Internalisation of External Costs of Transport

Synthesis Report of Topic B within the EU Research Project "External Costs of Transport and Internalisation"

August 31, 1995

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Overview of contents:

Executive summary

0 The most important facts on one page

The **objectives** of this research project carried out within the frame of the EU Environmental Research Programme were the following:

A) Providing a method to calculate avoidance costs of air pollution, climate change and noise caused by transport in the EU (topic A).

B) Discussing possible instruments for internalisation, assessing some selected instruments in more detail and discussing the use of avoidance cost assessments for internalisation (topic B).

Based on a theoretical discussion and on an overview of possible internalisation instruments the **following instruments** have been analysed in detail:

- a mileage tax for European road freight transport
- differentiated sales and vehicle taxes
- a variable track charge for railway noise

The **main general findings** of topic B are the following:

- The concept of internalisation has proved to be a feasible concept if it is understood in a broader sense (i.e. not striving for an optimal solution in the sense of a Pigou tax)
- The analysis has shown that assessments of avoidance costs and of external costs should rather be considered as complements than as substitutes.
- A wide range of useful possibilities to use avoidance cost assessments for internalisation (i.e. to develop a useful tax design) and other purposes (e.g. information about costs of environmental policy measures, forecasting of impacts) has been identified.
- Cost-benefit analysis of various differentiation options of the same internalisation instrument are important because the higher the "precision" of an instrument is, the higher are in general the implementation costs.
- Furthermore, it has become clear that only packages of different instruments will be suitable for making transport more sustainable.

With regard to the **three instruments** the conclusions and recommendations are:

- Mileage tax for European freight transport: This variable tax for trucks is a promising instrument for the future transport policy at EU level first of all because of the differentiation possibilities and technological incentive effects. The current development of automatic debiting systems at EU level and the synergies with infrastructure cost charges according to the territoriality principle will facilitate the implementation
- Sales tax and annual vehicle tax: Because of the relatively low implementation costs and the useful technological incentive effect - if designed in an appropriate way - the two fixed taxes can be considered as useful accompanying instruments of a usage related tax (e.g. fuel tax).
- Variable track charge for railway noise: Further investigations of this instrument can be recommended. The tax sets incentives to reduce noise at the source and therefore contributes to a high quality noise reduction. It could be introduced as a differentiation of the infrastructure fee planned in the context of the deregulation within rail sector.

1 Setting the stage

This synthesis report summarises the main findings within topic B "Internalisation" of the research project "External Costs of Transport and Internalisation". The project has been carried out within the frame of the EU Environmental Research Programme, Research Area III Economic and Social Aspects of the Environment.
The main **objectives of topic B** are:

1) to establish a survey of the concept of internalisation and to show how avoidance cost assessments - as carried out in topic A - can be used for internalisation;
2) to give an overview of possible internalisation instruments;
3) to describe and assess a selected number of internalisation instruments in more detail;
4) to discuss and recommend whether these instruments should be further analysed or even introduced at Community level.

The results of topic B are given in four separate reports: The synthesis report and three sub reports analysing the following **internalisation instruments** in detail:

- a mileage tax for European freight transport
- differentiated sales and vehicle taxes
- a variable track charge for railway noise

2 Theory of Internalisation

Chapter 2 of the synthesis report outlines the basic forms of internalisation. The following forms are distinguished:

- the **property rights** approach that emphasises the importance of well-defined property rights on resources for the efficient allocation through the market mechanism
- the approach of **Pigou** who says that welfare losses caused by external costs can be avoided if a tax is introduced of which the rate is calculated according to the welfare maximisation rule "marginal social costs have to equal marginal social benefits".
- the **standard-price-approach** and **tradeable permit systems** that propose the use of economic instruments to meet defined environmental targets.

Furthermore, first hints are given how to integrate **avoidance cost assessments** in the internalisation approach and what the relationship between avoidance costs and external costs (damage costs and willingness-to-pay) is.

The theoretical discussion points out the difficulties that arise and the aspects that have to be considered if the basic forms of internalisation are to be applied under real world conditions.

- Externalities vary over time and space, are affected by the technology of the vehicles and by the way of driving. Therefore, internalisation instruments should be **differen-**

tiated and it is most probable that only a **combination of different internalisation instruments** can be a successful approach.

- The **criteria** to evaluate different internalisation instruments are considered. An optimum combination of different instruments depends on criteria like efficiency, effectiveness or political feasibility.
- Furthermore, it is described that the use of internalisation instruments must be co-ordinated with **other transport policy measures** (e.g. control and command instruments).
- At last, **distributive effects** and the basic forms how to use the revenues of internalisation instruments are discussed.

3 Pre-selection of possible internalisation instruments

The pre-selection first gives an overview of possible internalisation instruments for the four transport modes road, rail, aviation and inland shipping. The overview is structured as follows:

- **description** of the instrument
- **leverage points**: point of intervention to influence mobility behaviour, target emissions and external cost components[1]
- **metering / charging system**: first hints concerning the technical systems and arrangements to measure the emissions and to define the charge
- **experiences**

In the pre-selection 20 possible internalisation instruments have been included. They are summarised in table S-1. Table S-1 furthermore shows the different leverage points of the different instruments.

Out of these instruments three have been chosen to be analysed in detail in sub reports. The selection based on five selection criteria:

1) Is the instrument closely **related to the usage** of the transport modes (i.e. to the activity that causes the external costs)?
2) Is it possible to **differentiate** the instrument according to different criteria (e.g. technology, time)?
3) Does the instrument set strong **incentives** for innovations?
4) Is the EU level the **accurate policy level** to introduce the instrument?
5) Is there still a **need for additional studies** or has the instrument frequently and thoroughly been analysed in other studies?

1 The overview concentrates on the externalities analysed in topic A of this research project, namely air pollution, climate change and noise and distinguishes between global, transboundary and local effects.

Based on these selection criteria the instruments bold typed in table S-1 have been selected.

Table S-1: Overview of internalisation instruments discussed in the pre-selection

	Externality:	global effects		transboundary effects			local effects local air poll.			noise
	Internalisation instrument:	CO2 (greenhouse effect)	NOx, CFC (stratospheric ozone loss)	NOx (acid rain gas, tropospheric ozone)	SO2 (soil acidification)	VOC (troposheric ozone)	SO2 (human health, bulidings)	NOx (human health, bulidings)	particulates, lead etc.	noise emissions
Road transport	**differentiated sales tax**	■		■	■	■			■	■
	differentiated vehicle tax	■		■	■	■			■	■
	tax on fuel	■			■					
	general kilometre (mileage) tax	■		■	■	■				■
	road pricing						■	■	■	■
	eco point system			■	■	■				■
	linked rail-road permits			■	■	■				■
	parking fees							■	■	■
Rail	fixed charge for rolling stock			■	■	■				■
	variable track charge			■	■	■				■
	tax on diesel	■			■		■			
	tax on electricity	■			■		■			
Aviation	emission charge	■	■	■						
	kerosene tax	■								
	differentiated landing fees					■		■	■	■
	movement taxes	■								
	bubble limits					■		■	■	
Shipping	tax on fuel	■			■					
	differentiated harbour dues			■		■		■	■	
	differentiated canal dues			■		■				

■ main leverage point, main impact of the instrument

■ secondary leverage point, side effects of the instrument

4 Main findings from the internalisation instruments

The main features of the three instruments analysed in detail within three sub reports are summarised in table S-2.

Table S-2: Main features of the instruments analysed in detail

Features of the tax/charge	**Mileage tax for European road freight transport**	**Differentiated sales and vehicle taxes**	**Variable track charge for railway noise**
basic idea	variable tax for heavy goods vehicles (HGV) to internalise external costs	"once only" and annual tax to internalise external costs of air pollution and noise	variable tax for railway companies to internalise external cost of noise
object of the tax	HGV, permissible total weight > 3.5 t	passenger cars	rolling stock of railway companies
field of application	whole road network of the Member States	new cars, registered cars	railway infrastructure, track
tax base	permissible total weight and kilometre driven	vehicle	train kilometres
tax rate	basic version: lower bound: 0.006 ECU/t_{tw}km upper bound: 0.012 ECU/t_{tw}km	**Air pollution** technology / sales t. / veh.t. petrol 1'238 136 petrol lean burn 286 31 petrol catalyst 333 36 diesel 2'286 252 diesel fuel mod. 2'000 219 diesel dir. inject. 1'976 217 LPG 1'595 164 LPG lean burn 340 37 LPG catalyst 393 43 **Noise** emissions / sales t. / veh.t. 74 dB (A) 0 0 75 dB (A) 67 7 76 dB (A) 134 15 77 dB (A) 201 22	if average avoidance costs are used: 0.3 ECU/train km if marginal avoidance costs are used: 0.01 ECU/train km
tax payer	owner of the HGV	buyer/owner of the car	rail operators
differentiation options	– "extended version": differentiation according to emissions of air pollutants and noise of vehicle type – "sophisticated version": taking account of spatially different levels of pollution and of congestion	fuel type, emission reduction technology	maybe according to specific sections and speed; there is a trade-off between incentive and efficiency

Features of the tax/charge	Mileage tax for European road freight transport	Differentiated sales and vehicle taxes	Variable track charge for railway noise
metering system	– electronic road pricing system – two-way data communication between vehicle and a vehicle identification system	– metering of emissions (or applied technology) – definition of different categories of the vehicles	probably electronic track pricing system
implementation	– EU: defining main features and minimum requirements (lower bound tax rate) – Member State: introduction	classification of cars at EU level	implementation in the frame of the deregulation within rail system (separation between infrastructure and operations)
introduction scheme	– gradual increase of the tax rate – transitional period for "first mover" initiatives of the Member States	information about the adjustment and objective of the new tax system	introduced in form of a differentiation of the infrastructure fee (deregulation as necessary condition)
use of the revenues	– stage 1: earmarking for less polluting transport modes, financing of rescue packages for the environment – stage 2: redistribution of the revenues to the economy	– subsidies for cleaner vehicles – improvements of public transport	use to cover the costs of sound insulation of buildings and/or noise barriers

Each instrument mentioned in table S-2 has been evaluated according to economic, ecological, technical and political criteria. Furthermore, some preliminary cost-effectiveness analysis of the instruments have been carried out.

a) Economic assessment

The main conclusion was that the impact of the three instruments on the European economies would be low due to the following reasons:

- The three instruments contribute to **redress an economic market failure**. With the introduction of internalisation instruments the transport sector will at least partly pay for these external costs. Therefore, the three instruments create an incentive for adjustment processes towards a more efficient and welfare optimising transport system.
- In most sectors of the economy the taxes analysed would result in only very **modest increases of production costs**.

- The **revenues** from the taxes are not lost but are recycled in the economic system.
- The three taxes increase the demand for less polluting vehicles and less noisy rolling stock by accelerating the replacement rate and set incentives for **innovations** that may raise the competitiveness of European industry.

b) Ecological effects

For all taxes analysed in the sub reports the **technology improvements seem to have a larger effect than the reduction of transport volumes**. More important is that the instruments analysed set lasting incentives to reduce the negative effects of transport on the environment and on human beings. This is especially true if the differentiation of the tax is not be related to an emission reduction technology but to an emission limit.

For all three solutions the incentive of the taxes to develop new technologies beyond today's knowledge can be increased if the tax differentiation includes **a class "future technologies"**, i.e. technologies that reduce emissions more than the best available technology.

Nevertheless, one can conclude that the three taxes alone will not solve the environmental problems caused by transport. But this fact is not an argument against these taxes because the same argument applies to any other instrument.

c) Technical assessment

Differentiated sales taxes and annual vehicle taxes are feasible: they have already been introduced in European countries. The two variable charges may probably profit from efforts taken in another context:

- In the case of the **mileage tax** this refers to the research projects in the field of automatic debiting systems and to the development of electronic fleet navigation system.
- The variable **track charge for railway noise** "profits" from the deregulation in the rail sector, namely from the probable introduction of an infrastructure fee for rail operators, because this fee could serve as base for the differentiated variable track charge.

d) Political assessment

For all three taxes it will be difficult to find political majorities. Therefore, potential measures to improve political acceptance have been made out in the sub reports. The measures are:

- **to improve and harmonise the evaluation of external costs** in order to increase the comparability and robustness of the findings. The research work within the 4th Framework programme will probably contribute to this objective.
- **to improve the transparency of internalisation measures** in order to reduce misunderstandings of the objectives of an internalisation of external costs.
- **to develop a convincing concept for the use of revenues** because distributive effects often dominate in the political debate. Therefore, the way the revenues of the internalisation instruments are used can considerably contribute to an increase of political acceptance. Ways have been found to ensure revenue neutrality (e.g. redistribution of the revenues by a reduction of social security contributions of the firms).

- **to implement a concise communication strategy** in order to include all major actors in the discussion on the objectives and introduction of the internalisation strategy.

5 Internalisation and avoidance costs

Based on the theory and on the findings of the sub reports three potential possibilities to use avoidance costs for internalisation have been identified:

a) Surcharge on a fixed tax

In the case of the sales tax or the annual vehicle tax the additional costs of the cleaner technology were used to define the tax applied to the conventional technology.

b) Tax differentiation of a variable tax

In the cases of the variable track charge for railway noise and of the mileage tax for road freight transport avoidance costs estimates were used to differentiate the tax rate in order to promote the use of less noisy rolling stock and less polluting vehicles.

In the case of the mileage tax the base for the tax differentiation were the additional costs of the less polluting technology and the average mileage of the vehicles. The incentive effect of this differentiation is obvious: If the mileage of a vehicle is above the average it is cheaper to use the cleaner technology, if the mileage is below the average it is cheaper to use the conventional technology and pay the higher tax. It should be noted that without defined environmental targets (e.g. a reduction of NO_x emissions of road freight transport by 30%) it is on principle not possible to determine a useful level of tax differentiation with the avoidance cost assessments alone.

If not an environmental target but external cost assessments (damage costs or willingness-to-pay) are available, the differentiation should reflect the different environmental impact of the cleaner and of the conventional technologies. Not the additional costs of the cleaner technology but the differences in the external costs caused should be decisive for the tax differentiation.

c) Defining the level of a variable tax with avoidance costs

If the level of a tax should be determined with estimates of avoidance costs, the following aspects are to be considered:

- It is essential that environmental policy **defines environmental targets**. Economically optimal targets would have to base on avoidance cost *and* external cost assessments. However, also other information could be the basis to define environmental targets in the political process like sustainability aspects and scientific knowledge about the negative impact of pollutants on the environment and on human health.
- There are many different possibilities to reduce harmful emissions of transport. Therefore, avoidance cost assessments should include a **wide range of policy measures and all the relevant cost components** (including the implementation costs).

If these conditions are met the results can be used to differentiate a variable tax or to define the level of an internalisation tax. Because of the uncertainties connected with the

avoidance cost assessments, a **step-by-step procedure** to implement transport policy instruments is recommended, starting with low levels of the tax rates.

Furthermore, avoidance cost assessments are not only useful to define tax rates but may also be used for **other purposes**:

- **Cost-effective mix of instruments**: Avoidance cost assessments can look at a wide range of measures and instruments whereas the internalisation concept concentrates on economic instruments.
- **Forecasting the impacts of the use of certain instruments**: Avoidance cost assessments allow to assess the impact of the implementation of certain instruments (e.g. a fuel tax) because reaction patterns are analysed.
- **Costs of environmental policy measures**: In the political process it is important that an answer can be given to the question what environmental policy measures cost. In this case avoidance cost assessments can be used to define the rate of a tax that is introduced to finance environmental policy measures (e.g. noise barriers) according to the polluter-pays-principle.
- **Definition of environmental targets**: If external cost assessments (damage costs or willingness-to-pay) are available economically optimal targets can be set by using avoidance cost assessments.

6 Conclusions and recommendations

Based on the main findings of topic B of this research project the conclusions and the recommendations for the further proceeding in this field of transport policy are the following:

- The **concept of internalisation** has proved to be a **feasible concept** if it is understood in a broader sense namely as a tool
  - to provide important information for the political discussion about transport policy measures
  - to emphasise the polluter-pays principle to be a main characteristic of an efficient transport policy and therefore
  - to promote the use of economic instruments to change price signals in the favour of a more environmentally compatible transport system
  - to define a useful range of the rate of internalisation taxes.

- The analysis has shown that **assessments of avoidance costs and of external costs** should rather be considered as complements than as substitutes. It can be concluded that further research work should aim at enlarging knowledge about both, external and avoidance costs.

- A wide range of useful **possibilities to use avoidance cost assessments** - as carried out in topic A of this research project - for internalisation and other purposes was found:

use for internalisation	use for further purposes
– defining differentiation options for taxes – defining the level of taxes	– defining economically sensible environmental targets (together with external cost estimates) – defining a cost-effective mix of instruments to achieve environmental targets – forecasting the impacts of the introduction of certain instruments – showing the costs of environmental policy measures

- The analysis within topic B of this research project pointed out the importance of **cost-benefit analysis of various differentiation options of the same instrument**. In general, the higher the "precision" of an instrument is, the higher are the implementation costs. Thus, only cost-benefit analysis can show what differentiation level can still be justified with the implementation costs. The analysis has shown that further information about implementation costs and potential welfare gains of additional differentiation options are needed to ensure that internalisation instruments do realise the polluter-pays-principle in an optimal way.

- Furthermore, it has become clear that only **packages of different instruments** will be suitable for making transport sustainable. The definition of such packages should be the next step as soon as all the promising internalisation instruments and further transport policy measures are described in detail. Cost-benefit analysis should then be carried on the base of packages of different instruments too.

With regard to the **three instruments** the conclusions and recommendations are the following:

- **Mileage tax for European freight transport**: From the analysis in the sub report it can be concluded that this variable tax for HGV is a promising instrument for the future transport policy at EU level:
  - The tax would be a suitable complement to a CO_2/energy tax if it is differentiated according to emission limits. If the differentiation rewards technologies that reduce emissions even more than the best available technology, the tax will set strong incentives for innovations.
  - According to preliminary cost-benefit analysis, a spatial differentiation of the tax would probably yield additional net welfare gains.
  - The mileage tax can take profit from the current development of automatic metering systems to charge road freight transport for its infrastructure costs according to the territoriality principle. It should be ensured that these metering systems do also

meet the requirements of a differentiated mileage tax aiming at an internalisation of external costs of transport.

