reduction measures. However, this system will give car manufacturers the incentive to develop measures which will reduce noise emissions against less costs.

In [1] the avoidance cost curves for air pollution have been estimated for different pollutants for the year 2005. These pollutants are:
- nitrogen oxides (NO\(_x\)),
- carbon monoxide (CO),
- volatile organic compounds (VOC),
- sulphur dioxide (SO\(_2\)),
- particulates (PM),
- carbon dioxide (CO\(_2\)).

The so-called emission cost approach is used to determine avoidance cost for air pollution. This methodology can be defined as setting cost on the total emission of NO\(_x\) and particulates of transport technologies, by applying the avoidance cost of the car catalyst on cars on petrol (about

Executive summary

4.56 ECU/kg NOₓ and low sulphur diesel for trucks (about 27.3 ECU/kg particulates).

Table S.2 for example, shows a differentiation of the sales tax and the annual vehicle tax for air pollution, which is based on the avoidance cost (ECU/kg) and the average emissions per year per vehicle technology.

Table S.2 *Differentiation of the sales and annual vehicle tax based on the emission cost approach*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Car on petrol</td>
<td>2294</td>
<td>750</td>
<td>12007</td>
<td>1238</td>
<td>136</td>
</tr>
<tr>
<td>Car petrol lean burn</td>
<td>392</td>
<td>28</td>
<td>12007</td>
<td>286</td>
<td>31</td>
</tr>
<tr>
<td>Car petrol catalyst</td>
<td>473</td>
<td>30</td>
<td>12007</td>
<td>333</td>
<td>36</td>
</tr>
<tr>
<td>Car on diesel</td>
<td>750</td>
<td>240</td>
<td>25241</td>
<td>2286</td>
<td>252</td>
</tr>
<tr>
<td>Car diesel fuel modified</td>
<td>750</td>
<td>192</td>
<td>25241</td>
<td>2000</td>
<td>219</td>
</tr>
<tr>
<td>Car diesel direct injection</td>
<td>688</td>
<td>200</td>
<td>25241</td>
<td>1976</td>
<td>217</td>
</tr>
<tr>
<td>Car on LPG</td>
<td>1400</td>
<td>20</td>
<td>23655</td>
<td>1595</td>
<td>164</td>
</tr>
<tr>
<td>Car LPG lean burn</td>
<td>239</td>
<td>17</td>
<td>23655</td>
<td>340</td>
<td>37</td>
</tr>
<tr>
<td>Car LPG catalyst</td>
<td>289</td>
<td>19</td>
<td>23655</td>
<td>393</td>
<td>43</td>
</tr>
<tr>
<td>Truck on diesel</td>
<td>13926</td>
<td>996</td>
<td>60000</td>
<td>35238</td>
<td>5442</td>
</tr>
</tbody>
</table>

The above mentioned differentiation will also give an incentive to car manufacturers to develop and sell emission reduction technologies which are more cost-effective than the above mentioned technologies. Moreover, it will give car owners an incentive to invest in environmental friendly technologies. This is illustrated in an example below. For example, a person owns a car on petrol and considers to invest in a lean burn engine. The cost\(^3\) of a lean burn engine is about 325 ECU, which will result in annual cost of 36 ECU for a vehicle with a lean burn engine. In this case the person who owns a car on petrol without the lean burn engine should pay an additional tax of 136 ECU per year. When this car owner invests in a lean burn engine, 36 ECU has to be paid for depreciation and the additional tax amounts 31 ECU for a car on petrol with a lean burn engine. This means an annual financial advantage of 69 ECU ((136-(36+31)) for a person who buys a car on petrol with a lean burn engine. Moreover, the lean burn engine is an energy efficient technology and this will result in annual fuel savings of 99 ECU, under the assumption of a constant annual mileage. Totally, this will result in a benefit of 168 ECU per year for a person who will invest in lean burn technology for a petrol car. However, in this example it is assumed that the decision maker disposes of all relevant information and that taxes can be determined exactly, which is often not the case.

The differentiation margin of the sales and annual vehicle tax for the internalisation of avoidance cost of air pollution lies between 1.4 % and 9.9% of the total costs\(^4\) of a passenger car and differs per technology. Of course, it

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\(^3\) In this case the cost concerns estimated production cost of a lean burn engine, which will differ from the market price of a lean burn engine.

\(^4\) Total costs of a vehicle without taxes, but including fuel duties.
is a positive aspect for society that these avoidance costs are so low. But for governments it is very difficult to internalise these low avoidance cost and at the same time reach the desired emission level per pollutant. However, two Dutch examples of the stimulation of more environmental friendly technologies, namely the three-way catalyst and unleaded petrol, showed that if according to consumers two products are complete substitutes of each other, consumers will buy the more environmental friendly product, if this product is cheaper than the more polluting product even by small price differences [18].

Under the assumption of an annual 2.7 percent growth in transport demand (unit: total vehicle kilometres per year) and a maximum penetration scenario of emission reduction technologies as described in [1] the following emission reduction of passenger cars will be achieved in the Netherlands:

Table S.3 Total emission reduction per pollutant in 2005 compared to 1990

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>12</td>
</tr>
<tr>
<td>CO</td>
<td>22</td>
</tr>
<tr>
<td>VOC</td>
<td>16</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
<td>0</td>
</tr>
<tr>
<td>PM</td>
<td>-31</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>-38</td>
</tr>
</tbody>
</table>

This means that, although there is a penetration of emission reduction technologies, the total emission of PM and CO\textsubscript{2} will still grow due to the fact that the growth in transport demand exceeds the decrease in emissions. In this report the total emission reduction is only estimated for passenger cars. The emission reduction of SO\textsubscript{2} will be higher when the emission reduction of trucks is included.

However, the total emission reduction presented in table S.3 will only be achieved when more cost-effective emission reduction technologies are also being implemented. These more cost-effective emission reduction technologies often are technologies which improve the energy-efficiency, like the lean burn engine. In combination with the three-way catalyst and low sulphur diesel, these more cost-effective technologies can lower the cost of the three-way catalyst and low sulphur diesel. In order to achieve the desired reduction levels, next to the differentiated sales tax or annual vehicle tax additional measures can be taken. A good example of an additional measure is the earlier mentioned energy tax or CO\textsubscript{2} tax, which will stimulate the implementation of more energy efficient technologies. The additional policy measures seem to be necessary because, although many reduction technologies are already cost-effective, they are hardly implemented yet. This is probably due to institutional or social barriers, e.g. the choice of a passenger car is not only based on economic grounds but also on status, lifestyle, safety, etc. More insight in these barriers is necessary in order to formulate additional measures to support the process of internalisation.

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The differentiated sales tax and differentiated annual vehicle tax can be evaluated against several criteria. For each a rating can be given, as follows:

- the instrument has a strong negative impact
- the instrument has a low negative impact
○ the instrument is neutral
+ the instrument has a low positive impact
++ the instrument has a strong positive impact.

Although the evaluation scheme (table S.4) has a strong indicative character, it is obvious that these instruments have no strong negative impacts, nor many strong positive impacts. The instruments will not result in strong positive impacts on the environment. One of the reasons is that both tax systems are related to vehicle ownership and not to vehicle use. There is a stronger relationship between vehicle use and emissions than between vehicle ownership and emissions. However, the effectiveness of the instruments depends on the variance in costs among types of vehicles and to what extent consumers assess the technologies as substitutes. Obviously, the instruments are technically as well as politically feasible and are a step towards cleaner vehicles and a less polluted transport system at a constant level of vehicle kilometres driven.

The sales tax is more reliable than the annual vehicle tax, because the effect of emission reduction technologies is decreasing during the years of car use. However, the increasing quantity of emissions caused by an increasing age of vehicles can be taken into account in the development stage of the classification scheme of passenger cars. Nevertheless, this is very difficult because the emissions between identical cars of the same age can vary as a result of differences in maintenance and use.
Differentiated sales and vehicle taxes

Table S.4 Rating of instruments on several criteria

<table>
<thead>
<tr>
<th>Type of assessment</th>
<th>Instrument</th>
<th>Sales Tax</th>
<th>Annual Vehicle Tax</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency transport system</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Transport quality</td>
<td></td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Impact on economy</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Impact on innovative behaviour</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Effectiveness</td>
<td></td>
<td>+/0</td>
<td>+/0</td>
</tr>
<tr>
<td>Ecological</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentives to switch to less polluting modes</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Impact on emissions and pollution</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Technical</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Implementation and running costs</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Flexibility towards further technical progress</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Coordination with regulation and existing policy</td>
<td></td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Reliability or fraud proof</td>
<td></td>
<td>++</td>
<td>+</td>
</tr>
<tr>
<td>Political</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal and institutional aspects</td>
<td></td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Acceptability</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Impact on national budgets</td>
<td></td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Distributive effects</td>
<td></td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

For a successful introduction of the instruments the following requirements can be defined from the assessment of economical, ecological, technical and legal aspects.