- **Sales tax and annual vehicle tax**: Both taxes show the disadvantages of fixed taxes, i.e. they mainly only have a technological incentive effect but almost no impact on transport volume. In the case of the sales tax, undesirable effects, namely postponement of the purchase of new cars, may result. Nevertheless, there are good reasons in favour of the use of these differentiated fixed taxes:
  - If appropriately designed, the technology incentive effect can be strong. Entirely new technological concepts can be promoted effectively. Therefore, the fixed taxes can be considered as a useful accompanying instrument of a usage related tax that does not directly take into account the emission abatement technology (e.g. a fuel tax). If ever possible the differentiation of the fixed taxes should not base on a certain technology but on emission limits.
  - The implementation costs are comparatively low (classification, low enforcement costs).

- **Variable track charge for railway noise**: Despite the difficulties to internalise railway noise by a tax further investigations of this instrument can be recommended, mainly due to the following reasons:
  - In the context of the deregulation within the rail sector the introduction of infrastructure fees is planned. This fee could be a useful starting point for the implementation of this internalisation instrument.
  - Preliminary cost-effectiveness estimates have shown that reducing noise from the rolling stock seems to imply costs in the same order as other reduction measures (e.g. noise barriers) but results in a higher "quality" of noise reduction because emissions are reduced at the source. Thus, a net social benefit can be expected from a track charge taking into account the characteristics of the rolling stock and therefore setting incentives to use less noisy rolling stock.
  - In most European countries other measures than a reduction at the source (e.g. complementary local measures) will be necessary to reduce noise annoyances of rail. The track charge would guarantee a financing of these measures according to the polluter-pays-principle.

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Abbreviations

CO_2	Carbon dioxide
CTP	Common Transport Policy
dB(A)	Decibel
DG	Directorate General
ECMT	European Conference of Ministers of Transport
ECU	European currency unit
EU	European Union
GVF	Dienst für Gesamtverkehrsfragen (Service for Transport Studies, Federal Department of Transport, Communications and Energy of Switzerland)
LRRP	Linked rail-road permits
Mill.	Million
MVEG	Motor Vehicle Emission Group
NFP	Nationales Forschungsprogramm (National Research Programme)
NO_x	Nitrogen oxides
OECD	Organisation for Economic Co-operation and Development
SBT	noise annoyance index
SO_2	Sulphur dioxide
T&E	European Federation for Transport & Environment
TEN	Trans European Network
tkm	Tonne kilometre
vkm	Vehicle kilometre
VOC	Volatile organic compounds

Part I: Theory and pre-selection of instruments

Contents:

1 Introduction

1.1 Setting the stage

The transport sector plays an important role in today's economies. It enables people to travel and goods to be distributed, and it is therefore an important basis for our society and our welfare.
On the other hand, transportation imposes several adverse effects on mankind and nature which in most cases are not taken into account when decisions on transport activities are being made. From an economic point of view this facts leads to a misallocation of resources. In the effort to correct this market failure, economists estimate the external costs of transport and try to internalise these costs. There are different methods to assess external costs. This project concentrates on the prevention approach. Therefore, not the external costs themselves are assessed but costs of measures designed to prevent loss. The estimation of avoidance costs of transport and their internalisation is the subject of this research project.

The project has been carried out within the framework of the **EU Environmental Research Programme**, Research Area III Economic and Social Aspects of the Environment.

The **general objectives** of the project are:

A) Providing a method to calculate avoidance costs of air pollution, climate change and noise caused by transport in the EU.

B) Discussing possible instruments for internalisation and assessing some selected instruments in more detail.

The project is divided in **topic A and B** reflecting the two general objectives. This synthesis report contains the main results of topic B. The results of topic A are published in a separate synthesis report.

The main **objectives of topic B** of this research project are:

1) to establish a survey of the concept of internalisation and to show how avoidance cost assessments - as carried out in topic A - can be used for internalisation;

2) to give an overview of possible internalisation instruments;

3) to describe and assess a selected number of internalisation instruments in more detail;

4) to discuss and recommend whether these instruments should be further analysed or even introduced at Community level.

1.2 Structure of topic B

The results of topic B are given in **four separate reports**:

- the synthesis report on topic B
- the sub report "A mileage tax for European freight transport"
- the sub report "Differentiated sales and vehicle taxes"
- the sub report "A variable track charge for railway noise"

Each **sub report** contains a thorough description of the instrument and an assessment according to economic, ecological, technical and political criteria.

The **synthesis report** is structured as follows:

- In **part I** the fundamentals of the theory of internalisation and a overview of possible internalisation instruments for the different transport modes are presented. Based on the theory and the overview the three instruments analysed in the sub reports are selected.
- **Part II** contains the summaries of the three sub reports.
- In **part III** the main findings of part I and of the three sub reports are summarised. From this discussion conclusions and recommendations are derived.

The subjects of topic B have been discussed on two **workshops**:

- The first workshop was held in Petten (NL) on March 22, 1995. On this workshop part I was discussed and the decision was taken what instruments should be analysed in the three sub reports.
- The second workshop was held in Berne (CH) on July 20, 1995. The objective of the workshop was to discuss the three sub reports with representatives of the EU, the Swiss national administration, Eastern European research institutes and the EU research project "The integration of environmental concerns into transport policy".

1.3 Project organisation and acknowledgement

The work within topic B has been carried out by the following institutes and experts:

ECOPLAN, Economic and Environmental Studies (Switzerland): ECOPLAN wrote part I and III of this synthesis report and elaborated the sub report "A mileage tax for European road freight transport". Being the co-ordinator of topic B, ECOPLAN organised the workshop held in Berne. Furthermore, comments were given to the contributions of the partners. The work was carried out by Stefan Suter (co-ordinater of topic B), René Neuenschwander and Felix Walter.

ECN Policy Studies (the Netherlands): Erna Schol was responsible for the sub report "Differentiated sales and vehicle taxes". Tom Kram, the co-ordinator of the whole project, Erna Schol and Bart Stoffer contributed with very useful comments to part I and III of this synthesis report.

COWIconsult, Consulting Engineers and Planners S/A (Denmark): Micheal Sorensen carried out the sub report "A variable track charge for railway noise" and gave important comments to the other parts of topic B.

Institute für Wirtschaftspolitik und Wirtschaftsforschung (**IWW**), Universität Karlsruhe (Germany): Astrid Gühnemann and Prof. Werner Rothengatter contributed with very valuable comments to the elaboration of the synthesis and the sub reports.

The research project was commissioned by the EU and supported by the following institutions:

- the Danish Energy Foundation
- Bundesamt für Bildung und Wissenschaft
- Dienst für Gesamtverkehrsfragen des Schweizerischen Verkehrs- und Energiewirtschaftsdepartements
- Forschungsprogramm "Energiewirtschaftliche Grundlagen" des Bundesamtes für Energiewirtschaft.

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2 Theory of internalisation

2.1 Introduction

The main **objects** of this chapter are:

- To give a short overview of the **state of knowledge** concerning the theory of internalisation. This overview will base on different existing studies, especially on those previously carried out by the project partners.(1) Apart from the studies of the project partners many other sources were used.(2) But it is not the objective to provide an extensive overview of the literature on internalisation.
- To show the **link to part A** of this research project (external costs of transport). The relationship between external costs and internalisation will be discussed within a four-quadrant-framework.
- To discuss the **criteria** according to which the specific evaluation of an internalisation strategy should be done.
- To define the **methodological cornerstones** within the second part of this research project. Every section of chapter 2 contains a conclusion that describes the significance of the different theoretical aspects in the evaluation of internalisation strategies.

The chapter is **structured** as follows:

- Section 2.2 treats the **basic forms of internalisation strategies**. We differentiate between the pure property rights approach, the price oriented internalisation and the quantity oriented internalisation. Pros and cons of these basic forms of internalisation are considered.
- In section 2.3 it will be discussed how the theory of internalisation can be implemented in real world conditions.
  - First, the factors are examined according to which internalisation instruments should be **differentiated**. It will be shown that only a combination of different internalisation instruments can be a successful approach.
  - Then the **criteria** to assess different internalisation instruments are considered. An optimum combination of different instruments depends on the weight which is given to criteria as efficiency, effectiveness or political feasibility.
  - It will be shown further that internalisation of external effects doesn't mean that **other transport policy measures** (e.g. control and command instruments) will be useless in the future.
  - At last, **distributive effects** and the use of revenues of internalisation instruments will be discussed from an economic point of view.

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1 COWIconsult (1994), Tax Provisions in the Transport Sector; ECOPLAN (1992), Internalisierung externer Kosten im Agglomerationsverkehr; IINFRAS / IWW (1994), External Effects of Transport; Rothengatter W. (1994), Obstacles to the Use of Economic Instruments in Transport Policy.

2 We particularly mention: OECD / ECMT (1994), Internalising the Social Costs of Transport; OECD (1994), Project and Policy Appraisal: Integrating Economics and Environment.

2.2 Basic forms of internalisation

2.2.1 Introduction

❑ Externalities and Internalisation

In the methodological chapter of Part I it was shown that externalities can be defined as "effects caused by activities outside the market". Many effects of today's transport systems are non-marketed, e.g. air pollution, noise and accidents to mention the most important ones. Correspondingly, market prices do not reflect marginal social costs of transport. They only reflect the internal (private) but not the external costs. As a consequence, these external costs of transport are not borne by those who generate them. This leads to distortions in the economy in the sense of a misallocation of resources and social welfare not being maximised. Internalisation is the approach of economists to remedy this fundamental market failure.

❑ Definition of Internalisation

Internalisation means that the external costs of an activity are integrated into the price of this activity according to the following rule:
price equals marginal social (internal and external) costs of the activity

The above definition places particular emphasis on the connection between internalisation and the **polluter-pays-principle**. If the market price contains not only the internal but also the external costs the polluter pays for the external costs he causes.[3]

❑ Characteristic features of internalisation

The internalisation of external costs is compatible with a **free-enterprise economy**: Production and consumption of goods is not regulated by command and control but by introducing the price mechanism for environmental goods as clean air and quietness. There is a change in relative prices (environmentally harmful activities get more expensive compared to environmentally friendly activities), but contrary to most command and control regulations freedom of choice is not restricted (but limited by the budget constraint). This is a necessary condition for optimum allocation of the scarce resources.
Although a "scientifically pure internalisation" of external effects is only possible with the introduction of property rights or a Pigouvian tax, also **quantity oriented instruments** have to be considered as internalisation strategies in a broader sense. In this case the price increase is based on environmental targets such as emission standards. The main criteria internalisation strategies have to meet is still achieved, namely to rise prices for activities that cause external costs.

3 So, the initial right is a clean environment. Instead, the right to pollute could be given to the polluters. Then the consumers of a clean environment would be asked to buy from the polluters a decrease of their pollution. Such a different allocation of the initial rights does not upset allocative efficiency, but of course has distributional effects. In this research project we assume - if not mentioned explicitly the contrary - that the initial right is a clean environment.

❑ Internalisation instruments and other environmental policy instruments

On the other hand, environmental policy instruments that do not affect the prices of environmental harmful activities normally are not called internalisation instruments. Almost all command and control regulations and the instruments of moral suasion belong to this category. However, these instruments may reduce external costs and therefore reduce the price increase occurring as a consequence of internalisation.
It is a question of definition what instruments can be declared as internalisation instrument and what not. If, for instance, the use of catalytic converters is declared compulsory for cars, prices of cars will rise and external costs of air pollution will decrease. Therefore, in some literature, command and control instruments are seen as resulting in "quasi-internalisation".[4] In the view of the above definition, such instruments clearly are not internalisation strategies:

- In fact, these instruments are not able to integrate the marginal external costs in the price (although they may reduce the marginal external costs).
- They also do not leave the freedom of choice. As a consequence, the allocative efficiency of internalisation instruments is not met.

❑ Basic forms of internalisation

There are three basic forms of internalisation strategies, which will be discussed in the next sections:

- Property rights
- Price oriented instruments: Pigouvian tax
- Quantity oriented instruments: Standard-price-approach and tradeable permits

2.2.2 Property rights

The main idea of the property rights approach can be summarised as follows: The reason why transportation activities cause external costs is the fact that they affect valuable resources for which no **property rights** do exist. The most obvious and ideal form of internalisation would therefore be to introduce property rights to these resources. Today there is rivalry in the consumption of environmental resources as clean air or peace and quiet and, subsequently, external costs occur. If there were clear defined property rights for this scarce environmental resources, the market would create an efficient allocation of these resources and the external costs would be internalised (with the help of private negotiations). Thereby the initial allocation of the property rights does not matter from an efficiency perspective.[5]

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4 See e.g. Button K. (1994), Overview of Internalising the Social Costs of Transport, p. 14.

5 That's the content under which normally the "Coase Theorem" is summarised. Several conditions were formulated which must be fulfilled for the "Coase Theorem" to be true. Most important conditions are that the property rights can be freely exchanged, that there is perfect competition and that the transaction costs of the property rights exchange are nil. See Cooter R.D. (1988), Coase Theorem.

In reality, it is nearly impossible to implement this pure and theoretically ideal form of the property rights approach to the case of transport externalities. It would be very inefficient to introduce property rights for environmental resources as clean air or peace and quiet for the following reasons:

- Private negotiations between different user groups of environmental resources would cause high **transaction and information costs** because a very large number of individuals is involved in the transport market and the potential market for clean air or peace and quiet.
- Furthermore, **strategic behaviour** by agents on markets of pollution rights could not be prevented. Agents have an expectation of the willingness to pay of their market opponents. This expectation can be false. Thus bargaining situations are inherently unstable.
- The consumption of environmental resources as clean air or peace and quiet lacks of the possibility to exclude from consumption. For instance, private households would have an incentive for free-rider behaviour as they can **not be excluded** from the consumption of clean air. Nobody has an interest to buy a property right under this circumstance.

Conclusion: In the context mentioned above it is not surprising that no practical internalisation instruments based on the introduction of property rights do exist. Therefore, in the discussion of possible internalisation instruments, we will not refer to the property rights approach.

2.2.3 Price oriented internalisation: Pigouvian tax

The English economist Arthur C. Pigou was the first to claim that the consequence of external costs are welfare losses which have to be avoided by introducing a tax. The level of this Pigouvian tax is calculated according to the welfare maximisation rule: marginal social costs have to equal marginal social benefits.

The Pigouvian tax is an optimum tax in the sense that it maximises social welfare. To clearly show the different sources of possible obstacles to realise this ideal solution of the externality problem we developed a four-quadrant-framework (**figure 2-1**). It should be noted that it is of a purely illustrative (qualitative) kind and does not represent actual quantitative values of the functions:

- The north-east quadrant shows the transport demand D as a function of the tax T to internalise the external costs. If the tax T equals zero the actual transport volume is V_0 and is determined by the intersection of the demand curve and the marginal internal cost curve. V_0 corresponds to the transport volume being born without any internalisation of external costs.
- V_0 leads to emissions E_0 for a given set of emission abatement technologies according to the emission-function E_j (V) (south-east quadrant).

- A possible transmission function (linking emissions to the level of pollution) is illustrated south-west. A lot of usually only partly available information is required to arrive at empirical values of these parameters.
- The different approaches for the measurement of external costs are shown north-west. In empirical research it is almost impossible to find complete functions for damages, willingness to pay and reduction (avoidance) costs, in order to determine a minimum marginal external cost envelope. An important point is not to include the reduction costs resulting from driving less in the same part of the figure. So we separated the "environmental market" (north-west) and the transport market (north-east).

Figure 2-1: Pigouvian tax in the four-quadrant-framework

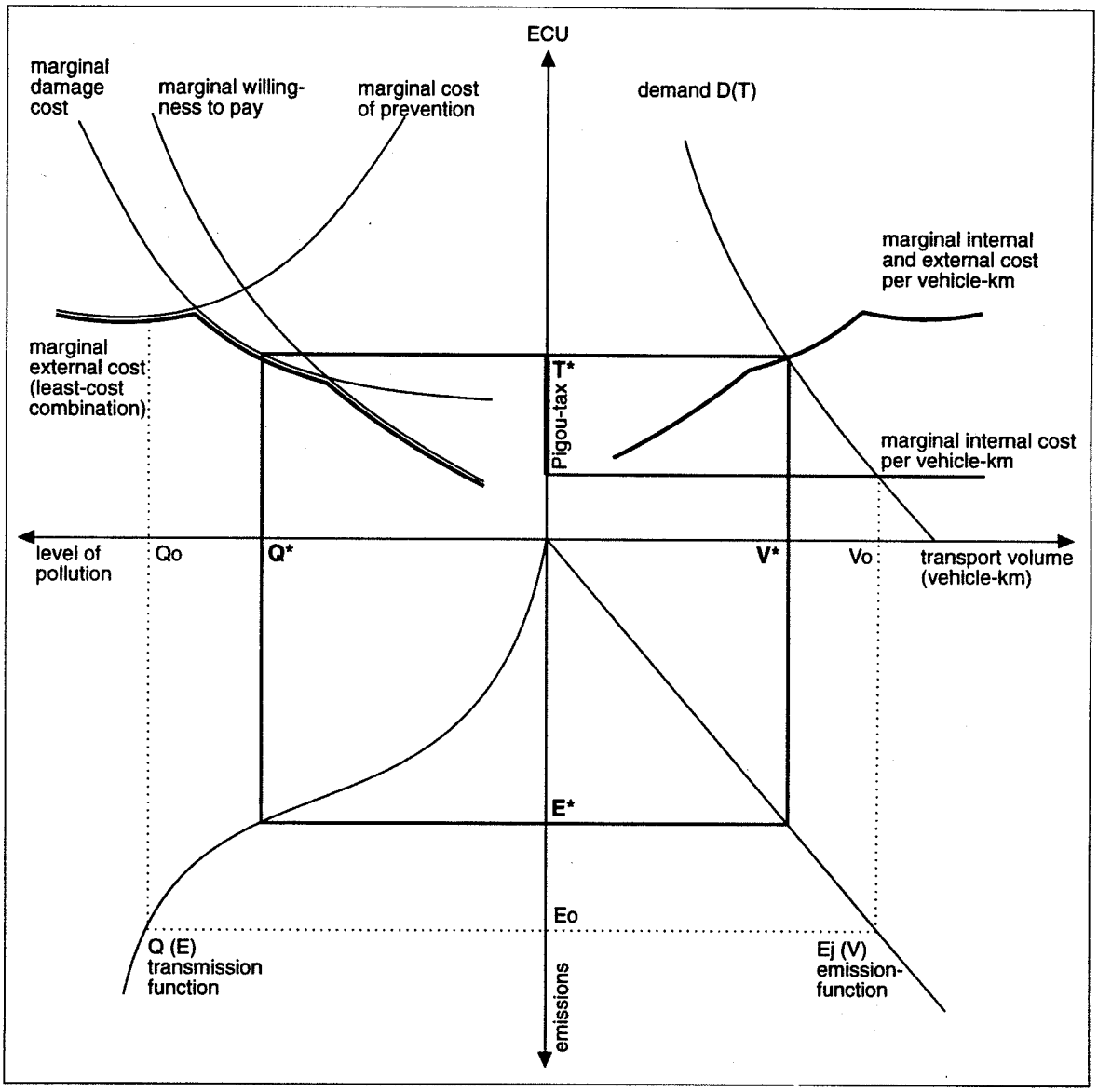


Figure 2-1 shows the welfare-maximising effect of the Pigouvian tax **T***: Only with the tax T* the marginal external costs equal the benefit of an additional (marginal) transport unity. The introduction of the T* results in a reduction of the vehicle-km driven from V_0 to

V*, which leads to the emissions E* and to an optimum level of pollution Q*. Internalisation obviously doesn't eliminate all environmental damages but reduces them as long as the cost of this reduction is lower than the loss of benefit that goes along with the introduction of a tax on environmental harmful activities.

The Pigouvian tax is a working model and not a practicable internalisation strategy. Too many conditions of this model cannot be met in the empirical implementation. We mention only the most important ones:

- The exact evaluation of the marginal external cost-curve is not possible:
  - most estimates of the external costs correspond only to a point on this curve and to average external costs instead of marginal external costs
  - many types of external costs can only be estimated in a broad range; this is true especially for accumulative and global environmental effects
- The transport demand as a function of marginal transport costs is not known exactly. Estimates of price elasticities in the transport sector vary quite a lot depending on the price variations and the period of time.
- In the four-quadrant framework the technology is determined exogenously by the emission-function E_j (V). But the Pigou tax should of course adapt the dynamic effects it gives rise to. If, for example, a Pigou tax on gasoline would be introduced the expected long term effects on the gasoline consumption of the car fleet should be taken into account in the calculation of the Pigou tax. Though it is very difficult, the tax should take into account technological dynamics: the development of abatement technologies and avoidance costs over time should influence the tax level, a periodical review of the tax is thus necessary.

Conclusion: Under real world conditions it is very difficult to determine the correct rate of the Pigou tax. The point of intersection of the marginal external cost curve and the marginal benefit curve will not be known exactly. Therefore, a stepwise introduction of an environmental tax is often suggested. Another solution is the so called standard-price-approach, which will be discussed in the next section.

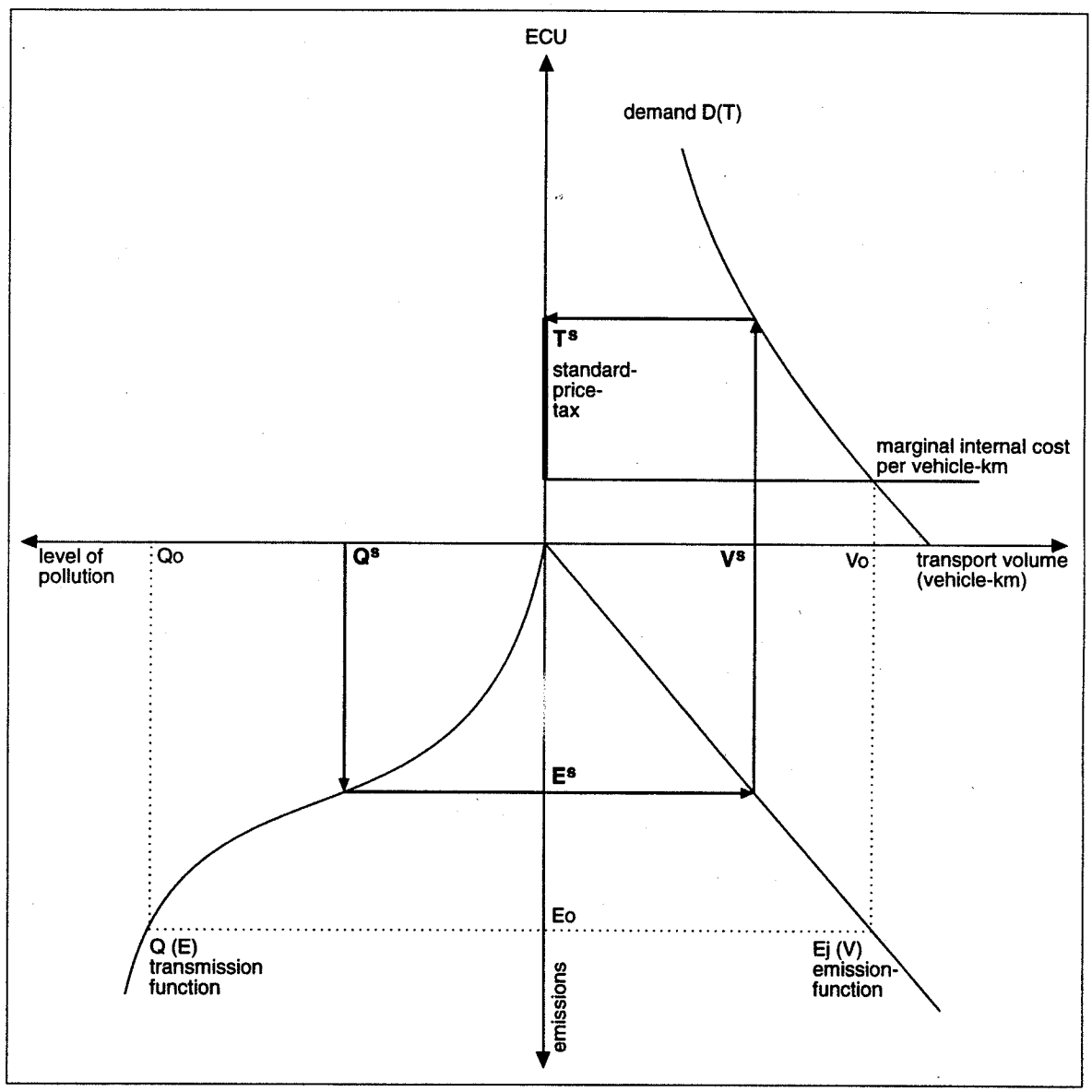
2.2.4 Quantity oriented instruments: Standard-price-approach and tradeable permits

The quantity oriented approach to internalise the external costs is based on given environmental levels of pollution (e.g. NO_x concentration in the air) - standards that must be met. Such standards or norms are based on scientific knowledge. They should ensure that the level of pollution remains sustainable. There are two possible market based instruments to meet the environmental standards, namely the standard-price-approach and tradeable permits.

a) Standard-price-approach

Like the Pigouvian tax, the standard-price-approach corresponds to the introduction of an environmental tax. The level of the tax is not defined according to the marginal external costs but to meet the environmental standard.[6] So, contrary to the Pigouvian tax, with the standard-price-approach there is no need to know the external costs. The aim is to find a tax that reduces the level of pollution to the politically or scientifically defined standard.
Figure 2-2 shows the standard-price-solution graphically.

Figure 2-2: Standard-price-approach in the four-quadrant-framework



6 The standard-price-approach has been suggested by Baumol W.J. and Oates W.E. (1972), The Use of Standards and Pricing for Protection of the Environment.

Starting point is the environmental standard Q^s. This standard is transformed to the permissible level of emissions E^s and to the permissible amount of vehicle kilometres V^s, respectively. Given the transport demand D, the tax to meet the environmental standard equals T^s.

Put into practice the standard-price-tax will be increased step by step until the environmental standard Q^s is reached. This procedure is favourable for two reasons:

- an "overshooting" over the environmental standard can be prevented
- the cost of adaptation will be lower for the economy and the society.

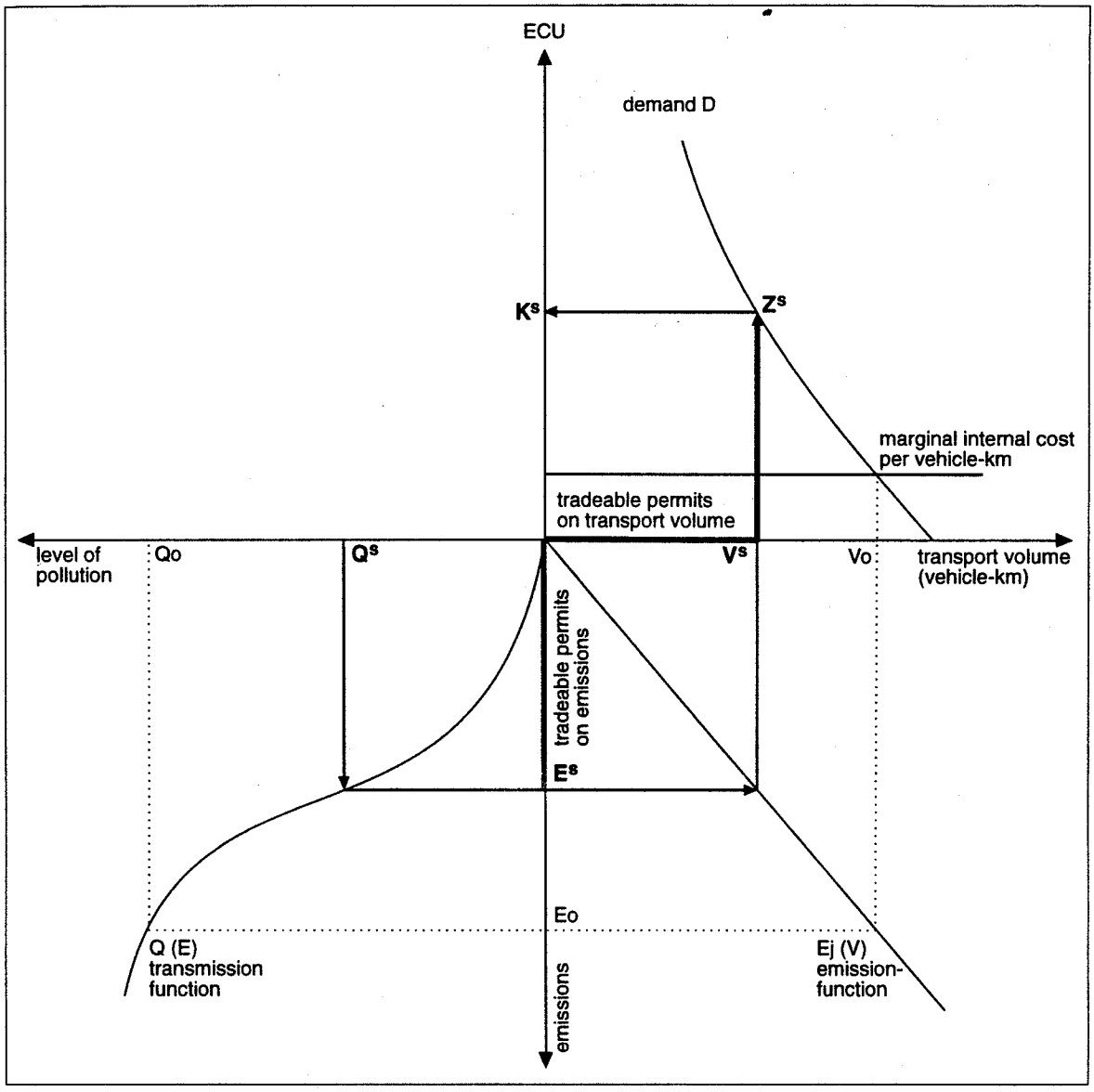
If avoidance cost estimates are available the final level of the tax that is necessary to meet standard Q^s can be assessed. Otherwise, the stepwise increase rather resembles a trial-and-error process.

Conclusions: Formally the standard-price-approach doesn't need any estimates of external costs. This argumentation neglects the problem of the setting of standards. In order to avoid welfare losses, environmental standards should not be set without cost-benefit-analysis. However, such cost-benefit-analysis assessments depend on the availability of assessments of external costs. Correspondingly, the supposed advantage of the standard-price-approach compared to a Pigouvian tax (namely the fact, that an estimation of the external costs is not necessary) often is not of great value in practice. If a standard is set, avoidance cost curves can provide important information to determine the standard-price-tax.

b) Tradeable permits

The tradeable permits approach is akin to the property rights solution. But instead of giving property rights to environmental goods, property rights are defined in the form of tradeable permits for a limited quantity of an environmentally harmful activity.
Contrary to a tax solution, in the tradeable permits system the transport volume allowed is strictly rationed. With the help of the tradeable permits the price for transport activities is an outcome of the market.
Figure 2-3 shows the tradeable permits solution in the four-quadrant-framework. Starting point is the environmental standard Q^s. The amount of vehicle kilometres allowed is V^s. This amount is brought on the market in the form of the inelastic offer Z^s of tradeable permits. The rate of the tradeable permits is K^s. This rate reflects the scarcity of the environmental good.

Figure 2-3: The tradeable permits solution in the four-quadrant-framework



In contrast to the price-standard-approach, with tradeable permits there is no need for a step by step procedure. The environmental standard Q^s will be met from the beginning. The problem of fixing the right price is solved by the market. Despite this advantage, the tradeable permits approach has severe problems which are particularly important in markets with many actors as it is at least partly the case in the transport market. To mention the most important ones:

- high transaction and information costs if there are many actors on the market
- the organisation of the first issue of the permits: who gets them? what's the price? how can be prevented that speculative and monopolistic behaviour will take place?
- definition of the period of validity of the permits?

It is therefore not astonishing that until today tradeable permits solutions can be found at most very rarely in the transport sector (e.g. "eco-points" for the transalpine freight trans-

port on roads in Austria) or they are applied to other leverage points. In the transport sector we should mention the Corporate Average Fuel Efficiency-standards in the U.S., which introduce limitations of the average fuel consumption of the whole car fleet an automobile manufactory produces. A tradeable permits solution would be created if between automobile manufactories permits for the fuel consumption of the new cars could be traded. Furthermore, in the industrial sector there is quite a lot of experience with emissions trading policies.[7]

Conclusion: In the transport sector there are almost no experiences with tradeable permits. In most cases, severe implementation and efficiency problems prevent useful solutions. There are some exemptions as the eco-points system in Austria or the CAFE-standard in the U.S., which should be looked at in more detail in the next chapter.

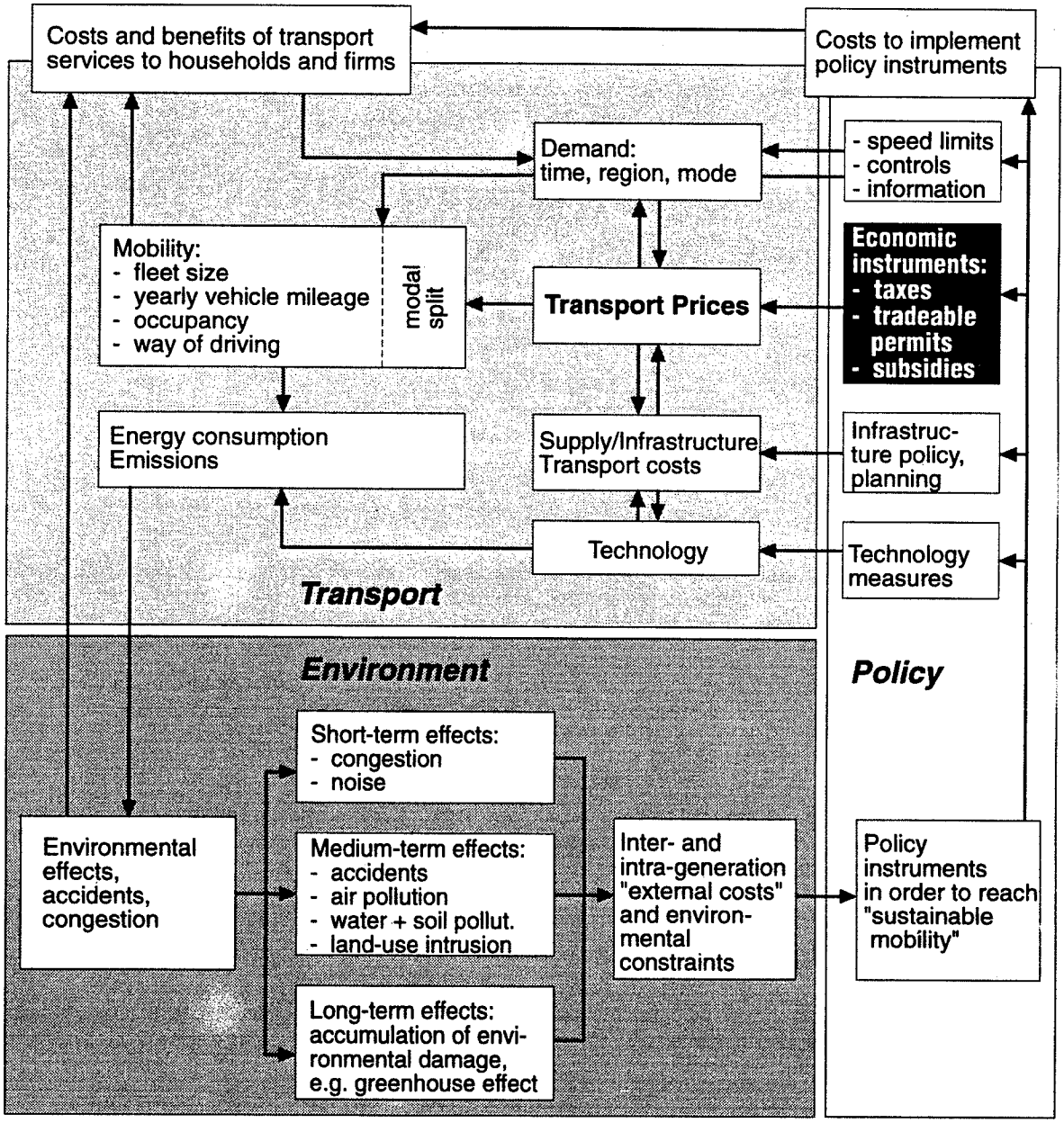
7 See e.g. OECD (1989), Instruments économique pour la protéction de L'environnement; Oates W.E. (1984), Economic Incentives for Environmental Management: The Recent U.S. Experience.