The instruments should:
- be consistent with the ‘no paradox’ principle (i.e. for any two cars the higher emitting car should have the higher charge),
- have to be implemented in a revenue neutral way,
- the revenues have to be used for improvement of alternatives for polluting cars,
- be levied on the basis of a continuous function relating the car tax in ECU to g/km emissions and noise,
- description of technology and emissions of a car model is needed,
- no regional differences have to be made,
- have to be introduced at a European level.

In the EU, the idea of basing fiscal instruments on environmental criteria is already subject of discussion. Not only at the European level there is a discussion on more environmentally based fiscal instruments but also at the national level it is an issue, for example in Sweden and in the Netherlands. However, it is in the interest of harmonisation and convergence that all Member States adopt internalisation measures, like differentiated sales and vehicle taxes. After all, if only a few Member States adopt these charges,
there will be a significant distortion of the internal market and adverse effects on the competitiveness of some countries will occur. With a Community approach, manufacturers will have wider, and hence a more effective, incentive to improve emissions of all car models.

The new tax system should not lead to too much disruption of the car market at once, neither for the motorist nor for the manufacturer. This means that these measures should be introduced gradually to replace existing annual car or sales taxes or other such charges.

It can be concluded that a differentiated sales tax and an annual vehicle tax are useful additional instruments to a CO\(_2\) or energy tax for those environmental aspects which do not completely correlate with fuel consumption such as the effects of a three-way catalyst. Also the annual mileage tax is an appropriate additional instrument to a CO\(_2\) or energy tax in this respect. The annual mileage tax also is more related to the usage of a vehicle and therefore to the quantity of emissions. However, for practical reasons policy makers might choose for a fixed tax, like the sales or annual vehicle tax.
1. INTRODUCTION

Our current transport system contributes to a large extent to the welfare of human beings in the sense of a feeling of freedom, the possibility to carry out a lot of diverse activities at other locations with a minimum loss of time for travel and consuming goods produced in different parts of the world. However, our role as an active 'globetrotter' is debatable because we do not pay the full price for our transport activities: the costs of effects like air pollution, noise and accidents are not fully paid for. Nowadays market prices only reflect the private costs and not the marginal external costs of transport. As a consequence, activities with negative external effects, such as driving passenger cars, take place on a too large scale. This leads to distortions in the economy in the sense of a misallocation of resources and non-optimized social welfare. In the effort to correct this market failure, economists estimate the external costs of transport and try to internalise these costs in the price of transport. There are several fiscal instruments available to internalise the environmental costs of transport. Examples of the available price instruments for road transport are the following: fuel taxes, sales taxes on new motor vehicles, recurrent annual vehicle charges, tax treatment of commuting expenses and road-user charges. The selection of instruments that is most appropriate for internalisation of environmental costs depends on several criteria like their effectiveness, their efficiency, technical feasibility and acceptability. This report will evaluate two instruments namely the differentiated sales tax and the differentiated annual vehicle tax on these and other criteria.

In the EU, the idea of basing fiscal instruments more on environmental criteria is already subject of discussion. For example, in directive 91/441/EEC the Council of Ministers committed itself to consider a proposal from the Commission on measures to reduce CO₂ emissions from cars [2]. The possible measures include, besides fiscal measures, also regulation, but the MVEQ ad hoc group recommends to apply a system of charges/credits to the price of new cars. This choice is based on the following reasons:
- the most effective way to reduce CO₂/km emissions is by market forces,
- much higher fuel prices might not be accepted by all Member States,
- the best complementary measure is the introduction of charges/credits,
- the measure must avoid the 'paradox effect'. This means that a higher CO₂/km emitting vehicle should always pay a higher charge than any lower emitting vehicle [3].

The focus is only on CO₂ and not on other environmental effects like noise and air pollution. One of the reasons for this limitation is the last above mentioned reason. Another reason is that including other environmental effects makes it more complicated.

Not only at the European level there is a discussion about more environmentally based fiscal instruments but also at the national level it is an issue

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5 The European countries levy taxes on private cars but these taxes are rarely based on environmental costs.
Differentiated sales and vehicle taxes

for example in Sweden and in the Netherlands. However, it is in the interest of harmonisation and convergence that all Member States should adopt the internalisation measures, like differentiated sales and annual vehicle taxes. Because if only a few Member States adopt these charges, there will be a significant distortion of the internal market and adverse effects on the competitiveness of some countries will occur. With a Community approach, manufacturers will have a wider, and hence a more effective, incentive to improve emissions of all car models.

Framework of the study

This study has been carried out in the framework of the second phase of the EU Environment Programme, Area III: Research on Economic and Social Aspects of Environmental Issues. The title of the whole project is 'External Costs of Transport and Internalisation'. The general objectives of the project are to:

a. provide a method to calculate external costs of air pollution, climate change and noise caused by transport in the EU;

b. discuss possible instruments for internalisation and access selected instruments for internalisation of the calculated external costs.

The project is divided in topic A and B reflecting the two general objectives. The results of this project are reported separately in the form of a Synthesis Report on Topic A: External Cost of Transport published by ECN and a Synthesis Report on Topic B: Internalisation of External Costs of Transport published by ECOPLAN. In the Synthesis report of topic A [1] a theoretical base is given for the evaluation of external effects. A review is also made of the literature on methodologies for estimation of external costs in the transport sector as well as a survey of existing studies on the external costs of transport. Moreover, an estimation is made of the avoidance costs of air pollution, climate change and noise caused by transportation. Finally on the base of these estimation of avoidance costs, information is provided for topic B: the internalisation of external effects. In the Synthesis Report on topic B [4] a description is given of the theory of internalisation and an overview of possible internalisation instruments. Three of these instruments have been selected to be analysed in more detail in sub reports, namely:

- Mileage Tax for European Road Freight Transport carried out by ECOPLAN [5],
- Variable Track Charge for Railway Noise carried out by COWIconsult [6],
- Differentiated Sales and Vehicle Taxes carried out by ECN Policy Studies.

The results of the last study are presented in this report. In this report the estimation of the avoidance cost of the use of passenger cars, which is a result of the topic A study, is used for the determination of the level of differentiation of the sales and annual vehicle tax.
**Objective**

The objective of this sub report is to evaluate a system of differentiated sales and annual vehicle taxes for passenger cars, including a tradeable permit system at the level of car manufacturers, on their suitability to internalise the external costs of transport. The arguments for focusing on two instruments, namely the differentiated sales tax and differentiated annual vehicle tax, are given below.

In a tradeable permit system the authorities are fixing the area wide level of emissions needed to meet a noise or an ambient air quality target or standard. Permits to pollute are issued and distributed to emitters via one of several possible methods. In order to cover the gap between uncontrolled emissions and those that the permits would allow, the emitter has several options: implementation of emission reduction measures, or the purchase of permits from others, who in turn will have to implement this emission reduction measures, or the choice to carry out the activity in such a way that the price of the tradeable permit would be lower, for example at another time, another place, or carry out the activity not at all. A market can be organized by the authorities for exchanging pollution permits and there are theoretical reasons to suggest that the emission targets will be reached in a cost-effective manner [7]. However, the tradeable permit approach has severe problems which are particularly important in markets with many actors, as is more or less the case for the transport sector. The most important problems are: the high transaction and information costs if there are many actors on the market and the organisation of the first issue of the permits, like who gets them and what is the price?