2.3 Implementation of the theory of internalisation

2.3.1 Introduction

In the preceding section the basic forms of internalisation strategies were discussed. It's a long way from this theoretical presentation to the actual implementation of an internalisation instrument. Of course, it's not possible to realise a pure form of internalisation in practice. The main points to be taken into consideration on the way from the theoretically ideal internalisation to real world solutions are discussed in this and the following sections. Figure 2-4 contains, as a starting point, a working model that shows the interrelationships of the determinants of mobility.

Figure 2-4: Interrelationships of the determinants of mobility



The working model of figure 2-4 shows that several variables determine the environmental impact of transport. We have to consider the number of vehicles, their annual mileage, the occupancy, the way of driving and (derived from this) the emissions and the energy consumption of different transport modes. This purely static view shows the different starting points from which to take measures to reduce energy consumption and environmental impact. The static variables are determined by other factors which are in the foreground in a dynamic view. Most important are the price of the different transport modes, the infrastructure supply and the progress in transport technology. For instance, average mileage of the vehicle stock is a function of the fuel price, the price of other traffic modes, the infrastructure supply and, of course, individual preferences.

Figure 2-4 underlines the different dimensions to be taken into consideration in the design of internalisation strategies:

- The box "Environment" shows that externalities vary over time and space. Furthermore, the technology of vehicles (see box "Transport") highly affects the negative environmental effects. Therefore, internalisation strategies have to be differentiated not only according to the types of externalities but also according to their occurrence over time and space, to the technology used and to the way of driving (see section 2.3.2).
- It directly follows that there is no single internalisation strategy to be effective and cost-efficient with regard to the different means of transport and the different external costs because in practice no single instrument can meet all the differentiation requirements mentioned above. Thus, there is no Pigouvian tax or standard-price-tax that will do the job alone as implicitly assumed in the theory of section 2.2. Only a mix of several strategies will be an ingenious solution. To define such a mix of different instruments **avoidance cost assessments** as carried out in topic A of this research project are imperative. In an ideal solution, the avoidance cost assessments show the optimal i.e. cost-minimising way to achieve an environmental standard set politically (standard-price-approach) or with the welfare maximisation rule "marginal social costs equal marginal social benefits". The cost-minimising tax rate would correspond to the marginal costs of the marginal avoidance measure.[8]
  The criteria that must be kept in mind to design a mix of instruments are discussed in section 2.3.3.
- The box "Policy" also points out to other transport policy measures. Internalisation strategies have to be integrated in the existing transport policy framework. Control and command regulations will continue to play an important role in an optimum policy mix (see section 2.3.4).
- At last, the use of tax revenues is an important topic of every tax-oriented internalisation instrument. The way tax revenues are used is political question of distribution on the one hand, and of efficiency on the other (see section 2.3.5).

8 The tax rate is only cost-efficient way if the assessment of the avoidance cost curve takes into account all possible and relevant avoidance measures: If relatively cheap avoidance measures are not considered the tax rate derived from the avoidance cost curve will be higher than necessary to meet the standard. Under real world conditions, it is extremely difficult to assess the cost of all the relevant avoidance measures: In topic A of this research project, for example, we had to restrict the analysis on technological avoidance measures. Possibly cheaper emission avoidance measures like for example less abrupt speeding up have not been assessed.

2.3.2 Differentiation of internalisation strategies

In chapter 2.2 basic forms of internalisation strategies were presented. These strategies have to be differentiated according to several **dimensions**. With the help of the four-quadrant-framework the main dimensions will be discussed in this section.

a) Transport modes

To take a look again at figure 2-1, we see the transport demand and the marginal internal cost per vehicle-km. For every transport mode such a demand and cost function does exist. Correspondingly, internalisation strategies have to be differentiated according to transport modes and transport means. For passenger and freight transport the following modes and means have to be taken into consideration:

Transport modes	**Transport means**
Road	Car, bus, lorry, motorbike, bike
Rail	passenger and freight trains, tram
Air	passenger and freight airplanes
Waterways	passenger and freight ships

b) Technology and way of driving

In the south-east quadrant of figure 2-1 the emission-function determines the amount of emissions for every transport mode. The emission-function depends on the technology of the vehicles in use, the "circumstances" of driving (e.g. cold start, gradient of the road) and of the way of driving. The technology in use most of times doesn't correspond to the environmentally friendliest (best) available technology and the way of driving often is not emission minimising.
According to the type of emission (air pollutants and noise) there are different technological measures to reduce the emissions. The environmentally friendlier the transport technologies are, the lower will be the level of pollution and the external costs. This is demonstrated in the four-quadrant-framework of figure 2-5 for two different emission-functions.

There are several ways to change the emission function. Most obvious are **technology instruments** as emission or safety standards or **behavioural instruments** as speed limits. Such standards are not for free. They can rise the fixed and variable costs of transport means. Correspondingly, the transport volume is reduced from V_0 to V_1. This leads to a reduction of the emissions from E_0 to E_1 according to the new emission function $E(V)_1$. The environmental quality is improved from Q_0 to Q_1.

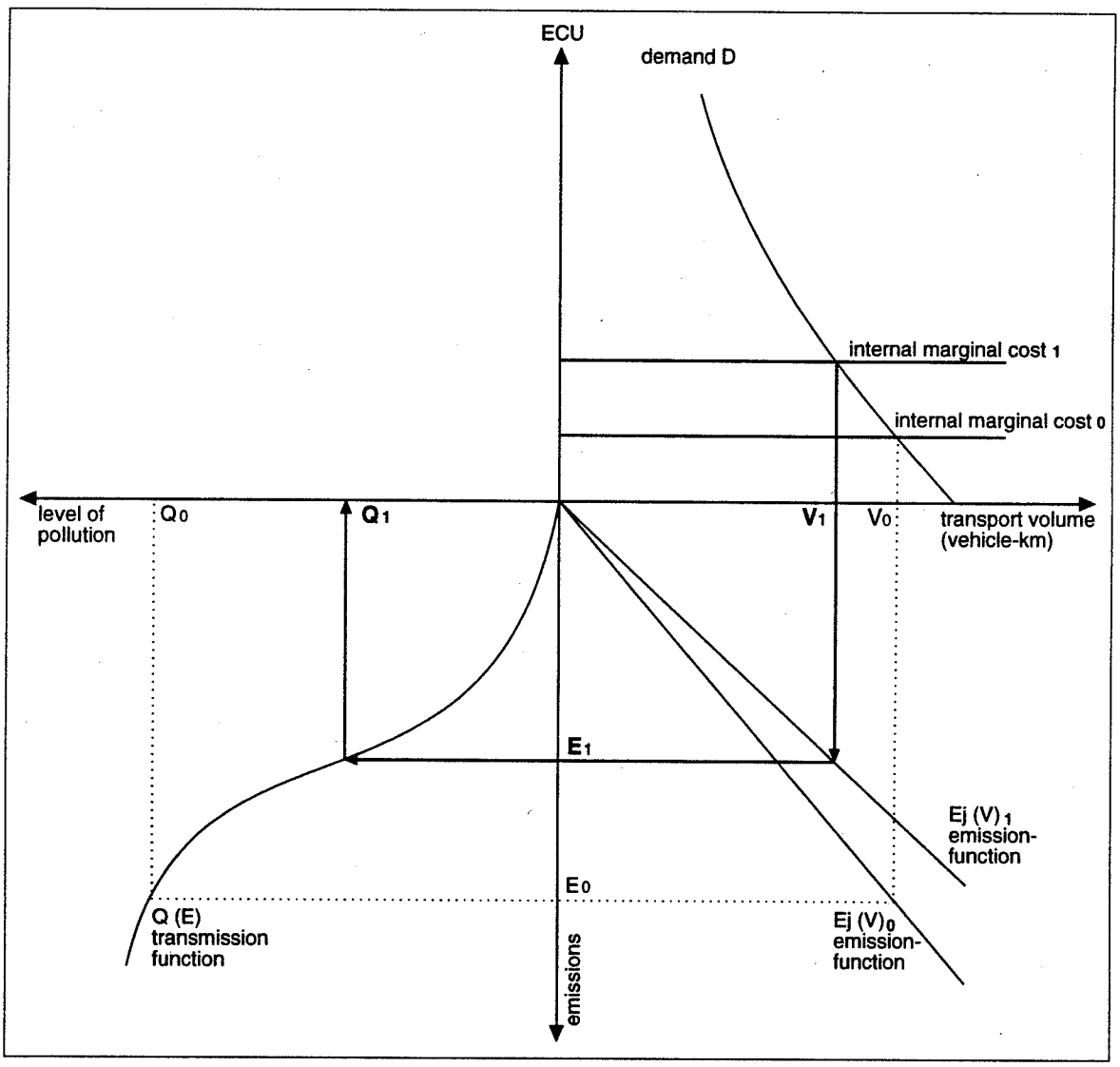
Figure 2-5 shows the **link between topic A of this research project and topic B**. The difference between the internal marginal cost curve 1 and 2 represent the additional costs of the environmentally friendlier technology 1 and correspond with the avoidance

costs assessed in topic A. If one could be sure that there are no cheaper emission reduction measures to attain the environmental quality Q_1 the difference would also represent the shadow price of the environmental standard Q_1.

Not only technology or behavioural instruments can change the emission function. As we will see later, **price signals** of market based instruments often are the more efficient method to influence the emission functions.

Conclusion: Technology and the way of driving are important leverage points for internalisation strategies.

Figure 2-5: Change of the emission function



c) Time and space

The distribution of external costs is unequal over time and between different geographical spaces. The transmission function between emissions and the level of pollution (see the south-west quadrant of figure 2-5) has to be differentiated according to types of emissions and to time and space.

The transmission functions of noise and air pollutants are very different. If we look at noise and air pollution the following effects can be identified:

	space		**time**
local	noise and air pollution in urban areas (smog)	**short-term**	"damages" due to above average loads (e.g. headaches)
trans-boundary	effects at adjacent areas due to troposheric ozone and acid rain	**medium-term**	crop damage water pollution deterioration of human health
global	greenhouse effect and depletion of stratospheric ozone	**long-term**	damages due to climate change (e.g. flood disasters, increasing risks of skin cancer)

Conclusion: Internalisation strategies have to be differentiated according to the type of externalities and to their occurrence in space and time. Therefore, the characteristics of transmission (transboundary effects) and the current pollution levels (time, space) have to be taken into consideration.

2.3.3 Criteria to evaluate an optimum combination of internalisation instruments

The above analysis shows that there is no single market based instrument to be effective and efficient with regard to the different modes of transport and the different external costs. Only a mix of several instruments will be an ingenious solution.

In developing an optimum combination of internalisation strategies different criteria have to be taken into consideration. In this section the most important criteria to evaluate possible internalisation strategies will be discussed, namely

- ❑ effectiveness
- ❑ efficiency
- ❑ implementation cost
- ❑ dynamic effects
- ❑ political feasibility

a) Effectiveness and aggregation problems

In the last section the focus was on the dimensions according to which internalisation strategies have to be differentiated. Main criteria to differentiate between internalisation strategies is the spatial occurrence of externalities. The greenhouse effect and the depletion of stratospheric ozone call for strategies at the European level as they are evenly distributed over space. Possible instruments are the introduction of an energy/CO_2-tax or the harmonisation and increase of taxes and charges on cars and lorries. On the other hand local strategies as road pricing and parking fees are typical instruments to internalise specifically urban externalities as noise, congestion and part of air pollution (particulates, NO_X).
In chapter 3 we will discuss these instruments. Here we conclude that the **effectiveness** (defined as the extent of the reduction of external costs) will be increased if several internalisation strategies are combined.

At the same time it is obvious that spatially and temporally different externalities are not independent of each other. If for instance the price of fuel is increased transport volumes on the road will be lower. This reduces the negative effects of air pollution on every spatial level. In other words: specific internalisation strategies often influence the level of several forms of externalities. It is therefore necessary to determine the effects of a combination of internalisation strategies **simultaneously**.

Conclusion: A combination of internalisation strategies is more effective than one single instrument. But attention must be given to repercussions and synergies between internalisation strategies. It's particularly important not to use the same external effect to justify several measures at different spatial levels.

b) Cost-benefit aspects, static efficiency and implementation costs

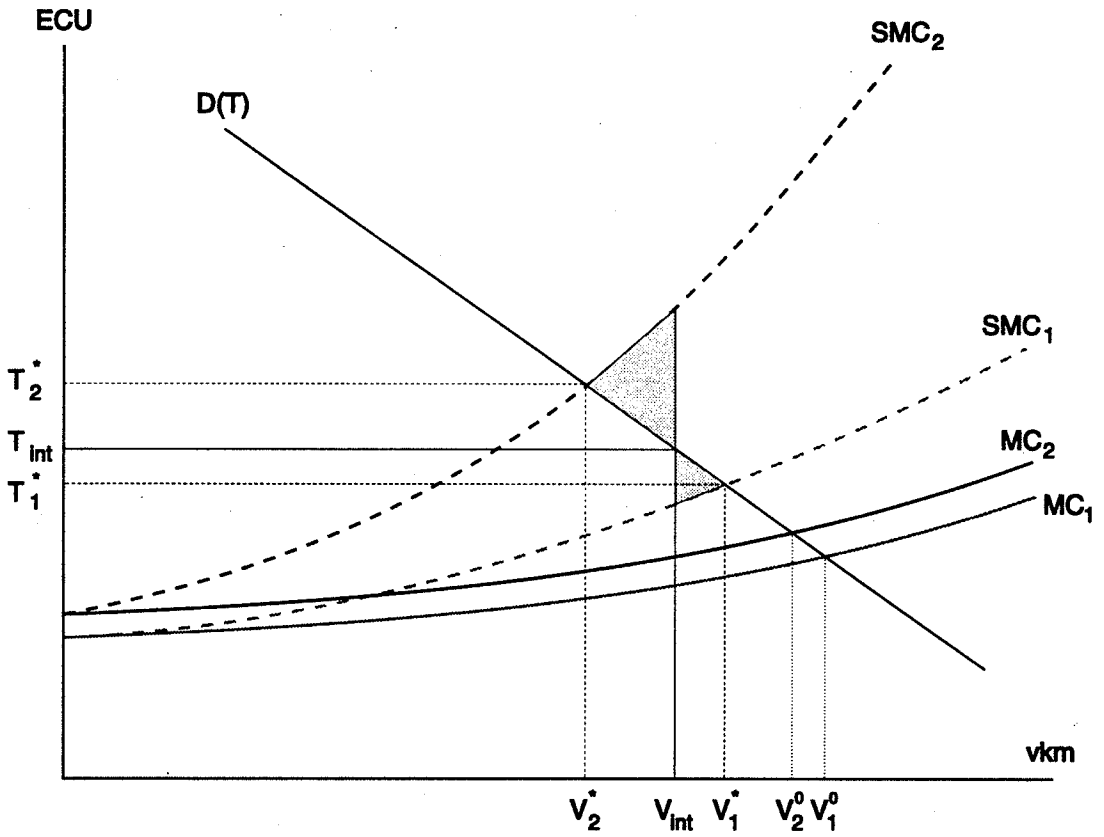
The assessment of different internalisation instruments not only has to consider the effectiveness but also the efficiency of each instrument.

The **static efficiency** criteria implies that the objective of internalising the external effects of transport should be achieved at **minimum cost**. Static efficiency can be defined as follows: An internalisation instrument is efficient if the sum of all cost components of an internalisation instrument is minimised for a given reduction of the external costs.
To compare the efficiency of different internalisation instruments a **cost-benefit ranking** of these instruments is needed (e.g. ECU / tonne CO_2-reduction). This is a difficult task as there are different **cost components**, namely:

- Implementation costs of the instrument:[9]
  - planning, installation and equipment costs
  - running costs
  - administrative costs
- Welfare gains and losses

A particularly strong **trade-off** between the practicability on the one hand, and the effectiveness of the instrument on the other hand must be taken into account: The better an internalisation instrument meets the **polluter-pays-principle** (the more the instrument is differentiated and user-related) the higher are, in broad tendency, the **implementation costs** of this instrument. Accordingly, the question to what extent a differentiation is useful can only be answered by considering implementation costs and the potential welfare gains. The potential welfare gains from a differentiation of an internalisation instrument are given in the figure below.

Figure 2-6: Differentiation and welfare gains



9 For instance the implementation costs of an instrument are lower
- the less new administrative schemes are necessary
- the more the introduction of an internalisation instrument is based on existing institutional structures
- the smaller the number of internalisation instruments that have to be combined
- the less opportunities to evade the charges exist
- the less the costs of installation and running the physical equipment
- the less the costs for information and advertising

Figure 2-6 shows the north-east quadrant of figure 2-1. D(T) is the transport demand, SMC are social marginal cost curves (i.e. internal and external marginal costs), MC marginal cost curves. The curves are drawn according to the following assumptions:

- The different shapes of the **social cost curves** reflect differences in the dimensions mentioned in section 2.3.2 that determine the external costs actually caused by a kilometre driven:
  - means of transport (example: SMC_1 shows the external costs per vehicle-kilometre (vkm) of a car, SMC_2 of a truck)
  - emission abatement technology (example: SMC_1 = new, clean truck, SMC_2 = old and more polluting truck)
  - way of driving (example: SMC_1 = low speed driving SMC_2 = high speed driving)
  - time (example: SMC_1 = driving in the rush hour, SMC_2 = driving in off peak time periods)
  - space (example: SMC_1 = driving in urban areas, SMC_2 = driving in rural areas)
- The way the **marginal cost curves** are drawn is rather unimportant for our analysis. The differences may be explained by different costs for the different transport means.
- V^0_1 and V^0_2 are the **transport volumes** in vkms before the external costs are internalised.

According to the theory of internalisation described in section 2.2.3 the optimum rates, i.e. the rates of the Pigouvian Tax, are given by T^*_1 and T^*_2. We now assume that in real world conditions the "average" tax rate T_{int} has to be applied because of technical difficulties to distinguish between the tax rates T^*_1 and T^*_2. The implication on social welfare is given by the two shaded areas in figure 2-6. In the case of SMC_2 the tax rate T_{int} is too low, the level of external costs remaining after the internalisation is still too high. For SMC_1 the contrary is true, the tax rate T_{int} is too high, the consequence is a loss of consumer surplus. The loss of social welfare caused by the average tax rate T_{int}, or in other words, the potential welfare gains of the differentiated tax rates T^*_1 and T^*_2 are the sum of the two shaded area.

If a differentiation between T^*_1 and T^*_2 is technically feasible but causes considerable implementation costs, the decision whether this differentiation is to be introduced or not should base on a comparison of the additional implementation costs with the social welfare losses resulting from the use of an "average" tax rate.

It is obvious that the potential welfare loss caused by an "average" tax rate is higher the more the external marginal cost curves differ from each other. If the differentiation of the tax refers to different emission abatement technologies of the vehicles the potential welfare gains of a tax differentiation is likely to decrease in the course of time, because old and polluting vehicles will be replaced by new and cleaner ones. However, this purely static view doesn't reflect that the technical requirements defining the different tax rates can be adjusted to future innovations in the emission abatement technologies.

As mentioned at the beginning of this sub section, the comparison of implementation costs and potential welfare gains of differentiation is of course also relevant for cost-benefit rankings of different instruments. To give two examples:

- With an **urban road pricing system**, capable of processing emission data by type of vehicle registered, motor vehicles can be charged directly for the external costs they cause with every kilometre driven. The polluter-pays-principle can be realised in an ideal way. But the implementation costs of a road pricing system of this type are very high. On the other side the road users are exactly charged for the external costs they cause, i.e. potential welfare losses are minimised.
- In the case of **higher parking fees** the situation is just the reverse. They may influence mobility patterns in the direction of the polluter-pays-principle. But they don't differentiate according to the length of the trip and to the emissions of different motor vehicles. Welfare losses for example in the form of reduced consumer surpluses will result.[10] On the other hand, compared to road pricing, higher parking fees cause much less implementation costs.

Conclusion: The internalisation of external effects should take place at minimum cost. It is difficult to compare the static efficiency of different instruments. Therefore, cost-benefit rankings are needed. Due to the need for data such rankings are only possible if a specific description of the internalisation instrument exists.

c) Dynamic effects and dynamic efficiency

The discussion so far has been in a static context. In the four-quadrant-framework the transport technologies are given in the form of the internal marginal cost curve and the emission function for every transport mode.
In a dynamic long-term view additional effects have to be taken in consideration:

- **Technology changes**: compared to command and control regulations the most important advantage of market based instruments are the direct financial incentives they put in the direction of technological innovation and new technologies. A rise of fuel prices, for instance, will create a **lasting incentive** to reduce fuel consumption of cars and lorries. This is not the case for emission standards, which don't establish any incentive to reduce fuel consumption more than to meet the standard. There are two forms of technological incentives of market based instruments: Firstly, the market **diffusion** of existing environmentally friendlier technologies will be encouraged. Secondly, the process of technological **innovations** is promoted as the change of relative prices promises higher potential profits for environmentally friendly technologies.
  Contrary to fixed emission or technology standards, with market based instruments the introduction of a new technology is not fixed to a given point of time. Rather it will happen smoothly according to the financial profitability of the environmentally friendlier technology. Thus the cost of the introduction of a new technology can be ex-

10 If, for instance, somebody drives one kilometre and then pays a parking fee of 5 ECU per hour because of the external costs of local air pollution this person pays too much as the external costs of a one-kilometre trip are lower.

pected to be lower if it is based on a change of relative prices than on a precisely timed new technology standard.

- **Demand changes**: the demand for transport services is more flexible in a dynamic long-term view. For instance, an increase of transport prices may influence localisation decisions of households and firms and subsequently lead to an additional reduction of the transport demand. As a consequence, the whole demand curve in the north-east quadrant of figure 2-5 may be shifted to the left in the long term.

- **Reliable signals**: It's most important to send reliable signals of the future prices of transport services. Dynamic incentives can only be expected if the market participants are sure about the announced rise of prices. To set continuous incentives and to reduce the adaptation costs of changed relative prices it makes sense to begin with a low price increase and then increasing it over time.

- **Limited use of external cost estimates**: Such a regime is also advisable because the use of external cost estimates is limited. The external cost estimates are not only incomplete, in the long-term they are also quite uncertain as future demand and technologies are unknown. Although the calculation of external costs is essential for guiding and developing the direction and priorities of transport policy, the specific figures of the external costs should not be understood as the exact basis for deriving optimum charges to be levied. So, external costs indicate what the optimum mix of market based instruments could be and what are the first steps in the right direction. But the "optimum" level of the price increase in the sense of a Pigouvian tax remains unknown.

d) Political feasibility

Political feasibility is another important criterion in evaluating internalisation strategies. The most effective and efficient instrument is useless if it misses political acceptance. Economists have proposed market based instruments to internalise the external costs of transport for decades. However, they were not accepted by politicians. It's true that today there is a general consensus about the fundamental advantages of market based instruments, but in detail there are always heated discussions and most of times specific proposals don't find a political majority.
Most important reservations concern the fear of negative effects on the **economic competitiveness** and of undesired **distributive effects**. Of course, the internalisation of external effects always affects some groups of the population over the average. That's why it is a *sine qua non* to show that society as a whole takes advantage from the introduction of market based instruments and that some limited relief schemes are taken to support heavy concerned groups. The word "concerned" must be understood in the right way: These are groups having the largest profit from the inefficient social cost allocation in the sense that they cause a lot of environmental damages for which they don't pay. Of course, the consequence of internalisation strategies are desirable restructuring processes to a more energy and environmentally efficient society. Correspondingly, environmentally harmful production and consumption forms will be much more expensive.

2.3.4 Internalisation and other transport policy measures

Market based instruments have to be integrated in the existing transport policy framework, in which control and command regulations until today play the central role. So far, concentration was laid on market based instruments. This section deals with the co-ordination of market based instruments with other transport policy measures. As shown in figure 2-4, other types of instrument play an important role in transport policy. Apart from market based instruments three different categories of transport policy strategies can be identified:

a) Instruments of education and information

These are policy measures to improve knowledge of the impact of transport on the environment in order to change mobility patterns or to increase political acceptance of a more restrictive transport policy. Examples are PR campaigns in favour of public transport, the publication of the results of air pollution monitoring or training of car drivers.

Education and information measures have the lowest possible degree of government intervention imposed on individuals and firms. They can increase public awareness of unsolved transport problems. But they have no power to enforce a change of today's transport system. As a supporting measure to enhance the effectiveness of other instruments they remain indispensable.

b) Command and control instruments

Regulatory policies contain technical standards of vehicles (e.g. emission standards), standards of behaviour for road users (e.g. speed limits) and the rationing of transport demand (e.g. zonal entry prohibitions).

In principle, with regulatory measures every reduction of pollution could be achieved. But compared to market based instruments regulatory measures achieve this reduction in a less efficient way. Regulatory authorities normally don't have the knowledge how to allocate pollution abatement measures efficiently across individual polluters. With market based instruments this knowledge is not necessary as the price-mechanism solves the problem of an efficient reduction of the pollution. In most cases, regulatory policies are dynamically inefficient, as they don't set incentives to reduce pollution levels below the standards.[11]

Despite the fundamental inefficiency of regulatory instruments in some situations they are more appropriate because they do not leave open the possibility to act in the one or the other way. For instance, a general ban of activities with environmentally very dangerous substances (e.g. some sort of toxic substances, radioactive substances) may be the welfare optimising policy. Or the imposition of speed limits cannot be replaced by market based instruments. The same seems to be true for safety standards

11 There are exeptions to the rule. For instance, the famous CAFE-standards in the US (CAFE means "corporate average fuel efficiency") set a lasting incentive to reduce fuel consumption of cars. In general, technological standards setting upper levels of allowed emissions have a better dynamic efficiency than standards that additionally say how (with which technology) the emission reduction has to be achieved.

of transport means. In general, the exact regulation of specific pollutants is - in the short term - only possible with regulatory measures.

c) Infrastructure and service instruments

These are measures to provide new infrastructure and to improve (public) transport services. Examples are the extension of the road network and speed-up programmes for public transport.

For decades, the main objective of transport policy was to satisfy growing demand by providing new transport infrastructure and transport services. A large and modern transport infrastructure was thought to be vital for the competitiveness of the economy and for achieving a higher standard of living from free trade. In the transport policy of the EU this approach is still an important factor.[12] On the other side, there is growing awareness for environmentally friendlier transport infrastructures. Examples are the extension of the public transport network, the building of additional tunnels to avoid noise in residential areas or to preserve unique landscapes.

d) Conclusion

Nobody claims that market based instruments can solve every problem in transport policy. What is needed is a well balanced, interdisciplinary policy mix. But it remains necessary to turn price signals in the direction of the "ecological truth". This is a vital condition for a sustainable development of the transport system. At the same time, specific transport measures and management remains important. Here, different categories of transport instruments are necessary. After all, only a combination of all transport policy instruments will be apt to tackle the serious problems caused by transport.

2.3.5 Distributive effects and use of the revenues

The distributive effects of market based instruments are one of the most cited obstacle against such instruments. In theory, it should be possible to create a win-win situation (meaning that everybody gets a higher welfare at the end), but in practice it is very difficult to distribute the welfare gains of a better environmental quality in such a way.

In this section we first show some possible patterns of direct distributive effects of different market based instruments. Then, the distributive and efficiency aspects of the ways tax revenues can be used will be discussed.

12 In June 1992 the EC announced a massive new road building programme. It proposes the construction of approximately 12,000 km of new motorways across Europe by the year 2002. This increase will probably accelerate the "vicious circle" of more negative impacts of transport.

a) Direct distributive effects of market based instruments

The direct distributive effect of market based instruments are first and foremost determined by the distribution of property rights:

- Every form of internalisation taxes or charges implicitly assigns property rights of environmental resources to public authorities, which levy a price for these resources according to their scarcity.
- On the other side, the distributive effects of tradeable permits depend on the first issue of the permits. From an efficiency point of view, it's not important who gets the permits first as long as strategic and monopolistic behaviour can be prevented.

b) Use of the revenues

If external costs are internalised by an increase of existing taxes or by an introduction of new taxes, the use of the tax revenues becomes an important topic. It is important to realise that the theory of externalities and internalisation doesn't say anything about the use of about the use of the revenues obtained by the government. The objective of internalisation is to get to an efficient allocation of the scarce resources. The important goal is to modify the behaviour of the polluters. Consequently there is no a priori reason why public authorities should spend more on whatever purpose after introducing an internalisation tax. This means that basically the revenue should be redistributed in some way. Nevertheless, the different possibilities to use the revenues will be shortly discussed.

b1) Earmarking for improvement of the transport systems

The following forms of earmarking can be distinguished:

- improvement of public transport supply
- improvement of infrastructure for combined freight transport
- improvement of road infrastructure
- subsidies for the use of energy efficient and/or less polluting means of transport.

From an allocative point of view there is no reason for an earmarking of internalisation revenues for the improvement of transport systems. If external costs are internalised no market failure will happen anymore. Under this circumstance, subsidies for transport systems only cause new distortions on the transport market.
In a second best perspective, subsidies for environmentally friendly transport modes can be efficient as long the external costs of the environmentally harmful transport modes are not internalised. The efficient amount of the subsidy is determined according to the cross-price-elasticities between environmentally friendly and environmentally harmful transport modes. The higher this elasticity the more subsidies for environmentally friendly transport modes are justified.

b2) Redistribution of the revenues

- **Lump sum redistribution**: As internalisation theory doesn't say anything about the use of revenues the implicit assumption is that revenues are redistributed through lump sum transfers which do not affect the behaviour of the agents. A lump sum redistribution will not cause an additional distortion in allocative efficiency and therefore often is favoured by economists. Internalisation taxes usually have a slightly negative (regressive) distributive effect. A lump sum redistribution also compensates this effect.

- **Lowering existing taxes**: Instead of a lump sum redistribution existing taxes could be reduced. If distortionary taxes do exist (which is the case in almost every country) the reduction of such taxes will create an additional benefit. That's the idea of the so called double-dividend hypothesis.[13] In a large scale general equilibrium model (featuring 41 sectors and 6 household classes) the double-dividend hypothesis was examined for Switzerland for the case of a tax reform that uses the revenues of a CO_2 tax to lower the currently high marginal labour income tax rates. The simulation results confirm the double dividend hypothesis that environmental tax reforms not only enhance environmental quality but also lower the excess burden imposed on the economy from taxation.[14]

b3) Compensation of the "victims" of external costs?

From an efficiency view there is no reason to compensate the "victims" of external costs. The reason is very simple: after the polluter pays the tax for the external cost, an optimum situation is reached (all prices equal social marginal cost). In other words: the compensation of the victims would cause new welfare distortions because an incentive would be created to live at places where high external costs occur.
For example, houses at noisy streets usually have lower values and their apartments have lower rents. This is what hedonic regressions prove (one method to evaluate external costs). This means that compensation already happens through lower rents. A further compensation only would create an incentive to live at noisy streets. At the end, this would lead to an increase of the value of the houses because house owners could rise the rents.

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13 See Goulder L.H. (1994), Effects of Carbon Taxes in an Economy with Prior Tax Distortions: An Intertemporal General Equilibrium Analysis.
Goulder offers three distinct definitions of the concept of a double dividend:
"*Weak form*: By using revenues from the environmental tax to finance reductions in marginal rates of an existing distortionary tax, one achieves cost savings relative to the case where the tax revenues are returned to taxpayers in lump-sum fashion.
Intermediate from: It is possible to find a distortionary tax such that the revenue-neutral substitution of the environmental tax for this tax involves a zero or negative gross cost.
Strong form: The revenue-neutral substitution of the environmental tax for typical or representative distortionary taxes involves a zero or negative gross cost."

14 See ECOPLAN (1994), Wirtschaftliche Auswirkungen und Verteilungseffekte verschiedener CO_2-/Energieabgabe-Szenarien.

c) Conclusion

Internalisation theory implicitly assumes that the revenues are redistributed. The overall tax level is not changed and the budget of public authorities will not be increased (budget neutrality). There is no ideal redistribution scheme as every scheme has different distributive effects. From an efficiency point of view it should be aimed at opportunities to create a double-dividend situations. This can be done, for instance, by a reduction of marginal labour income tax.

If the internalisation tax is not high enough to cover full marginal external cost a second-best subsidy to environmentally friendly transport modes could improve overall efficiency. Victims of external costs never should be compensated permanently according to the damage occurring to them.

3 Pre-selection of possible internalisation instruments

3.1 Introduction

In the last chapter we have summarised the theoretical aspects and cornerstones of internalisation of external costs. In this chapter we discuss the possibilities to transfer the findings of chapter 1 into "real world conditions":

- In a first step (section 3.2) we give an **overview of possible instruments** to internalise the external costs of the different transport modes. Part of this overview is a short summary of the status of implementation of the instruments in European countries.
- In a second step (section 3.3) the instruments will briefly be discussed according to selected criteria that base on the theoretical framework of chapter 2. In this short **discussion of the internalisation instruments** we will not go into any details, this will be done in the three sub reports of topic B (see part II of this synthesis report).
- Basing on the results of previous section a the **instruments** that are subject of three sub reports are **selected** in section 3.4.

3.2 Overview of possible internalisation instruments

3.2.1 Introduction

With regard to the overview we like to make the following preliminary remarks:

- Due to the theoretical arguments mentioned in chapter 2 and due to the fact that financial incentives play only a minor role in the control of external costs of transport in European countries we focus our attention on **economic instruments**. Pure command-and-control regulations will not be discussed in this pre-selection.[1] However, forms of institutional change will be considered as far as they are necessary conditions for a successful implementation of internalisation instruments.
  The restriction on economic instruments does not mean that we deny the potential of command-and-control regulations to reduce emissions of transport.
- Furthermore, we concentrate our discussion to instruments that contribute to an **internalisation of the external costs of climate change, air pollution and noise**, i.e. the externalities that were analysed in part A of this project.
- The overview of the different instruments will be **structured** as follows:
  - **description** of the instrument: short portrait of the instrument

1 In the sub reports the interrelationships between command-and-control regulations and economic instruments will be part of the discussion.

- **leverage points**: point of intervention to influence mobility behaviour, target emissions and external cost components
- **metering / charging system**: first hints concerning the technical systems and arrangements to measure the emissions and to define the charge
- **experiences**

- In our first conclusions we will - as proposed in section 2.3.2 - distinguish between the three **different spatial dimensions** of the external effects:[2]
  - **Local effects**: effects in the area immediately adjacent to the transport activity (e.g. noise nuisance).
  - **Transboundary effects**: effects in areas that are not directly affected by the transport activity (e.g. acid rain in remote regions). The transboundary effect tend to impact in the medium term rather than immediately.
  - **Global effects**: long term effects on the atmospheric composition (e.g. "greenhouse effect").