Until now, the tradeable permit system can be found very rarely in the transport sector. For example, the ‘eco-point’ system for the transalpine freight transport on roads in Austria and the Corporate Average Fuel Efficiency-standards in the US, which introduce limitations of the average fuel consumption of the whole car fleet an automobile manufacturer produces. In the industrial sector there is quite a lot of experience with emission trading policies. However, the tradeable permit system has been more applied in the US than in the EU and the system seems to be a more suitable instrument for the American economic culture (the market will set the right price) than for the European economic culture with more influence of the governments on the market price. Moreover, it would be very difficult to link the tradeable permit system with the results of the estimations of the avoidance costs, because the price is already determined by the avoidance costs curve⁶. For these reasons the possibilities of the tradeable permit system for the internalisation of environmental costs will not be evaluated in this study. Thus the study will focus on the differentiated sales tax and the differentiated annual vehicle tax.

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⁶ However, it should be mentioned that in the case of CAFE standards the manufacturer whose fleet average fuel consumption does not meet the standard is subject to a fine of $ 5 for each vehicle produced. Moreover, vehicles which fail to meet certain minimum fuel economy figures are subject to a ‘gas guzzler’ tax ranging from $ 500 to a maximum of $ 3850 (1986 figures in [8]). The gas guzzler tax was doubled in 1991. It now ranges from $ 1000 to $ 7700 per 0.1 mile/gallon below the limit value [9]. In this case the avoidance costs can be used to set the price of the fine.
Differentiated sales and vehicle taxes

The basic assumption of this sub report is that the system of differentiated sales and vehicle taxes for passenger cars will be an additional instrument to an energy/CO$_2$ tax. The reason is that due to the far-reaching characteristics, the incentives for innovation and the fact that fuel taxes are relatively easy to implement, the core of any internalisation strategy at an international level should consist of a taxation on fuel. The introduction of an energy/CO$_2$ tax at EU level has been suggested by the EU commission in May 1992 and also within the discussion of the possibilities and the limits of an ecological tax reform the taxation of energy has been one major element.

The structure of the report is as follows. In chapter two the relation between avoidance cost and internalisation is described. In chapter three the instruments will be described as well as the link between these instruments and the CO$_2$ or energy tax. An assessment of the instruments will be made in chapter four. This report will end with some conclusions and recommendations.
2. AVOIDANCE COSTS OF NOISE AND AIR POLLUTION

In order to internalise the external costs of transport one needs to estimate the external costs of transport. In our topic A report on the external costs of transport, the avoidance cost approach has been used to find a base for the economic quantification of the environmental costs of noise, air pollution and climate change. In this report the results of the estimation of avoidance costs of noise, air pollution and climate change will be used to determine the level of differentiation in the sales tax and the annual vehicle tax among types of vehicles.

The main results of the estimation of avoidance costs of noise, air pollution and climate change will be described below as far as relevant to this study on the suitability of the differentiated sales tax and the differentiated annual vehicle tax for internalisation of environmental costs of transport. The avoidance cost curves have been estimated for Denmark, Germany, Switzerland and the Netherlands. In this report only the marginal avoidance costs for passenger cars will be discussed, because this report focus on measures for passenger transport. For a more detailed description of the avoidance cost methodology and the application for noise and air pollution see [1].

2.1 The avoidance costs of noise

The noise situation in a country can be described as the share of dwelling units which is exposed to various noise levels. Assuming that the number of people in all kinds of dwelling units is the same, the share of dwellings is equivalent to the share of the population. Figure 2.1 shows the share of dwellings exposed to more than 55 dB(A).

Road traffic is the largest contributor to the noise annoyance situation in each of the four countries. This is caused by a considerable volume of road traffic compared to other modes of transport and is also due to the location of roads close to dwellings. In Switzerland and in the Netherlands almost 55% of the dwellings are exposed to noise annoyance from road traffic, while in Denmark only 20% of the dwellings are exposed to noise annoyance. In the case that every country will set the same target level on the allowed number of dwellings exposed to a certain level of noise annoyance Denmark has to take less measures than Switzerland or the Netherlands. This also means another level of environmental cost and thus another charge for the internalisation of these environmental cost. Regional differences in noise annoyance within countries exist as well. For these reasons it can be discussed if internalisation of noise annoyance should be implemented at a local level rather than a EU level.

Despite this discussion, the avoidance cost of noise for the differentiated sales and differentiated vehicle taxes will be estimated.
To reduce noise the following avoidance measures for passenger cars can be distinguished:

- reducing the impact of noise:
  - sound insulation of buildings
  - noise barriers

- reducing noise from the source:
  - insulation of the engines
  - less noisy road surfaces
  - less noisy tires
  - less noisy versions of means of transport (e.g. electric vehicles)
  - speed limits
  - changing transport means of transport (mode change)

- traffic regulations:
  - constructions of by-pass roads.

INRETS [10] estimates the cost of vehicle noise reductions on approximately a 1% increase in vehicle production cost per dB(A) reduced. According to [1] the cost-effectiveness of reduction measures at the source, like insulation of engines and noise barriers, is not substantially higher than measures aiming to reduce its negative impact like sound insulation of buildings. However, reduction measures at the source will also decrease the noise outdoor. For this reason, reduction measures at the source are to be preferred.

In order to estimate the avoidance cost of noise for passenger cars a target reduction level has to be determined. The existing 1990 EU noise emission limit for passenger cars is 77 dB(A). A proposal for a further tightening of the emission limit will be 74 dB(A) per passenger car; the so-called 1996 limit. In order to reach this target level, the noise emission per passenger

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7 Military aviation is also included in the Dutch figure.
Avoidance costs of noise and air pollution

car has to be reduced by 3 dB(A), which means approximately a 3% increase in vehicle production cost. At an average vehicle production cost of 6700 ECU per passenger car\(^8\) the marginal avoidance cost for noise is about 200 ECU per passenger car. In other words the reduction cost for noise annoyance is about 67 ECU per dB(A) reduced.

2.2 The avoidance costs of air pollution

The passenger car is a major player in the field of air pollution caused by the transport sector in EU countries. With the exception of sulphur dioxide and particulates the passenger car is the main contributor to the emissions of the transport sector. The truck is the main contributor to sulphur dioxide and particulates emissions of the transport sector due to the high sulphur dioxide and particulates emissions per vehicle kilometre.

For the above mentioned reasons the avoidance cost curves have been estimated for passenger cars and trucks in [1].

In [1] the avoidance cost curves have been estimated for the following pollutants:
- nitrogen oxides (NO\(_x\))
- carbon monoxide (CO)
- volatile organic compounds (VOC)
- sulphur dioxide (SO\(_2\))
- particulates (PM)
- carbon dioxide (CO\(_2\)).

The marginal avoidance cost curves have been estimated for the year 2005. With a longer time horizon more emission reduction measures could be taken into account, but this will also imply more uncertainties in the estimations about the development of the costs of these measures, the moment of availability and implementation of these measures. Moreover, the avoidance costs will be used as a base for the determination of the level of a tax, for which a longer time horizon is less appropriate. Base year of the estimations was 1990.

The following emission reduction technologies have been taken into account:
- three-way catalyst,
- two-way catalyst,
- modified frame (improvement of tyres and aerodynamics, and decrease of weight),
- improved internal combustion (low resistance lubricants and a sophisticated motor management system),
- modified improved internal combustion (lean burn engine, direct injected diesel engine),
- modified fuel (low sulphur diesel).

\(^8\) See [1] table 7.12.
Differentiated sales and vehicle taxes

The simultaneous effect of the emission reduction technologies on the different pollutants has been taken into account for the estimations of the avoidance cost curves of the different pollutants. The sequence and the level of penetration of emission reduction technologies determines the total reduction effect. Furthermore, combinations of these emission reduction technologies applied on vehicles result in a non-linear effect.

In order to consider the effect of simultaneous emission reduction of different emission reduction technologies for the estimations of the avoidance cost of all considered pollutants for air pollution, subjective and temporary choices have to be made about which is the main environmental problem and which is the main pollutant. For clear and transparent outcomes the best place for implementation of these choices is the stage between the separate avoidance cost curves for pollutants and the internalisation part. Of course, these choices have an influence on the outcome of the estimations of the avoidance costs.

Under the assumptions and the applied methodology of our research in topic A, a useful base for the economic quantification of the environmental costs of climate change (carbon dioxide) has not been found, because the avoidance cost curve for carbon dioxide was negative as a result of the higher returns on energy savings than the investment cost of CO$_2$ reduction technologies.

In this research nitrogen oxides were chosen as main pollutant. Nitrogen oxides have regional as well as local effects. The most relevant reduction technology, the three-way catalyst, also decreases hydrocarbon and carbon monoxide emissions. In addition to nitrogen oxides, for particulates the marginal cost of low sulphur diesel has been included to estimate the total marginal reduction costs for air pollution. Besides a reduction of particulates emissions, low sulphur diesel will also decrease sulphur dioxide emissions. It appeared that nitrogen oxides and particulates can be chosen as main pollutants in order to obtain a reduction of the other pollutants. The cost of a three-way catalyst is about 718 ECU per passenger car on petrol or LPG and the cost of low sulphur diesel is about 0.02 ECU per litre. The so-called emission cost approach is used to determine avoidance cost for air pollution. This methodology can be defined as setting cost on the total emission of NO$_x$ and particulates of transport technologies, by applying the avoidance cost of the car on petrol (about 4.56 ECU/kg NO$_x$) and low sulphur diesel for trucks (about 27.3 ECU/kg particulates).
Under the assumption of an annual 2.7 percent growth in transport demand (unit: total vehicle kilometres per year) and a maximal penetration scenario of emission reduction technologies as described in [1] the following emission reduction of passenger cars will be achieved for the Netherlands:

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Reduction [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO\textsubscript{x}</td>
<td>12</td>
</tr>
<tr>
<td>CO</td>
<td>22</td>
</tr>
<tr>
<td>VOC</td>
<td>16</td>
</tr>
<tr>
<td>SO\textsubscript{2}</td>
<td>0</td>
</tr>
<tr>
<td>PM</td>
<td>-31</td>
</tr>
<tr>
<td>CO\textsubscript{2}</td>
<td>-38</td>
</tr>
</tbody>
</table>

This means that, although there is a penetration of emission reduction technologies, the total emission of PM and CO\textsubscript{2} will still grow due to the fact that the growth in transport demand exceeds the decrease in emissions. In table 2.1 the total emission reduction is only determined for passenger cars. The emission reduction of SO\textsubscript{2} will be higher if the emission reduction of trucks is included.

However, the total emission reduction presented in table 2.1 will only be achieved if the more cost-effective emission reduction technologies will also be implemented. These more cost-effective emission reduction technologies are often technologies which improve the energy-efficiency, like the lean burn engine. In combination with the three-way catalyst and low sulphur diesel, these more cost-effective technologies can lower the cost of the three-way catalyst and low sulphur diesel. In order to achieve the desired reduction levels, next to the differentiated sales tax and annual vehicle tax, additional measures can be taken. A good example of an additional measure is the earlier mentioned energy tax or CO\textsubscript{2} tax, which will stimulate the implementation of more energy efficient technologies. The additional policy measures seem to be necessary because, although many reduction technologies are already cost-effective, they are hardly implemented yet. This is possibly due to institutional or social barriers, e.g. the choice of a passenger car is not only based on economic grounds but also on status, lifestyle, safety, etc.

For the considered countries, the avoidance costs are in the same order of magnitude. This could be a base for EU policy, e.g. in the field of a differentiated sales tax and a differentiated annual vehicle tax, if this is also the case for other EU countries. In this case profit can be made of the large EU market to develop environmental friendly technologies with economies of scale, which will result in a transport sector moving towards a more sustainable direction against less cost compared to the cost of separate policies developed by every EU country alone. However, Denmark, Germany, the Netherlands and Switzerland are not representative for the EU.
3. MAIN FEATURES OF THE SALES AND VEHICLE TAX

In this chapter the differentiated sales tax and the differentiated annual vehicle tax will be described. Also the relationship with an energy/CO₂ tax will be explained. A short description will also be given of the recent base of the sales tax and the annual vehicle tax in EU countries. Moreover, in chapter 3.4 the level of differentiation of the sales tax and annual vehicle tax will be based on the avoidance costs of noise and air pollution as described in chapter two. Finally, some aspects of the implementation of the instruments will be described.

3.1 Description of the sales and vehicle tax

The differentiated sales tax is a tax on the sale of new passenger cars. Up to now this instrument is more used to get revenues rather than to influence the purchase decision in the direction of the purchase of more environmentally friendly type of passenger cars in the EU. The modification of this tax in order to internalise the external costs of transport requires the definition of different categories of vehicles based on the differences in specific emissions of noise and air pollutants.

The differentiated annual vehicle tax is a recurrent annual tax for vehicle registration. In some countries the revenues are used for the finance of road infrastructure. Historically, the goal of this instrument is to receive revenues. However, many countries based the level of the tax on vehicle parameters like weight, cylinder capacity and/or kind of fuel which can be considered as more or less environmental performance indicators of a type of vehicle.

3.2 Link to an energy tax or CO₂ tax

The energy tax or CO₂ tax is related to the use of a vehicle while the differentiated sales and annual vehicle tax are related to the possession or ownership of a vehicle. In general, the closer the pricing system is related to the usage of the transport modes the higher the effectiveness of the instrument, because the quantity of emissions is related to the use of a transport mode. However, the quantity of emissions per vehicle kilometre depends on the used technology (emission reduction technology, kind of fuel, cylinder capacity, vehicle weight), speed, driving conditions (e.g., cold start) and other circumstances. In other words there is a relationship between the emissions of air pollution, climate change, noise and energy use. However, the strength of the relationship between energy use and air pollution, climate change and noise is different. Table 3.1 shows the exceptions on the linear relationship between energy use and environmental effects focused on the source of the effect and the suitable instruments for internalisation.
Table 3.1 *Exceptions on the linear relationship between energy use and environmental effects focused on the source of the effect and the suitable instruments for internalisation*

<table>
<thead>
<tr>
<th>Environmental effects</th>
<th>Exceptions</th>
<th>Suitable instrument</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Climate change (CO₂)</em></td>
<td>difference in 'CO₂' fuel content, difference in mining, refining and transport per kind of fuel</td>
<td>fuel, vehicle or mileage tax</td>
</tr>
<tr>
<td>Air pollution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• NOₓ</td>
<td>fuel, technology, speed</td>
<td>fuel, vehicle or mileage tax, vehicle or mileage tax, road tax</td>
</tr>
<tr>
<td>• CO</td>
<td>fuel, technology, cold-start emissions</td>
<td>fuel, vehicle or mileage tax, vehicle or mileage tax, road tax, vehicle tax, parking</td>
</tr>
<tr>
<td>• VOC</td>
<td>fuel, technology, speed, cold-start emissions</td>
<td>fuel, vehicle or mileage tax, vehicle or mileage tax, road tax, vehicle tax, parking</td>
</tr>
<tr>
<td>• SO₂</td>
<td>difference in 'SO₂' fuel content, difference in mining per kind of fuel</td>
<td>fuel, vehicle or mileage tax, vehicle or mileage tax</td>
</tr>
<tr>
<td>• Particulates</td>
<td>fuel, technology, 'SO₂' content of a fuel</td>
<td>fuel, vehicle or mileage tax, vehicle or mileage tax</td>
</tr>
<tr>
<td>Noise</td>
<td>technology, speed, kind of road surface, acceleration/brake</td>
<td>vehicle tax, vehicle tax, road tax, vehicle tax</td>
</tr>
</tbody>
</table>

Table 3.1 shows that the relationship between climate change and energy use is the most correlated one and the relationship between noise and energy use is the lowest correlated one. The differences per pollutant in the content of the fuel can be internalised by a change in the fuel tax or a change in the vehicle tax. Of course a change in the fuel tax is the most direct way of internalisation. However, up to now it was not possible to internalise it in this way, because experts did not agree on the direction to deal with opposite environmental effects of the different pollutants per kind of fuel. It is possible to deal with these opposite environmental effects by using the estimated avoidance costs per kind of fuel. We did not take explicitly the influences of speed, acceleration, brake and cold start emissions in our estimations of the avoidance costs, so it is not possible to include this in our study. However, it is possible to deal with the cold-start emissions by introducing the costs and the effects of the pre-heated catalysts in the estimations of the avoidance cost curve. Moreover, the indirect emissions of transport, like the emissions of mining, refining and transport of fuels, were not included in our research.
Main features of the sales and vehicle tax

It can be concluded that the differentiated sales and annual vehicle tax are useful additional instruments to a CO₂ or energy tax for these environmental aspects which are not correlated with fuel consumption. Also the annual mileage tax is a suitable additional instrument to a CO₂ or energy tax in this respect. The annual mileage tax is also more related to the usage of a vehicle and therefore to the quantity of emissions. However, for practical reasons policy makers can choose for a fixed tax like the sales or annual vehicle tax.