3.2.2 Road transport

a) Differentiated sales taxes

- **Description**: "once-only" tax on the sale of new vehicles to influence the acquisition decision
- **Leverage points**: specific emissions of noise and of air pollutants (NO_x, VOC, CO etc.), specific fuel consumption (or CO_2)
- **Metering / charging system**: The tax is added to the sales price of the vehicles with the "more polluting" technology. Its introduction requires the definition of different categories of vehicles and of the testing methods to meter the emissions.
- **Experiences**: in 1991 the EC Council of Ministers adopted a directive (91/441/EEC) entitling the Member States to introduce within certain limits a differentiated motor vehicle acquisition tax. In spring 1993 various proposals of a uniform system for a differentiation of the taxation of new vehicles have been discussed within the Motor Vehicle Emission Group (MVEG). The objective was to provide consumers with an incentive to buy vehicles with low energy consumption and/or low exhausts of certain air pollutants.[3] So far, there is no agreement on what the common model should look like.

  Some OECD-countries have integrated ecological aspects into the sales tax for passenger cars.[4] Table 3-1 lists some examples of car sales tax differentials between cars with high and low consumption/emissions in OECD-countries.

2 See Button K. (1994), Overview of Internalising the Social Costs of Transport, p. 15.

3 See Kageson P. (1993), Economic Instruments in European Environmental Policy, p. 48.

4 For an overview of the sales tax bases in different European countries see ECOPLAN (1993), Umweltabgaben in Europa, p. 24.

Table 3-1: Car sales tax differentials[5]

Country	Tax base and rate
Belgium	Cars not satisfying emission standards: ECU 314 - 419
Canada	Fuel efficiency: ECU 340 - 1985
Finland	Cars not equipped with catalytic converter: ECU 714
Greece	Degree of compliance with emission standards
Japan	Tax deductions for cars with low emissions, electric cars and cars on alternative fuels
Norway	Cars not equipped with catalytic converter: ECU 774
Sweden	Degree of compliance with emission standards: ECU -474 - ECU 237
USA	Cars with fuel efficiency below 22.5 miles/gallon ("gas guzzler tax"): ECU 655 - 4587

b) Differentiated annual vehicle tax

- **Description**: recurrent annual charges for vehicle registration to promote the purchase of less polluting vehicles
- **Leverage points**: specific emissions of noise and of air pollutants (NO_x, VOC, CO etc.), specific fuel consumption (or CO_2)
- **Metering / charging system**: introduction requires the definition of different categories of vehicles and of the testing methods to meter the emissions
- **Experiences**: The annual vehicle tax is normally based on technical criteria of the vehicle (e.g. gross weight).[6] As in the case of the sales tax some countries have introduced financial incentives to promote the use of more environmentally friendly cars. In Austria, for example, the vehicle tax is dependent on the vehicle weight and varies between cars with and without catalytic converters: Cars not equipped with a catalytic converter are classified in the next higher weight class. In Germany, the cylinder capacity and the emission abatement technology of the vehicle are decisive for the annual vehicle tax.[7]

  For heavy goods vehicles there is no differentiation according to environmental properties. As figure 3-2 shows the taxation of heavy goods vehicles varies enormously between the member states despite the minimum rate that is fixed in the directive 93/89/EEC.[8]

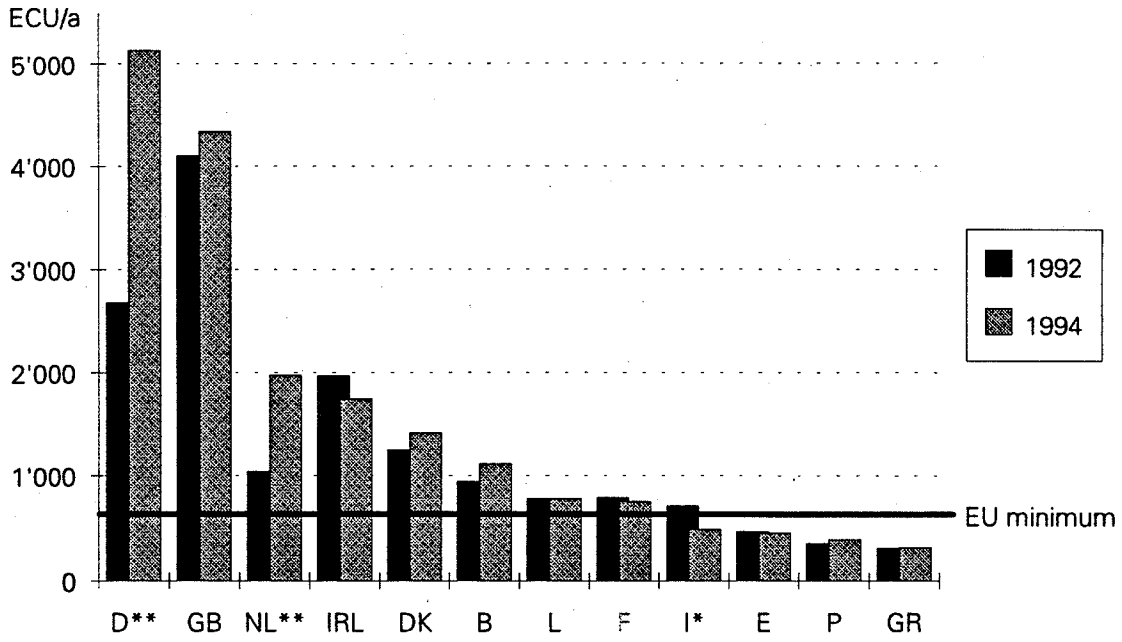
5 Source: OECD (1994), Managing the environment, p. 70.

6 For an overview of the vehicle tax bases in different European countries see ECOPLAN (1993), Umweltabgaben in Europa, p. 26.

7 See OECD (1994), Managing the environment, p. 71.

8 Source: Untersuchungsausschuss über den Strassengüterverkehr im Europäischen Binnenmarkt (1994), Der Strassengüterverkehr im Europäischen Binnenmarkt, p. 37.

Figure 3-2: Annual vehicle tax for heavy goods vehicles in EU member states



* = year 1989, data for 1994 not available

** = after April 1, 1994: D 2'790 ECU, NL 1'855 ECU

c) Taxes on fuel

- **Description**: environmentally motivated taxation of petrol and of diesel to influence individual driving behaviour and vehicle buying patterns
- **Leverage points**: fuel consumption, CO_2 content of petrol and diesel, sulphur content of diesel[9]
- **Metering / charging system**: no additional metering and charging system necessary, exemption: measuring of sulphur content in the case of a sulphur tax
- **Experiences**: Figure 3-3 and 3-4[10] show that fuel - being an excellent base for taxation is subject to a number of different taxes. Nevertheless, only in a few countries environmental concerns are reflected in the taxation of fuel. So far, Sweden is the only country having introduced taxes that explicitly take into account the external costs of transport.[11]

9 If the sulphur content of diesel is - as planned - reduced by regulation to 0.05% by the year 1996, there will be hardly any reason for the introduction of a sulphur tax.

10 Source: IEA (1994), Energy Prices and Taxes, second quarter 1994.

11 For an overview see for example Hansson L. (1992), Pricing of Air Pollution in the Swedish Transport Policy.

Figure 3-3: Taxation of petrol in OECD-countries, second quarter 1994

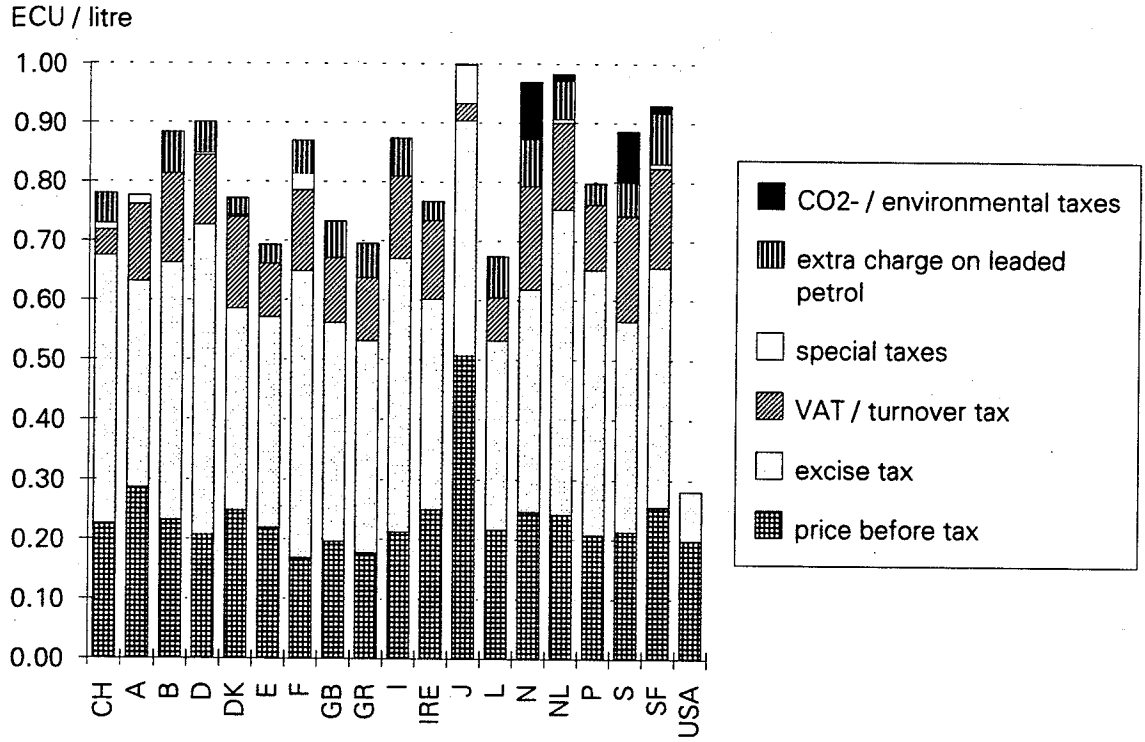
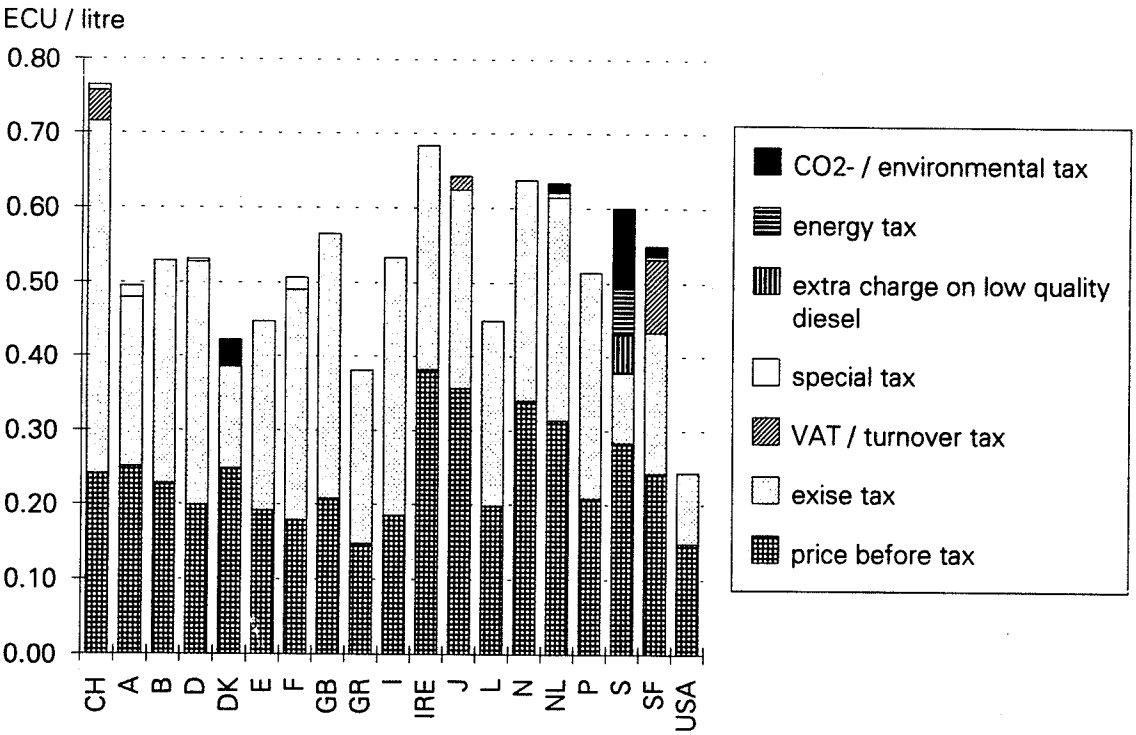


Figure 3-4: Taxation of diesel in OECD-countries, second quarter 1994



d) General kilometre tax (mileage tax)

- **Description**: distance dependent tax with a differentiation of the tax rate according to the emission abatement technology of the vehicles
- **Leverage points**: mileage, emissions of noise and of air pollutants, specific fuel consumption
- **Metering / charging system**: meters in the vehicles registering the usage of the vehicle, tachograph and self-declaration in the case of freight transport, automatic debiting system in the car (on-board equipment) and alongside the road (beacon)
- **Experiences**: This kind of tax has been introduced in the Scandinavian countries Sweden and Norway for heavy goods vehicles and for diesel powered cars. The tax rate was differentiated on the basis of the gross weight and the number of axles. The tax has been abandoned because the two countries applied for membership of the EU. It was replaced by a tax on diesel.
  In Switzerland, it is planned to introduce a kilometre tax for trucks that takes account of the external costs of road freight transport.

e) Road pricing[12]

- **Description**: Broadly speaking one can distinguish two types of road pricing schemes:
  - Road pricing schemes for urban areas (e.g. tolls, cordon rings, area licensing schemes): well known and extensively analysed examples are Singapore, Oslo, Bergen and Trondheim)
  - Road user charges (e.g. for the use of certain parts of the road network like motorways, tunnels, bridges)

  The level of the charge can be based on the kilometres travelled or is established on a "lump sum" basis (e.g. motorway vignette).
- **Leverage points**: emissions of noise and of air pollutants
- **Metering / charging systems**: automatic debiting system in the car (on-board equipment) and alongside the road (beacon), meters in the vehicles registering the usage of the vehicle, manual charging/coin machines, vignettes[13]
- **Experiences**: In most of the cases of urban road pricing the charges have been used to collect money to finance the extension and maintenance of the road infrastructure (Oslo, Bergen, Trondheim). Only in Singapore the reduction of congestion in peak house was the main objective for the introduction of an area licensing scheme. The possibilities of road pricing to contribute to an internalisation of other external effects than congestion has only been the subject of theoretical analysis so far. In practice this objective hasn't ever been the reason for the introduction of a road pricing scheme.

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12 For a comprehensive overview of the possibilities and experiences see Nigel C.L. (1993), Road Pricing and ECMT (1994), Charging for the use of urban roads.

13 For an overview of the different charging systems see for example Pol H. (1994), Charging for the use of urban roads: Netherlands,

f) Eco point system

- **Description**: The eco points system is based on the idea of tradeable permits: Every year a fixed amount of eco points is released. Each goods transport by truck requires a certain number of eco points. The eco point system could be concentrated on the Trans European Network (TEN) or be expanded to all roads. The eco points can be traded between the road haulage companies. The specific emissions of noise and air pollutants of the vehicles could be taken into account when the number of eco points that are needed for a transport of a certain distance is fixed. In order to enlarge the emission reduction the total number of eco points available for road hauliers is reduced every year.
- **Leverage points**: emissions of noise and of air pollutants
- **Metering / charging systems**: Hauliers would have to submit a document containing information about the emission abatement technology of their vehicles or an official list with the information for every type of vehicle must be elaborated.
  The charging technologies could be similar to the ones of a mileage tax: automatic debiting system in the vehicle (on-board equipment) and alongside the road (beacon) or meters ("smart cards") in the vehicles registering the usage of the vehicle. Furthermore, the installation of a eco point stock exchange would be necessary.
- **Experiences**: Europe has already gained experience with the eco point system. Austria and the European Union agreed on the introduction of an eco point system to reduce the emissions of air pollutants and noise of heavy goods transit traffic.[14] The target of the eco points system is a reduction of the total NO_x emissions by 60% by the end of the year 2003. The eco points are distributed among the member states of the EU and from them handed out to the haulage companies. They are not traded.

g) Linked rail-road permits (LRRP)

- **Description**: The LRRP-system is also based on the idea of tradeable permits: The number of permits for heavy goods road transports is coupled with the demand for transport by rail (container, piggyback, etc.).The characteristics of the LRRP-system are the following: Firms using rail for their transports receive tradeable permits for road transports. The number of permits is linked to the ton-kilometres of the rail transports. The haulage companies can use the permits themselves or can sell them on a stock exchange to other companies. To assure the functioning of the stock exchange a certain percentage of the permits (e.g. 10%) should be available for trading and therefore sold directly at the stock exchange. At the time of the implementation of the system the total number of the tradeable permits must be fixed according to the amount of ton-kilometres of goods transport by rail and road in the corresponding year. By keeping the total number of permits constant but raising the ratio between rail ton-kilometres and permits for road transports the desired shift from road to rail can be achieved. The ratio of the LRRP-system directly influences the modal split between rail and road transport. Of course it is also possible to differentiate the system

14 Bundesgesetzblatt der Republik Österreich (1992), Abkommen zwischen der Republik Österreich und der Europäischen Gemeinschaft über den Güterverkehr im Transit auf der Schiene und der Strasse.

according to the emission abatement technology of the vehicles (the "cleaner" the vehicle is the lower is the amount of permits required).