3.3 Recent tax base in EU countries

The recent base of the sales tax and the annual vehicle tax differs per EU country. Norway and Finland already base their sales tax on emission levels of cars. Austria plans a sales tax based on energy consumption. Sweden bases the sales tax partly on emission levels and partly on weight. The vehicles are divided into three classes in Sweden. Consumers who would like to buy cars from class three, the cars which fulfil just the mandatory emission limits, have to pay a charge of 220 ECU. Consumers who would like to buy cars from class one receive a tax reduction of 440 ECU. Entering EU, Sweden changed the subsidy on class one cars from a lowered sales tax to a lowered annual vehicle tax of 33 ECU per year for the first five years. For electric vehicles the sales tax is abolished for three years. Cars from class three still pay an extra sales tax. Furthermore, the fixed part of the sales tax on cars is 0.7 ECU per kg. As the weight of a vehicle can also be considered as an environmental performance parameter this is already a reasonable environmentally based sales tax.

At present, member states set annual taxes for cars according to different criteria: engine size, car weight, 'fiscal horse power', etc. As a result of this annual car taxes can vary considerably for a certain type of car, in absolute terms as well as among car types and among member states.

In Finland, Denmark and Austria, the annual vehicle tax is already based on emission levels of cars. In Belgium the annual vehicle tax is based on engine performance only, while Denmark, Ireland and Portugal base their annual vehicle tax on engine power only. The United Kingdom bases its annual vehicle tax on vehicle type only. Several countries base their annual vehicle tax on more than one variable. Switzerland bases its annual vehicle tax on the most variables, namely on vehicle type, engine performance, engine power and car weight. Austria bases its annual vehicle tax on car weight and emissions. The level of the annual vehicle tax of Germany depends on engine power and emissions. Italy bases its annual vehicle tax on both engine aspects: engine power as well as engine performance. The Netherlands bases its annual vehicle tax on weight and kind of fuel. The Swedish annual vehicle tax is based on weight with a subsidy for cars which are registered in some peripheral regions.

9 The mileage tax as an instrument for internalisation of external effects of road freight transport is described in more detail by ECOPLAN [5].
Differentiated sales and vehicle taxes

3.4 Level of differentiation

As described in chapter two, the results of the estimation of avoidance costs of noise, air pollution and climate change [1] will be used for the determination of the level of differentiation in the sales tax and the annual vehicle tax among types of vehicles. The key figures of the avoidance cost of noise (approximately 67 ECU per dB(A) reduced) and the avoidance cost of air pollution (about 4.56 ECU/kg NO\textsubscript{x} and 27.3 ECU/kg particulates) will be used for the determination of the level of differentiation. These key figures are described in chapter 2.1. and 2.2.

For example, a differentiation of the sales tax and annual vehicle tax for the internalisation of the avoidance cost of noise can be made as presented in table 3.2. The annual vehicle tax in table 3.2 is calculated under the assumption of a lifetime of passenger cars of 12.5 years and a interest rate of 5%.

Table 3.2 Differentiation of a sales tax and an annual vehicle tax for noise

<table>
<thead>
<tr>
<th>Noise emission of a passenger car</th>
<th>sales tax [ECU per vehicle]</th>
<th>vehicle tax [ECU/y per vehicle]</th>
</tr>
</thead>
<tbody>
<tr>
<td>74 dB (A)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>75 dB (A)</td>
<td>67</td>
<td>7</td>
</tr>
<tr>
<td>76 dB (A)</td>
<td>134</td>
<td>15</td>
</tr>
<tr>
<td>77 dB (A)</td>
<td>201</td>
<td>22</td>
</tr>
</tbody>
</table>

In this case the additional tax which car owners have to pay per type of vehicle is equal to the additional cost of the investment in noise reduction measures. However, this system will give car manufacturers the incentive to develop measures which will reduce noise emissions against less cost.

A differentiation of the sales tax and the annual vehicle tax for the internalisation of the avoidance cost of air pollution can be based on the total emissions of a vehicle and the avoidance cost of air pollution (ECU/kg). In the most proper way this differentiation of the tax is based on the actual emissions of a vehicle. However, these metering systems are not available on the market yet. Moreover, the present estimations of the emitted emissions per vehicle during ECE driving cycles are already very expensive. Under the assumption that figures on the average emissions of NO\textsubscript{x} and particulates per vehicle kilometre per car model are available, the actual emissions can be assessed on the base of the annual mileage per vehicle. It is to be preferred to base the annual mileage on metering systems, which measure the actual mileage instead of using the average annual mileage per vehicle type. However, doubts exist with regard to the fraud proofness of these metering systems.

For example, table 3.3 shows a differentiation of the sales tax and the annual vehicle tax for the internalisation of the avoidance costs of air pollution, which is based on the avoidance cost (ECU/kg) and the average emissions per year per vehicle technology.
Table 3.3 Differentiation of a sales and annual vehicle tax for air pollution based on the emission cost approach

<table>
<thead>
<tr>
<th>Transport technology</th>
<th>NO\text{\textsubscript{x}} \hspace{1em} [mg/vkm]</th>
<th>Particulates \hspace{1em} [mg/vkm]</th>
<th>Annual mileage \hspace{1em} [vkm/y]</th>
<th>Sales tax \hspace{1em} [ECU/vehicle]</th>
<th>Vehicle tax \hspace{1em} [ECU/y]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car on petrol</td>
<td>2294</td>
<td>750</td>
<td>12007</td>
<td>1238</td>
<td>136</td>
</tr>
<tr>
<td>Car petrol lean burn</td>
<td>392</td>
<td>28</td>
<td>12007</td>
<td>286</td>
<td>31</td>
</tr>
<tr>
<td>Car petrol catalyst</td>
<td>473</td>
<td>30</td>
<td>12007</td>
<td>333</td>
<td>36</td>
</tr>
<tr>
<td>Car on diesel</td>
<td>750</td>
<td>240</td>
<td>25241</td>
<td>2286</td>
<td>252</td>
</tr>
<tr>
<td>Car diesel fuel modified</td>
<td>750</td>
<td>192</td>
<td>25241</td>
<td>2000</td>
<td>219</td>
</tr>
<tr>
<td>Car diesel direct injection</td>
<td>688</td>
<td>200</td>
<td>25241</td>
<td>1976</td>
<td>217</td>
</tr>
<tr>
<td>Car on LPG</td>
<td>1400</td>
<td>20</td>
<td>23655</td>
<td>1595</td>
<td>164</td>
</tr>
<tr>
<td>Car LPG lean burn</td>
<td>239</td>
<td>17</td>
<td>23655</td>
<td>340</td>
<td>37C</td>
</tr>
<tr>
<td>Car LPG catalyst</td>
<td>289</td>
<td>19</td>
<td>23655</td>
<td>393</td>
<td>43</td>
</tr>
<tr>
<td>Truck on diesel</td>
<td>13926</td>
<td>996</td>
<td>60000</td>
<td>35238</td>
<td>5442</td>
</tr>
</tbody>
</table>

Table 3.3. shows that an owner of a car on diesel has to pay more than an owner of a car on petrol as a result of a higher annual mileage of a car on diesel than a car on petrol, although a car on diesel emits less NO\text{\textsubscript{x}} and particulates per vehicle kilometre. The truck pollutes not only more than a passenger car, but also drives more kilometres per year. As a consequence an owner of a truck has to pay more than an owner of a passenger car. However, an owner of a truck has less possibilities to invest in cost-effective emission reduction technologies than owners of a passenger car, because truck owners already applied a lot of energy saving measures which also decreased the emissions. In this respect it has to be noted that the results of two other methodologies to estimate the price for internalisation, i.e. the emission reduction cost approach and the vehicle cost approach, differ from the results of the emission cost approach (described in [1] appendix H). For example, the emission reduction approach takes into account the feasibility of a reduction in emissions per technology. An owner of a truck has to pay less in case of the emission reduction cost approach than the emission cost approach. Therefore, for the implementation of economic instruments one should keep in mind under which conditions these figures are estimated.