- **Leverage points**: emissions of noise and of air pollutants
- **Metering / charging system**: The possibilities for metering are the same as for the eco points system, goods transport on rail (in tkm) have to be measured and controlled
- **Experiences**: none

h) Parking fees

- **Description**: Specifically urban externalities could be internalised by a time-independent fixed charge.[15] The level of such a parking charge should depend on the average length of car trips connected with the use of the parking space.
- **Leverage points**: local effects like the emissions of noise and of air pollutants (NO_x)
- **Metering / charging systems**: parking meters, electronic systems (automatic debiting in the car)
- **Experiences**: As every car trip begins and ends on a parking space parking policy measures are suitable for a differentiated policy strategy to reduce the negative impacts of car traffic on the environment and on human life. In many urban areas parking policy has become a key policy to influence car use.[16] Nevertheless, parking fees in the form of a time-independent fixed charge haven't been realised in practice so far.

i) Conclusion

In table 3-5 we have summarised the main findings of the discussion above. The table shows what type of external effects could be the main "target" of the different internalisation instrument (black area) and we have marked those externalities that are also affected by the instruments ("side effects", shaded area) but normally are not decisive for the design of the instrument.

Table 3-5 makes clear that only a bundle of different instruments is suitable to tackle the different external effects by road transport. The same is true with regard to the spatial dimension: some instruments will contribute to an improvement of the quality of the local environment, the leverage point of other instruments are global or transboundary effects.

15 See ECOPLAN (1992), Internalisierung externer Kosten im Agglomerationsverkehr, p. 103 ff.

16 For an overview see for example ECOPLAN (1994), Greening Urban Transport - Parking Policy.

Table 3-5: Summary of leverage points and internalisation instruments for road transport

Externality:	global effects		transboundary effects			local effects local air poll.			noise
Internalisation instrument:	CO2 (greenhouse effect)	NOx, CFC (stratospheric ozone loss)	NOx (acid rain gas, tropospheric ozone)	SO2 (soil acidification)	VOC (troposheric ozone)	SO2 (human health, bulidings)	NOx (human health, bulidings)	particulates, lead etc.	noise emissions
differentiated sales tax (f/p)	■		■	■	■			■	■
differentiated vehicle tax (f/p)	■		■	■	■			■	■
tax on fuel (f/p)	■			■					
general kilometre tax (f/p)	■		■	■	■				■
road pricing (f/p)						■	■	■	■
eco point system (f)			■	■	■				■
linked rail-road permits (f)			■	■	■				■
parking fees (p)							■	■	■

f : freight transport

p : passengers transport

■ main leverage point, main impact of the instrument

□ secondary leverage point, side effects of the instrument

3.2.3 Rail transport

Most of the European railway companies are confronted with the problem that their revenues do not cover the running costs of the railway network and least of all the investment costs. These growing deficits present a heavy financial strain on public finances. Their amount is likely to succeed the external costs of rail. The following points are often mentioned to be responsible for this development:

- **External costs of road transport**: The fact that the competitor of rail does not pay its full costs lessens the competitiveness of rail versus road transport. In face of the low prices in the road transport sector the railway companies are forced to offer their performance for non cost-covering prices.

- **Large investments in road infrastructure**: The rail infrastructure and network has not been extended and renewed in the same extensive way as in the case of road transport. Again, the competitiveness of rail was negatively affected.
- **Lack of competition within the rail sector**: Most of the companies hold a monopoly on the use of the railway network. Thus the incentives to produce at minimum cost have been too low.
- **Dependence on policy**: Apart from a few exemptions the management of the rail companies has more strongly been influenced by policy decisions than by developments in the transport market.

In 1991, the council of the European Communities has agreed on a directive that will improve the situation of the railway companies (e.g. independence of the management, division of infrastructure and transport) and result in a liberalisation within the railway sector (key word: free access).[17] Once realised, these measures will result in a more market-oriented structure in the rail sector and will prepare the ground for a more effective use of economic instruments mentioned below.

a) Fixed charge for rolling stock

- **Description**: Once the railways are divided into a transport company and an infrastructure "owner" - most probably a national authority - the infrastructure owner could levy an annual fixed charge for locomotives and carriages that use its infrastructure to cover the investment and maintenance costs. The fixed charge corresponds to the annual road vehicle tax.
- **Leverage points**: The rate of the charge could depend on the emission abatement technology of diesel locomotives (i.e. different air pollutants) and on the noise emissions of the carriages.
- **Metering / charging system**: registration of carriages and locomotives, classification of locomotives and of carriages, fixed charge per year per wheel axle (carriage) and per drive axle (locomotive)
- **Experiences**: none

b) Variable track charge

- **Description**: Similar to road pricing schemes, infrastructure "owners" could introduce some kind of a "track pricing" for railway companies. The charge could be implemented in form of a train kilometre charge.
- **Leverage points**: As in the case of the fixed charge the charge level could be differentiated according to characteristics of the respective locomotive or rolling stock. We would give priority to a noise charge on rolling stock.

17 See Council of the European Communities (1991), Council Directive 91/440/EEC of 29 July 1991 on the development of the Community's railways.

- **Metering / charging system**: defining a method to measure the emissions of noise, classification and marking of rolling stock
- **Experiences**: In Sweden, accident charges are levied in the form of a train kilometre charge ("operation charge").[18]

c) Tax on diesel

- **Description**: Diesel for locomotives of public transport is often exempted from taxation. Nevertheless, some of the external costs of rail could be internalised with a taxation of fuel for locomotives.
- **Leverage points**: fuel consumption, CO_2 content and/or sulphur content of diesel
- **Metering / charging system**: diesel for locomotives has to be integrated within the "normal" taxation of diesel, no large additional installations or metering systems necessary, administration comparable to tax on diesel in the case of road transport, measuring of sulphur content in the case of a sulphur tax
- **Experiences**: Sweden has introduced an environmental charge for public transport in form of a diesel tax.

d) Tax on electricity

- **Description**: Depending on the way the electricity for railways is produced (e.g. in nuclear power station or in coal power station) the more or the less external costs are caused. A tax on electricity could be used to internalise these external costs. The tax should be levied at the power stations in order to take account of the differences in the technology of the electricity production and emission abatement.
- **Leverage points**: CO_2-, NO_x-, sulphur- and/or VOC-emissions of power stations
- **Metering / charging system**: integration of electricity production within a general CO_2/energy tax, deductions for railways that use only hydropower for electricity production
- **Experiences**: An environmental tax on electricity is levied in Denmark. 50% of the tax is refunded to commercial users.

e) Conclusions

Table 3-6 summarises the leverage points and main impacts of the four internalisation instruments for rail transport discussed in this section.

Though table 3-6 contains instruments to internalise external effects caused by air pollutants one should keep in mind that rail's contribution to overall air pollution of transport is negligible. More important are the emissions of noise and therefore a differentiated variable track charge.

18 Ministry of Transport and Communications (1992), Traffic charges on socio-economic conditions, p. 36.

Table 3-6: Summary of leverage points and internalisation instruments for rail transport

Externality:	global effects		transboundary effects			local effects local air poll.			noise
Internalisation instrument:	CO2 (greenhouse effect)	NOx, CFC (stratospheric ozone loss	NOx (acid rain gas, tropospheric ozone)	SO2 (soil acidification)	VOC (troposheric ozone)	SO2 (human health, bulidings)	NOx (human health, bulidings)	particulates, lead etc.	noise emissions
fixed charge for rolling stock			■	■	■				■
variable track charge			■	■	■				■
tax on diesel	■			■		■			
tax on electricity	■			■		■			

■ main leverage point, main impact of the instrument

secondary leverage point, side effects of the instrument

3.2.4 Air transport

a) Emission charge

- **Description**: From a theoretical point of view an emission tax is most appropriate because it is not a proxy of the emissions that is charged but the actually metered emissions. In the case of air transport emissions of some air pollutants can be assessed by multiplying specific emission factors with trip lengths or operating hours.
- **Leverage points**: total emissions of VOC and NO_x
- **Metering / charging system**: definition of a testing method to meter the emissions of the different aircraft, self-declaration of operating hours or trip lengths by the airlines, introduction of a control system, development of an on-board charging system

- **Experiences**: In 1989 Sweden introduced the environmental tax on the emissions of hydrocarbons and nitrogen oxides from domestic aviation. The tax is levied for aircraft exceeding a weight of 5.7 tons. For aircraft types with known emissions, the tax rate is fixed based on an average flying distance of all domestic flights. The individual tax is then calculated as the ratio of the total flying distance for each company and the average flying distance.[19]

b) Kerosene tax

- **Description**: Though fuel is an excellent basis for taxation there are no taxes on kerosene. The main reason for this are international agreements and apprehensions of the countries to put their airlines at a disadvantage.[20] Nevertheless, kerosene could be integrated into any environmentally motivated taxation of fuel.
- **Leverage points**: CO_2 content of kerosene, fuel consumption
- **Metering / charging system**: no large additional installations or metering systems necessary, administration comparable to tax on diesel in the case of road transport
- **Experiences**: none

c) Differentiated landing fees

- **Description**: At present, landing fees are largely based on a cost per tonne of take-off weight. The fees can be differentiated according to emissions of the different aircraft to promote the use of less polluting aircraft.
- **Leverage points**: noise emissions, air pollutants (NO_x and VOC) and/or total fuel consumption of the aircraft in all operational modes.[21]
- **Metering / charging system**: classification of aircraft according to specific emissions and/or consumption (partly existing), payment of the fee can base on existing administrative schemes
- **Experiences**: In some European countries landing fees are differentiated according to noise classes of aeroplanes. The revenues of the fees are often earmarked for noise abatement. The current solutions in different OECD-countries are given in table 3-7.[22]

19 See Ministry of the Environment and Natural Resources (1994), The Swedish Experience, p. 17.

20 Of course, the taxation of fuel for domestic flights is not subject of these agreements.

21 See for example Rommerskirchen S. (1993), The Effects of individual measures, and of combinations of measures, on reducing CO_2 Emissions of Transport in Germany, p. 125.

22 See OECD (1994), Managing the environment, p. 60.

Table 3-7: Aircraft noise charges in OECD-countries

Country	Charge base	Revenue spending
Belgium	Type of aircraft, time of day	Noise abatement
France	Noise characteristics	Noise abatement
Germany	Noise class of aircraft	Noise abatement
Japan	Weight and noise level of aircraft	General budget
Netherlands	Weight and type of aircraft	Noise abatement
Norway	Noise characteristics	No net revenue (bonus-malus-system)
Switzerland	Noise characteristics	Noise abatement

d) Movement taxes[23]

- **Description**: Movement taxes can be applied to passengers or freight air transport. The environmentally motivated taxes generally encourage a switch to other modes of transport and better operational patterns.
  - Freight movements: The tax is added to air transport costs to raise the competitive position of less polluting transport alternatives such as rail, road and ship.
  - Passengers movements: An extra tax is added to the costs of the air tickets. The movement tax lowers the competitiveness of flights for shorter journeys.
- **Leverage points**: lump sum base or relating the surcharge to the trip length (i.e. fuel consumption)
- **Metering / charging system**: surcharge on the normal price
- **Experiences**: none

e) Bubble limits[24]

- **Description**: Bubble limits set ceilings to total emissions of certain air pollutants from all emission sources of a particular geographic region (e.g. airports) or of economic groupings (e.g. airlines). It would be up to the management of the airports or of the airlines to define the reduction strategy and the use of the instruments to meet the ceiling.
- **Leverage points**: total emissions of air pollutants (NO_x, CO_2 and or VOC)
- **Metering / charging system**: environmental monitoring system for airports, calculation of total emission per pollutant
- **Experiences**: none

23 Source: Barret M. (1994), Pollution Control Strategies for Aircraft, p. 39.

24 Source: Barret M. (1994), Pollution Control Strategies for Aircraft, p. 39.

f) Conclusions

The summary of the possibilities to internalise the external costs of air transport by economic instruments are given in table 3-8.

Table 3-8: Summary of leverage points and internalisation instruments for air transport

Externality:	global effects		transboundary effects			local effects local air poll.			noise
Internalisation instrument:	CO2, water vapour (greenhouse effect)	water vapour, NOx, CFC (stratospheric ozone loss)	NOx (acid rain gas, tropospheric ozone)	SO2 (soil acidification)	VOC (troposheric ozone)	SO2 (human health, bulidings)	NOx (human health, bulidings)	particulates, lead etc.	noise emissions
emission charge	■	■	■		▒		▒	▒	
kerosene tax	■	▒	▒		▒		▒	▒	
differentiated landing fees	▒	▒	▒		■		■	■	■
movement taxes	■	▒	▒		▒		▒	▒	▒
bubble limits					■		■	■	

■ main leverage point, main impact of the instrument

▒ secondary leverage point, side effects of the instrument

Table 3-8 shows that in the case of air transport each relevant external effect can be focused by an internalisation instrument.[25] Obviously, the main challenge of future air transport policy is not to develop new internalisation strategies but to overcome the institutional and political factors that oppose to an introduction of environmentally motivated economic instruments in the field of air transport.

25 The contribution of aircraft to total sulphur emissions is negligible.

3.2.5 Shipping

a) Tax on fuel

- **Description**: In comparison to road transport ships often use diesel with a high sulphur content of 2-4%. A fuel tax differentiated according to the sulphur content could accelerate the use of less polluting diesel.
- **Leverage points**: fuel consumption and sulphur content
- **Metering / charging system**: no large additional installations or metering systems necessary, administration comparable to tax on diesel in the case of road transport, measuring of sulphur content in the case of a sulphur tax
- **Experiences**: Some Scandinavian ferry lines have substituted this quality of diesel by low-sulphur oil (max. 0.5%).

b) Differentiated harbour dues

- **Description**: differentiation of harbour taxes to promote the use of less polluting vessels
- **Leverage points**: emission of air pollutants (NO_x and VOC)
- **Metering / charging system**: classification of vessels according to their emission abatement technology, payment of the fee can base on existing administrative schemes
- **Experiences**: none

c) Differentiated canal dues

- **Description**: Like motorways in the case of goods road transport, canals offer best opportunities for electronic charging systems (limited number of vessels, impossibility of circumventing). The canal dues could be distance-dependent and differentiated according to the emission abatement technology of the engine if a useful classification of the vessels is possible.
- **Leverage points**: emission of air pollutants (NO_x and VOC)
- **Metering / charging system**: classification of vessels according to their emission abatement technology, manual payment system: payment of the fee can base on existing administrative schemes, electronic payment system: automatic debiting system in the vessel (on-board equipment) and alongside the canal (beacon), meters in the vessels registering the usage of the vessel
- **Experiences**: none

d) Conclusions

In table 3-9 we have summarised policy options to internalise the external costs of inland navigation. The three internalisation instruments cover all major external effects of shipping. Noise emissions from vessels are negligible.

Table 3-9: Summary of leverage points and internalisation instruments for shipping

Externality:	global effects		transboundary effects			local effects local air poll.			noise
Internalisation instrument:	CO2, water vapour (greenhouse effect)	NOx, CFC, water vapour (stratospheric ozone loss)	NOx (acid rain gas, tropospheric ozone)	SO2 (soil acidification)	VOC (troposheric ozone)	SO2 (human health, bulidings)	NOx (human health, bulidings)	particulates, lead etc.	noise emissions
tax on fuel	■		▒	■	▒	▒	▒	▒	
differentiated harbour dues	▒		■	▒	■	▒	■	■	
differentiated canal dues			■	▒	■	▒	▒	▒	

■ main leverage point, main impact of the instrument

▒ secondary leverage point, side effects of the instrument

The most important result of the discussion so far can also be found in the case of shipping: one internalisation instrument alone will not do the job. For shipping and for all other modes of transport a bundle of instruments will be needed to design a transport policy strategy that meets the requirements of sustainability.

3.3 Selection of the instruments

3.3.1 Selection criteria

The previous sections have shown that a bundle of instruments will be needed to design a transport policy strategy that meets the requirements of sustainability. In this section, those instruments that shall be analysed in detail in three sub reports are chosen. The theoretical background for this selection is given in section 2.3.3 where we have defined criteria to evaluate an optimum combination of internalisation instruments. We have mentioned the following:

- The bundle should lead to substantial reduction of the negative impacts of transport on the environment and on human life (criteria "effectiveness").
- The objective of making transport more sustainable should be attained at minimum costs (criteria "efficiency").
- The instruments to internalise external costs should be designed in a way that they minimise the introductory and running costs (criteria "implementation costs").
- The bundle should set lasting incentives to change mobility behaviour and to improve the technology used by the different means of transport (criteria "dynamic effects").
- Last but not least there should be some realistic chance to achieve public acceptance and thus to find political majorities in favour of the strategy (criteria "political feasibility").

Which of the instruments described in section 3.2 meet these requirements at the best and should therefore be part of an "optimum" internalisation strategy? This question can hardly be answered without having discussed the features of each instrument in detail. The **example of a sales tax for passengers cars** may illustrate this problem.

- **Implementation costs**: The implementation costs depend on the way the tax differentiation is defined. If, for example, the sales tax is differentiated according to the emissions of air pollutants all passengers cars must be assigned to a certain category of cars. As a consequence, it may be necessary to work out a new classification system at the European level or an existing national classification system may be adopted. In the first case the implementation costs will be much higher than in the second one.
- **Dynamic effects**: Also the innovation incentives of a differentiated sales tax depend on the characteristics of the tax. The incentive is comparatively strong if the tax rate differentials are rather high and if the lowest tax rate is not applied to the best available technology but to technologies beyond the technical limits of today. Such a sales tax may set even stronger incentives for car manufacturers to develop less polluting cars than a fuel tax because buyers of cars with high emission factors could hardly be found anymore.