Despite the owners of trucks have less possibilities for investments in cost-effective emission reduction technologies than owners of a passenger car, at least this tax system will give a large incentive to truck manufacturers to develop and sell emission reduction measures. The above mentioned differentiation will also give an incentive to car manufacturers to develop and sell emission reduction technologies, which are more cost-effective than the above mentioned technologies. Moreover, it will give car owners an incentive to invest in environmental friendly technologies. This is illustrated in an example below. For example, a person owns a car on petrol and considers to invest in a lean burn engine. The cost\textsuperscript{10} of a lean burn engine is about 325 ECU and by using the same depreciation method as for noise this will result in annual cost of 36 ECU for a vehicle with a lean burn engine. In the case the person owns a car on petrol without the lean burn engine the per-

\textsuperscript{10} In this case the cost concerns estimated production cost of a lean burn engine, which will differ from the market price of a lean burn engine.
son should pay an additional tax of 136 ECU per year. While, if this car owner invests in a lean burn engine then 36 ECU has to be paid for depreciation and the additional tax amounts 31 ECU for a car on petrol with a lean burn engine. This means an annual financial advantage of 69 ECU \((136-(36+31))\) for a person who buys a car on petrol with a lean burn engine instead of without one. Moreover, the lean burn engine is an energy efficient technology and this will result in annual fuel savings of 99 ECU under the assumption of a constant annual mileage. Totally, this will result in a benefit of approximately 168 ECU per year for a person who will invest in lean burn technology. However, in this example it is assumed that the decision maker has all relevant information available and that the taxes can be determined exactly, which is often not the case in reality.

The differentiation of the sales tax and annual vehicle tax for internalisation of avoidance cost of air pollution lies between the 1.4 % and 9.9% of the total costs\(^\text{11}\) of a passenger car and differs per technology. Of course, it is a positive aspect for the society that these avoidance costs are so low. However, for governments it is very difficult to internalise these low avoidance costs and at the same time reach the desired emission level per pollutant.

3.5 Aspects of implementation of the sales and vehicle tax

In this chapter some aspects which are important for the implementation of the instruments will be dealt with, like metering systems, spatial differentiation, introduction schemes and possibilities for the use of the revenues.

**Metering systems**

As already mentioned in chapter 3.4 metering systems for the measurement of actual emissions of cars are very expensive at the moment. However, if the differentiated sales tax and differentiated vehicle tax are defined in a simple way, these measurement technology is not really needed. For a simple definition as a first step into the direction of more environmentally based fiscal measures, the only information which is needed is: which technology is applied for a car? A second step can be to measure emissions under normal driving conditions for each car model. In Germany the Verkehrsclub Deutschland (VCD) already made a VCD classification scheme and Sweden made a classification scheme, which is also used in Finland, Norway and Denmark, in order to give consumers information about the environmental performance of different car models. On the basis of both schemes the European Federation for Transport and Environment (T&E) proposed another scheme which can be used to make differences in the sales tax or in the annual vehicle tax [13].

Besides emission metering systems per car model, metering systems of actual annual mileage per vehicle are also needed. In Sweden measurement systems of annual mileage per passenger car are already used to determine the level of the kilometre tax applied to diesel driven vehicles.

\(^{11}\) Total costs of a vehicle without taxes, but include fuel duties.
Main features of the sales and vehicle tax

The kilometre tax, introduced in 1974, was abandoned for reasons of joining the EU. Although measurement systems of actual annual mileage per passenger car are already applied, doubts exist about the fraud-proof of these systems.

Moreover, metering systems for the measurement of noise emissions and emissions which will lead to air pollution are different, because the level of emissions depends on different factors. For example, the level of noise emissions depends on technology, speed, acceleration/brake and kind of road surface, while the level of emissions to the air does not only depend on technology and speed, but also on driving style, kind of fuel and the number of cold-start emissions.

Spatial differentiation

Although there are regional differences in environmental impacts of car driving, a regional difference in the sales tax and annual vehicle tax can lead to fraud and distortion in competition among countries. For example, there are already Dutch car buyers who buy their car in Germany or Belgium because the consumer price for some models is lower. It can be concluded that the differentiated sales tax and the differentiated vehicle tax are not the right instruments to internalise the regional differences in environmental impact. For a local problem as noise annoyance, this aspect of the instruments can be an important drawback.

Introduction schemes

In order to achieve the effect that consumers buy more environmental friendly cars the consumers have to be informed well about: the reasons for changing the system, the adjustments in the tax systems and their objectives and bases. For this reason the measure must be clear and transparent. The adjustments should be such, that consumers are stimulated to choose more environmental friendly cars and car manufacturers to produce these cars. However, the adjustment must not be too high at once, in order to avoid distortions in the economy.

Use of revenues

The acceptance of the differentiated sales tax and differentiated annual vehicle tax will increase if the revenues will be used to clean the environment and to improve the performance of the alternatives for private car use. The revenues can be used as follows:

- to subsidise the purchase of cleaner and more quiet vehicles like electric vehicles and hybrid vehicles,
- to subsidise research and development of cleaner and more quiet technologies,
- to improve the public transport system,
- to subsidise the purchase of cleaner and more quiet buses for public transport like electric, LPG, CNG or bio-fuelled buses.
Differentiated sales and vehicle taxes
4. ASSESSMENT OF THE SALES AND VEHICLE TAX

4.1 Introduction

In this chapter the differentiated sales tax and the differentiated annual vehicle tax will be assessed against several criteria in order to evaluate these instruments on their suitability as internalization instruments in addition to an energy/CO$_2$ tax. Besides economic criteria like efficiency, effectiveness and the impacts on the economy, this chapter will also deal with ecological, technical and political criteria. In chapter 4.3, which deals with the ecological criteria, a description will be given of the impact of the differentiated sales tax and the differentiated annual vehicle tax on emissions and the incentives to switch to less polluting transport modes. Examples of the technical criteria which will be assessed are the technical feasibility and the reliability of the differentiation in the tax system. The acceptability and the distributive effects of the differentiation in the tax system will be described in chapter 4.5, about the political criteria. This chapter will end with an evaluation of the differentiated sales tax and the differentiated annual vehicle tax against the above mentioned criteria.

4.2 Economic assessment

Efficiency of the transport system

The efficiency of the transport system will be optimal if there is an optimal allocation of production factors in order to reach the targets of the transport system. However, the different actors have set other targets for a transport system. For example, the government would like to reach optimal welfare for the whole society including the transport system. Companies would like to use the transport infrastructure and transport services, with less costs and loss of time and much convenience in order to reach the real goals of the company like maximal profit or continuation of the company. The private consumer would like to use the transport system in order to carry out activities at different locations with less costs, loss of time and much convenience and quality.

There are several reasons for the government to interfere in the results of the allocation by the market price. One of the reasons to collect money by an annual vehicle tax rather than by a road tax or annual mileage tax is for example that the costs needed for collecting money by an annual vehicle tax are lower. From this point of view it will be efficient to increase the annual vehicle tax or sales tax with the environmental costs per vehicle type. The transport system will be more efficient if companies and consumers can use and value the low polluting vehicles as their current vehicles and the cost of the low polluting vehicles are lower.

Impacts on the quality of transport

There are quite a lot of quality aspects related to a transport system, which will differ for example per country, per region, per city and per mode. In
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[14] the following quality aspects of the transport system are mentioned: flexibility, speed, comfort, frequency, capacity, reliability, accessibility, level of penetration, safety, opportunity for a seat in public transport and the number of transfers etc. The valuation of each quality aspect will differ between consumers and kind of goods. In this report it is assumed that the level of the sales tax and the annual vehicle tax depends on the level of emissions of a type of vehicle, in other words on the applied emission reduction technology. In some circumstances an emission reduction technology will influence the quality of transport negatively. In terms of accessibility, speed and reliability for example this is the case for electric cars.

**Impacts on the economy including regional differences**

Probably, the environmental differentiation of the sales tax or annual vehicle tax will not have an impact on the economy, because the level of those taxes compared to GDP is very low. The level of those taxes can be differentiated by regions according to the differentiations in environmental impacts of passenger car traffic on different regions per country. However, there is a good chance that people turn aside this differentiation in taxes by buying or registering the cars in regions with the lowest taxes. Also in this case the impacts on regional differences in the economy would be negligible.

**Impact on innovative behaviour**

If the differentiation of the tax is high enough for a substantial number of consumers to take into consideration the purchase of a more environmental friendly passenger car, the car manufacturers will be motivated to develop more environmental friendly passenger cars.

**Effectiveness of the instruments**

The effectiveness of the different instruments depends on the absolute level of the taxes in the different Member States. For this reason, the effect of the instruments differs per country. Also for other reasons the effect will differ per country. For example, the environmental costs, the valuation of attributes of car types like status, comfort, lifestyle, income level, etc. differs per country.

In [15] the results of preliminary research on the impact of car taxes on the composition of the vehicle stock are presented. This research made an international comparison between the level and the definition of car taxes and their influence on the size and composition of the vehicle stock. According to this research the size and the use of the vehicle stock has not been influenced by the level and the definition of car taxes. The variable car taxes seem to have an impact on the composition of the vehicle stock. A higher variable tax will lead to a lower vehicle weight and a lower engine capacity, while a lower variable tax will lead to heavier vehicles with a larger engine capacity. The fixed taxes have an influence on the average lifetime of the vehicle stock. In the case of high fixed taxes, which is for example the case in Denmark, the average vehicle stock is older. The impact of the fixed taxes on the composition of the vehicle stock can not be explained from this research due to the definition of the fixed taxes which is related to attributes of the composition like vehicle weight or engine capacity. These definitions differ per country. The above mentioned results are
results from an international comparison, which means that these results can change if the impact of a change in taxes will be studied for one country.

In other studies price elasticities are mentioned about the impact of an increase in fixed taxes on the fuel efficiency per car and the composition of the vehicle stock. For example, in [16] a price elasticity is mentioned of -0.01 for the short term (year 2000) and -0.04 for the long term (year 2015) as an effect on the average efficiency of passenger cars of a 10% increase of the fixed tax. Preliminary research on the impact of different price instruments on the composition of the vehicle stock shows unambiguous results [17]. However, the general conclusion can be that the price elasticities are rather low and change over time and depend on conditions like level of price change, country specific conditions etc.

As mentioned in chapter 2.2 the avoidance costs of passenger cars are rather low compared to the total costs per vehicle per year. It can be expected that by these low avoidance costs and the low price elasticities the effectiveness of the instruments will be rather low. However, the case of the stimulation of the use of unleaded petrol through a price difference of about 0.02 ECU between unleaded and leaded petrol in several European countries shows that a price difference between two substitutes can be rather small in order to stimulate consumers to buy the more environmental friendly product. Also the Dutch case with the stimulation of the purchase of cars with three-way catalyst, described in [18], shows that if according to consumers two products are complete substitutes of each other a small difference in price of the substitutes will be enough for consumers to buy the more environmental friendly product if this product is cheaper than the more polluting product. Chapter 3.4 shows that in the case of a differentiation of the sales tax and the annual vehicle tax for the internalisation of avoidance cost of air pollution, there is an incentive for consumers to buy more environmental friendly cars. In that case car manufacturers will also get an incentive to put more effort into the development of more environmental friendly cars.

According to Koopman [19] the most cost-effective way to limit CO₂-emissions is by introducing carbon taxes. Carbon taxes are superior to CAFE/gas-guzzler systems and annual car ownership taxes. One of the reasons is that the sales and annual vehicle tax are related to vehicle ownership and the carbon tax to vehicle use. The latter is a better explanatory variable for the amount of pollution than vehicle ownership.

4.3 Ecological assessment

*Incentives to switch to less polluting transport modes*

Although, in some situations from an economic point of view it is efficient to differentiate the sales tax or annual vehicle tax with the environmental costs of passenger cars, it is not the 'right' translation from the environmental point of view, because the emissions of air pollution will increase by the use of the vehicle which is not the case by a differentiated sales or annual vehicle tax. It must be said that the optimal system of taxation from
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an environmental point of view like an electronic tax system based on actual metered emissions, is not available yet, because the actual emission metering system as well as the electronic pay system is not available for market implementation.

In the case of a differentiated sales tax or annual vehicle tax there is no direct incentive to use less polluting transport modes. However, there is an indirect incentive in those situations in which the available income for transport purpose is a limited factor and people like to have the same car. In those situations there are two solutions, namely a reduction of the annual mileage and/or the usage of transport means of which the costs are lower than the variable costs of an own car, for example the usage of a bike which is also a less polluting vehicle. The reduction of the annual mileage will also reduce the environmental effects of the activities of consumers if it will not be replaced by activities which will effect the environment even worse.

While there are only indirect incentives to switch to less polluting transport modes, there is a direct incentive to buy and own less polluting vehicles. For this reason car manufacturers will also get an incentive to produce more low polluting vehicles. To which extent the tax will influence the purchase decisions depends on the differentiation of the tax level, the level of price elasticities and to the extent consumers consider the cleaner technologies and the more polluting technologies as substitutes. The in chapter 3.4 described differentiation of the sales tax and annual vehicle tax will give a slight incentive to buy less noisy vehicles and a considerable incentive to consumers to buy a less polluting vehicle insofar they consider the cleaner technologies as substitutes for the more polluting ones. It will also give an incentive to car manufacturers to develop and sell cleaner and more quiet technologies. The car manufacturers can be supported by subsidies for research and development of cleaner and more quiet technologies.

Impact on emissions and on the level of pollution

The differentiation of the tax level, the level of the price elasticities and to the extent consumers consider the cleaner technologies and the more polluting technologies as substitutes, will also determine to which extent the tax will influence the impact on emissions and the level of pollution. In the case of the in chapter 3.4 described differentiation of the instruments, it can be expected that the noise emissions will probably decrease with 0-3 dB(A) per passenger car. For the emissions which contribute to air pollution it can be expected that the emissions will decrease per vehicle kilometre but the total emissions of particulates and carbon dioxide will still increase due to the higher growth in transport demand than the reduction in emissions. Probably, the other considered emissions which contribute to air pollution will decrease.
4.4 Technical assessment

**Technical feasibility**
Both tax systems already exist thus a differentiation of both taxes would be technically feasible. The technical feasibility of a differentiation of both taxes which corresponds more with the impact on the environment, depends on the definition of the differentiation. If the differentiation corresponds with technical descriptions of the car, a differentiation in the sales tax will be technically feasible. For so far as the techniques are irreversible, a differentiation in the annual vehicle tax will also be technical feasible.

**Implementation and running costs**
Both tax systems already exist thus a differentiation of both taxes will have a negligible effect on the implementation and running cost. Probably, in the introduction phase of the differentiation in taxes there will be an increase in implementation costs. The level of implementation and running costs by a differentiation of both taxes which corresponds more with the impact on the environment depends on the definition of the differentiation. In general, the higher the complexity of the definition the higher will be the implementation and running costs.

**Flexibility towards further technological progress in the different transportation systems**
The differentiation of the sales tax and/or annual vehicle tax will not set any limits on the technical progress of different transportation systems. If the differentiation of the sales tax and/or annual vehicle tax will be high enough to stimulate consumers to buy more environmental friendly cars and thus stimulate the car manufacturers to develop these cars this can form an incentive to develop new transportation systems. For example, if consumers are used to have less space in the car and used to a lower performance of the car, because the adjustments in taxes stimulated them to drive in smaller cars and maybe have an other perception of the status of their car, it can be one step into the direction of a Personal Rapid Transit system (PRT) in cities. According to Gustavsson [20] PRT might have a positive effect on the quality of life in medium-sized cities.

**Coordination with regulation and existing transport policy**
As said before, the sales tax and annual vehicle tax are existing tax systems in transport policy. However, adjustments in both tax systems have to be coordinated with other transport policy, for example with the increase in fuel tax as mentioned in chapter three. The impact of adjustments in the sales tax and annual vehicle tax can be strengthened by additional transport measures like seasonal parking tickets per m² car, limited access to certain neighbourhoods which depends on the level of pollution of car types, stronger environmental legislation for passenger cars etc. The impact of the differentiated sales tax and annual vehicle tax can also be strengthened by an environmental direction of spending the revenues of this tax system. For example, a subsidy of the purchase of cleaner and more quiet vehicles, a subsidy for research and development of cleaner technologies and an improvement of the public transport system are possibilities for an environmental direction of spending the revenues of this tax system.
Reliability or fraud proof
A differentiation in the sales tax will be fraud proof if this differentiation in the sales tax will be at about the same level for the whole European Community, otherwise the number of people who would like to buy a car in another country would increase. The level of reliability by a differentiation of both taxes which corresponds more with the impact on the environment depends on the definition of the differentiation. In general, the higher the complexity of the definition the higher will be the chance on fraud. For example, if metering systems of actual annual mileage and/or electronic emission systems will be applied there is more chance on fraud, however, these systems make it possible to develop a tax system more based on the actual impact on the environment. The level of reliability of a differentiation of the annual vehicle tax also depends on the possibility of technical irreversibility of the techniques.

4.5 Political assessment

Legal and institutional aspects
Both tax systems already exist thus probably there are no legal barriers to adjust both tax systems.

Acceptability
The acceptance of both measures depends on the order of magnitude of the adjustments of both tax systems. In general, the higher the adjustments the lower the acceptance but the higher the effect. The acceptance of the measures will increase in the case that car manufacturers succeed in supplying enough more environmental friendly cars with characteristics that match the demand of consumers for passenger cars like comfort, space, status, etc.. The acceptance of the measures also depends on the way the revenues will be spend. For example, the acceptance of the measures will increase if the measures will be implemented in a budget neutral way. The acceptance will also increase if the tax measures will be linked to measures which offer an alternative to car mobility through an improvement of the access and quality of public transport and an improvement of the quality of cities which can compete with the quality of life in suburbs. According to Crozet [21] an internalisation of externalities is necessary but not sufficient for a sustainable urban mobility. Next to price measures, additional measures will be needed to reach a sustainable mobility.

Impact on the national budgets
In the Netherlands the transport sector has a share of 8% in GDP in 1993 [22]. The total revenues of the Dutch government related to transportation were 8.7 thousand million Dutch guilders in 1991 (4.2 thousand million ECU12). Of these total revenues the annual vehicle tax contributed about 1 thousand million ECU, fuel tax 1.7 thousand million ECU and the sales tax 1.2 thousand million ECU. Total revenues of the Dutch government were about 81 thousand million ECU in 1991. This means that the share of the annual vehicle tax was about 1.2 % and the share of the sales tax was

12 Used exchange rate 1 ECU = 2.09 DFL.
about 1.5% in total government revenues. The impact on the national budget depends on the order of magnitude of the internalisation tax and also on the way the revenues will be spend. If the restriction is to implement these measures in a budget neutral way the total impact on the national budget will be zero. There will only be a shift in the revenue pattern and expenditure pattern. In this case, the tax will be based more on environmental considerations.

**Distributive effects (equity)**

The distributive effects of adjustments of above mentioned measures depend on the definition of these measures and also on the direction of redistribution of the revenues. The objective of the internalisation of external costs is to adjust the market price for external effects so that producers and consumers can take into account the effects on the environment of their activities. The idea is that polluters modify their behaviour which will result in an optimal situation for an efficient allocation of resources and a welfare optimum. This means that in all directions of taxation and redistribution actors will be effected and will be stimulated to make other choices concerning the use of scarce resources as this is the objective of the internalisation of external effects. In this case consumers who own a polluting car (big and/or old) will suffer of these kind of measures. On the other hand, it is possible that consumers who can not afford to own a big car or do not like bigger cars or use public transport, can take a profit of this measure. This is for example the case if the revenues are used to decrease the tax on more environmental friendly passenger cars. The manufacturers will also be stimulated to develop more environmental friendly cars which will increase the supply of those cars and decrease the price of these cars due to economies of scale.

### 4.6 Evaluation of the assessment of the sales and vehicle tax

The differentiated sales tax and differentiated annual vehicle tax can be evaluated against each assessment. For each a rating can be given, as follows:

- -- the instrument has a strong negative impact
- - the instrument has a low negative impact
- o the instrument is neutral
- + the instrument has a low positive impact
- ++ the instrument has a strong positive impact
Table 4.1  Rating of instruments on several criteria

<table>
<thead>
<tr>
<th>Type of assessment</th>
<th>Instrument</th>
<th>Sales Tax</th>
<th>Annual Vehicle Tax</th>
</tr>
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<tbody>
<tr>
<td><strong>Economic</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Efficiency transport system</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Transport quality</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Impact on economy</td>
<td>o</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Impact on innovative behaviour</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Effectiveness</td>
<td>+/-o</td>
<td>+/-o</td>
<td></td>
</tr>
<tr>
<td><strong>Ecological</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Incentives to switch to less polluting modes</td>
<td>o</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Impact on emissions and pollution</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Technical</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Implementation and running costs</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Flexibility towards further technical progress</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Coordination with regulation and existing policy</td>
<td>++</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Reliability or fraud proof</td>
<td>++</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td><strong>Political</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Legal and institutional aspects</td>
<td>++</td>
<td>++</td>
<td></td>
</tr>
<tr>
<td>Acceptability</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Impact on national budgets</td>
<td>o</td>
<td>o</td>
<td></td>
</tr>
<tr>
<td>Distributive effects</td>
<td>+</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

Although this evaluation scheme has a strong indicative character, it is obvious that these instruments have no strong negative impacts, nor many strong positive impacts. The instruments will not result in strong positive impacts on the environment. One of the reasons is that both tax systems are related to vehicle ownership and not to vehicle use. There is a stronger relationship between vehicle use and emissions than between vehicle ownership and emissions. However, the effectiveness of the instruments depends on the level of the differences in costs among types of vehicles and to what extent consumers assess the technologies as substitutes. Obviously, the instruments are technical as well as political feasible and will be a move towards cleaner vehicles and a less polluted transport system at a constant level of vehicle kilometres driven.

The sales tax is more reliable than the annual vehicle tax, because the effect of emission reduction technologies is decreasing during the years of car use. However, the increasing quantity of emissions caused by an increasing age of vehicles can be taken into account in the development stage of the classification scheme of passenger cars. Nevertheless, this is very difficult because the emissions between identical cars of the same age can vary as a result of differences in maintenance and use.
For a successful introduction of the instruments the following requirements can be defined from the assessment of economical, ecological, technical and legal aspects.

The instruments should:
- be consistent with the 'no paradox' principle (i.e., for any two cars the higher emitting car should have the higher charge),
- have to be implemented in a revenue neutral way,
- the revenues have to be used for the improvement of the alternatives for the polluting cars,
- be levied on the basis of a continuous function relating the car tax in ECU to g/km emissions and noise emissions,
- description of technology and emissions of a car model is needed,
- no regional differences have to be made,
- have to be introduced at a European level.

The new tax system should not lead to too much disruption of the car market at once, neither for the motorist nor for the manufacturer. This means that these measures should be introduced gradually to replace existing annual car or sales taxes or other such charges.
5. CONCLUSION AND RECOMMENDATIONS

On the base of this preliminary research it can be concluded that the differentiated sales tax and the differentiated annual vehicle tax have no strong negative impacts, nor many strong positive impacts. The instruments will not result in strong positive impacts on the environment. One of the reasons is that both tax systems are related to vehicle ownership and not to vehicle use. There is a stronger relationship between vehicle use and emissions than between vehicle ownership and emissions. Obviously, the instruments are technically as well as politically feasible and will be a move towards cleaner vehicles and a less polluted transport system at a constant level of vehicle kilometres driven.

The sales tax is more reliable than the annual vehicle tax, because the effect of emission reduction technologies decreases during the years of car use.

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- be consistent with the 'no paradox' principle (i.e. for any two cars the higher emitting car should have the higher charge),
- the instruments have to be implemented in a revenue neutral way,
- the revenues have to be used for the improvement of alternatives for polluting cars,
- the taxes should be levied on the basis of a continuous function relating the car tax in ECU to g/km emissions and noise,
- a description of technology and emissions of a car model is needed,
- no regional differences should be made,
- the taxes have to be introduced at a European level.

The new tax system should not result in an abrupt disruption of the car market, whether for the motorist or the manufacturer. This means that these measures should be introduced gradually to replace existing annual car or sales taxes or other such charges.
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REFERENCES


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