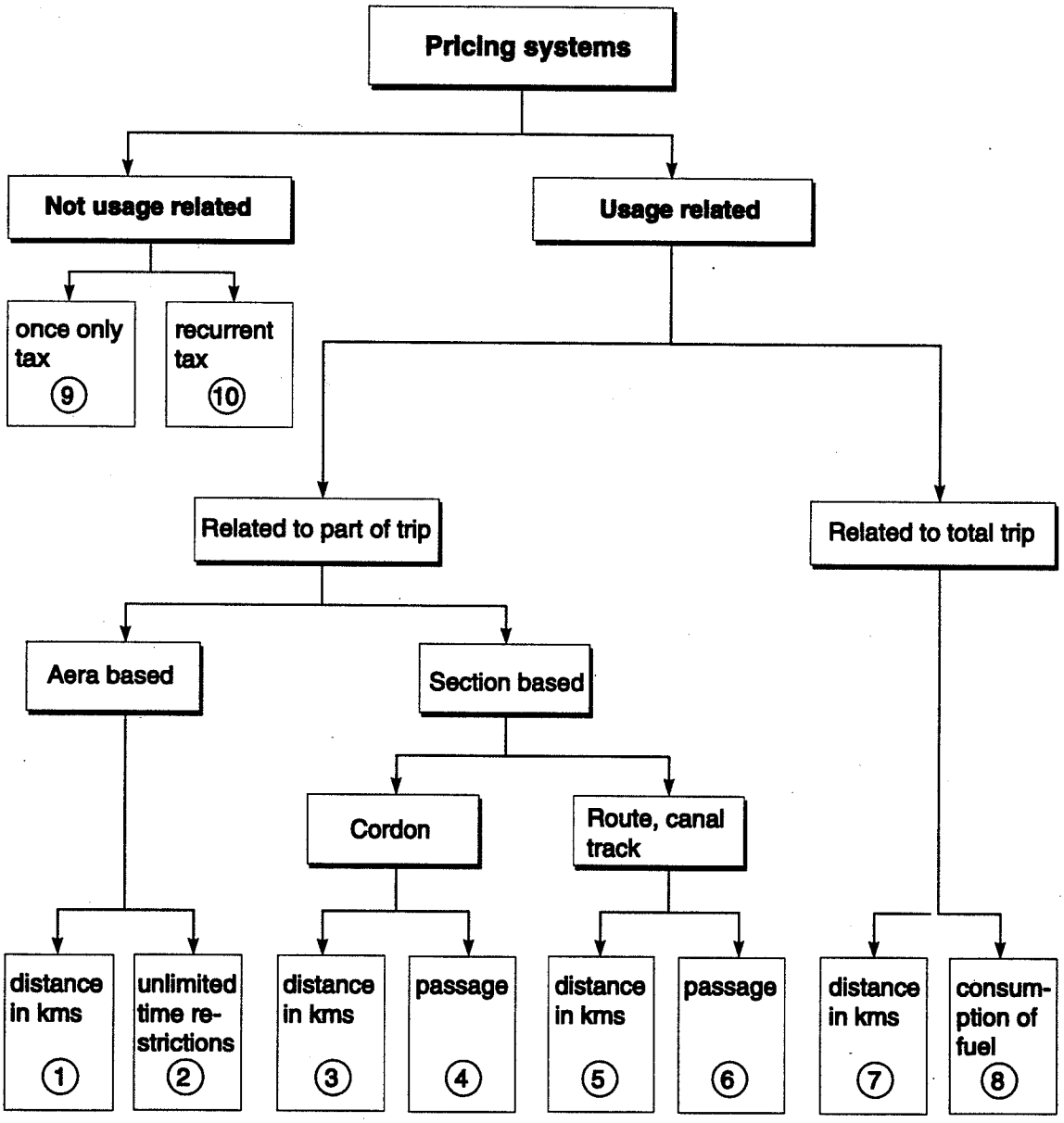
Obviously, without having described the instruments in detail it is not possible to make - for example - a rating of the instruments based on the criteria "efficiency". How can a kilometre tax be compared with fuel tax if the way the kilometre tax is differentiated and the technology that is used as metering and charging system are not known? Therefore ,

in this pre-selection **some "general" selection criteria** are defined that can be applied without knowing the exact features of the instruments, i.e. we define characteristics that must be met but we renounce to make comparisons between the different instruments.

The instruments to be analysed in detail have to meet the following requirements:

- **Usage related and non usage related instruments**: Broadly speaking, the closer the pricing system is bound to the usage of the transport modes (i.e. the activity that causes the external effects) the better the effectiveness requirement is met.

Figure 3-10: Overview of pricing systems



In figure 3-10 the different forms of usage related and non usage related pricing systems are summarised. The advantages of usage related pricing systems are well-known from the economic theory:

- short term and lasting incentive to change mobility behaviour
- realising the polluter-pays-principle (i.e. minimising unjustified changes in the consumer surplus).

Each of the instruments discussed in section 3.2 can be assigned to one of the eight boxes in figure 3-10. Fuel taxes are assigned to box 8 as - fuel efficiency of the vehicle and driving behaviour given - consumption of fuel depends on the distance of total trip. Annual registration fees belong to box 10. In the valuation of the instruments we will distinguish between the following categories:

✘✘✘ fully usage related (boxes 1,3, 5, 7 and 8)	✘✘ partly usage related (boxes 2,4 and 6)	✘ not usage related (boxes 9 and 10)

- **Differentiation options**: In section 2.3.2 we have stressed the importance of a differentiation of the instruments according to the dimensions technology, time and space. Some of the instruments are suitable for a differentiation according to these dimensions, in other cases the potential is rather low. The following stages of differentiation options will be distinguished in the valuation of the instruments:

✘✘✘ many differentiation options	✘✘ some differentiation options	✘ hardly any differentiation options

- **Incentives for innovation**: It should be possible to define the features of the instrument in a way that technological innovation and new technologies are encouraged. The introduction of the instrument should thus improve the competitiveness of European industry and transport services in the long run. We will discuss whether an instrument sets strong, medium or modest incentives for technological innovations:

✘✘✘ strong incentives for techn. innovation	✘✘ medium incentives for techn. innovation	✘ modest incentives for techn. innovation

- **Policy level**: The analysis will concentrate on instruments for which the introduction at the European level makes sense. A strategy at Community level is useful if
  - one must expect that national and local authorities will not be able to introduce an instrument to internalise external costs single-handedly because they are confronted with strong opposition arising from the fear of a lost of competitiveness of the own industry and services.
  - the introduction of an instrument requires the development of technical equipment that could once be used in all European countries (e.g. the metering equipment for a electronic road pricing scheme).
  - the external effect considered comprises a strong international dimension.

The following leverage points of policy action will be distinguished:

- ✘✘✘ introduction at EU level
- ✘✘ introduction at national or local level, co-ordination at EU level
- ✘ introduction at national or at local level

In case ✘✘ the tasks of the Community could consist in defining categories of vehicles according to their emission abatement technology, setting minimum values of tax levels etc.

- **Previous evaluations**: Some of the instruments mentioned in section 3.2 have already been analysed in detail in other research projects and will therefore not be treated in this research project. For the valuation of the instruments we choose the following categories:
  - ✘✘✘ subject of few evaluation studies, need for additional studies
  - ✘✘ subject of some evaluation studies, some need for additional studies
  - ✘ subject of many evaluation studies, small need for additional studies

In the following section the instruments described in 3.2 will briefly be discussed according to these criteria.

3.3.2 Valuation of the instruments

The following valuation of the different instruments should be considered as "guestimates" of the authors. There are no underlying "proofs" for the tables 3-11 to 3-14.

Table 3-11: Valuation of instruments for road transport

Instruments	Related to usage	Differentiation options	Incentives for innovation	Policy level, EU dimension	Need for add. studies
sales tax	✘	✘✘	✘✘✘	✘✘	✘✘
vehicle tax	✘	✘✘	✘✘✘	✘✘	✘✘
tax on fuel	✘✘✘	✘	✘✘✘	✘✘✘	✘
kilometre tax	✘✘✘	✘✘	✘✘✘	✘✘✘	✘✘
electr. road pricing	✘✘✘	✘✘✘	✘✘✘	✘✘	✘
vignette systems	✘✘	✘✘	✘✘	✘	✘
eco points	✘✘✘	✘✘	✘✘	✘✘✘	✘✘
LRRP	✘✘✘	✘✘	✘✘	✘✘✘	✘✘✘
parking fees	✘✘	✘✘	✘✘	✘	✘✘

Remarks:

- The fact that the sales and the vehicle tax do not influence other decisions than the type and features of the vehicle bought or taken off the road makes these two eco-

nomic instruments unsuitable to realise the polluter-pays-principle. On the other hand both instruments - if the tax rate differentials are large enough - set strong incentives for car manufacturers to develop less polluting and/or less consuming vehicles. From these points of view the sales and the vehicle tax should be part of a comprehensive internalisation strategy but they should not be the main instruments to make road transport pay its full costs.

- Taxation of fuel has often been analysed in the recent past as most of the proposals that stress the importance of a stronger taxation of energy and resources include fuel taxes. The limited differentiation options of fuel taxes should not be considered as major disadvantage of this instrument. The reason is that taxes on fuel could be introduced as "global economic incentive charge" for all transport modes and then be combined with specific charges that are differentiated according to the dimensions time, space and technology.[26]
- The general distance-dependent kilometre tax can be an alternative or a complement to a taxation of fuel depending on the way the tax is differentiated (emission abatement technology or fuel consumption). The future development of metering and charging systems will allow some differentiation of the tax rate. Because each vehicle must be equipped with a metering system in a first step the introduction of a general mileage tax could be restraint to heavy goods vehicles, simply because they are less numerous than passenger cars.
- If the tax is restraint to certain areas or certain section of the road network (different forms of road pricing and vignette systems) it would be an excellent complement to a fuel tax as especially electronic road pricing schemes offer best opportunities for a differentiated transport policy strategy.
  For the special case of urban areas and passenger cars traffic parking policy measures are to be considered as "less sophisticated" alternatives to road pricing schemes.
- Alternatives to pricing at EU level are the two instruments eco points and linked railroad permits that base on the idea of tradeable permits. Proposals for solutions at European level haven't been worked out so far. This maybe go back to the fact that the two instrument are not mentioned within the principles of the Common Transport Policy.

Table 3-12: Valuation of instruments for rail transport

Instruments	Related to usage	Differentiation options	Incentives for innovation	Policy level, EU dimension	Need for add. studies
fixed charge	✘	✘✘	✘✘✘	✘✘	✘✘✘
var. track charge	✘✘✘	✘✘✘	✘✘✘	✘✘	✘✘✘
tax on diesel	✘✘✘	✘	✘✘✘	✘✘✘	✘
tax on electricity	✘✘✘	✘	✘✘✘	✘✘✘	✘

26 See the proposal of a comprehensive internalisation strategy of Infras / IWW (1994), External effects of Transport, p. 256.

Remarks:

- As in the case of road transport the taxation of diesel and of electricity has often been discussed within proposals concerning ecologically motivated taxation schemes for energy and resources.
- Track charges for rail haven't been an important argument in transport policy discussion so far. One reason maybe that institutional changes within rail sector are a necessary condition to implement track charges successfully.

Table 3-13: Valuation of instruments for air transport

Instruments	Related to usage	Differentiation options	Incentives for innovation	Policy level, EU dimension	Need for add. studies
emission charges	xxx	xx	xxx	xxx	xxx
kerosene tax	xxx	x	xxx	xxx	xxx
landing fees	xx	xxx	xxx	xx	xx
movement taxes	xx	xx	xx	xx	xxx
bubble limits	xx	xx	xx	x	xxx

Remarks:

- According to the knowledge of the authors internalisation instruments for air transport haven't been analysed very extensively in the recent past. This situation will probably change if a stronger inclusion of air transport in environmentally motivated taxation schemes will be decided.
- As in the case of road transport a kerosene tax or emission charges could take the role of "global" incentives at EU level. They could be accompanied by instruments that are effective at the local level and offer more possibilities of a differentiation.

Table 3-14: Valuation of instruments for shipping

Instruments	Related to usage	Differentiation options	Incentives for innovation	Policy level, EU dimension	Need for add. studies
tax on diesel	xxx	x	xxx	xxx	x
harbour dues	x	xxx	xxx	xx	xxx
canal dues	xxx	xxx	xxx	xx	xxx

Comments:

- Only the tax on diesel is suitable for a solution at EU level (within the frame of a general taxation of energy or CO_2 emissions).
- Harbour and canal dues could be introduced as complements to the taxation of fuel. However, one should consider that the contribution of shipping to air pollution, climate change and noise is quite small. Thus a tax on diesel used by vessels may render superfluous the introduction of environmentally motivated canal or harbour dues.

3.4 Conclusions: Selection of the instruments

3.4.1 What transport modes?

The three sub reports concentrate on **road, rail and air transport**. Shipping is ignored due to two reasons:

- From the point of view of external costs of air pollution, climate change and noise shipping is a minor problem in comparison to the other three transport modes.
- At EU level the introduction of a fuel tax within the frame of a general taxation of energy and/or CO_2 would be the most appropriate policy measure.

3.4.2 What instruments?

For all transport modes a **taxation of fuel** could be introduced to internalise those externalities that are closely related to fuel consumption (see tables 3-5, 3-6, 3-8 and 3-9). Due to the far-reaching characteristics, the lasting 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 of fuel**.

Such a tax could, for example, take the form of the CO_2/energy tax. Its introduction at EU level has been suggested by the EU Commission in May 1992. The features of this and of similar taxes and the impacts of the introduction have extensively been discussed at EU and at national level. Also within the discussion of the possibilities and the limits of an ecological tax reform the taxation of energy (including fuel for transport) has been one major element.

Therefore and because a comprehensive proposal for a energy and fuel tax for all transport modes has been worked out very recently[27] an analysis of such a "global economic incentive charge" is not carried out in this research project. The focus of the sub reports is more on specific internalisation instruments for the three transport modes.

a) Road transport

For **freight transport** an analysis of the following instruments is assessed to be useful:

- **Differentiated kilometre tax (mileage tax) for freight transport (top priority)**
  The differentiation of the mileage tax should take account of the specific emissions of air pollutants that are only indirectly affected by the tax on fuel (i.e. NO_x and VOC).

27 See Infras / IWW (1994), External Effects of Transport, p. 255 ff.

The following reasons speak in favour of this proposition:

- At European level road freight transport is the second most important polluter (approx. 20% of total external costs caused by all transport modes).[28] Only passengers cars contribute a larger share to total external costs.
- If differentiated as proposed above a mileage tax would be a complement to a general taxation of fuel.
- Road freight transport is one of the most important fields of the Common Transport Policy (CTP).
- The differentiated mileage tax meets most of the selection criteria of section 3.3.1 (see table 3-11).
- Any differentiated mileage tax requires the development of a metering system (see point d) of section 3.2.2). Similar systems are probably developed to charge road freight transport for the use of road infrastructure according to the territoriality principle.

❑ **Tradeable permit system: eco point system or linked rail-road permits (second priority)**

Also tradeable permit systems meet to a large extent the selection criteria (see table 3-11). Furthermore, these systems haven't been analysed in detail so far and would therefore be a suitable subject of this research project. Nevertheless, tradeable permit systems are considered as second priority instruments due to two reasons:

- The Common Transport Policy focuses on road user charges rather than on tradeable permit systems.
- It is more difficult to implement a usage related permit system than a mileage charge (implementation costs, stock market, problem of uncertain prices).

In the case of **passengers transport** it is rather difficult to define a useful proposal for an analysis in detail:

❑ The tax on petrol is included in the general taxation of energy.

❑ Road pricing schemes and vignette systems have been extensively discussed in the recent past.[29] At the moment technical problems of electronic road pricing schemes dominate the discussion.

❑ The accurate policy level for the introduction of parking policy measures is the local level or the national level rather than the EU level.

Nevertheless, if we assume a taxation of fuel to be the centre of any internalisation strategy an analysis of a **system of differentiated sales and vehicle taxes co-ordinated at EU level** is fruitful because of the complementary character of the two types of instruments.

28 See Infras / IWW (1994), External Effects of Transport, p. 183 ff.

29 See for example Lewis N.C. (1993), Road Pricing, ECMT (1994), Charging for the use of urban roads and Nordplan (1994), Urban road pricing.

b) Rail transport

In the case of rail transport the focus of the sub report is on

- the **institutional changes** that are a prerequisite for the implementation of any internalisation strategy (key word: free access)
- an analysis of a **variable track charge** to internalise the external costs of noise of the rolling stock.

The reasons for this are:

- Noise emissions are the most important external effect of rail transport.
- The possibilities and limits of a variable, differentiated track charge haven't been subject of many research projects within the recent past.
- The variable track charge meets most of the criteria of the pre-selection (see table 3-12)
- The fuel and the electricity tax are included within the general taxation of energy.
- The fixed track charge doesn't come off well in the valuation of the instruments for rail transport.

c) Air transport

For air transport useful instruments to be analysed in detail are:

- **Emission charge (top priority)**
  With regard to the objective of an internalisation of external costs such charges come rather close to the theoretically ideal case as the emissions are directly charged. Accordingly, the emission charges meet almost perfectly the criteria of the pre-selection (see table 3-13). As there is very little experience with emission charges for air transport the main objective of the analysis would be to answer the question of the feasibility of an emission charge.

- **Kerosene tax (second priority)**
  Though the kerosene should be part of a general taxation of fuel would be a suitable subject of a research work. The main reason is that - in contrast to the other taxes on fuel - there are only very few studies on this topic.

The other instruments for air transport are not considered because of the following reasons:

- Differentiated landing fees have already been introduced on a number of air ports. A comprehensive study could first of all consist of an overview of the different solutions. Furthermore, from our point of view differentiated landing taxes are to be introduced by national authorities rather than at EU level. On the other hand the classification of the air craft is most probably a task of an international organisation.
- The introduction of bubble limit is a local job.

3.4.3 Summary and selection

In table 3-15 the discussion of the previous sections is summarised. The table shows what internalisation instruments could have been discussed within the three sub reports.

Table 3-15: Summary of the possible instruments

Transport mode	Top priority	Second priority
Road freight transport	**mileage tax** differentiated according to the emissions of air pollutants (NO_x, VOC)	tradeable permit system: – **eco point system** – **linked rail-road permits**
Road passengers transport	system of **differentiated sales and vehicle taxes**, including a tradeable permit system at the level of car manufacturers (CAFE-standard)	
Rail transport	**variable track charge** differentiated according to the noise emissions of the rolling stock; strong emphasis on the institutional prerequisites	
Air transport	feasibility of an **emission charge** Alternative: comparison of emission charge and kerosene tax	analysis of a **kerosene tax**

On a workshop held in March 1995 out of these possibilities the following had been **selected**:

- A mileage tax for European road freight transport
- Differentiated sales and vehicle taxes
- A variable track charge for railway noise.

The following **part II of the synthesis report** contains the **summaries of the three sub reports**.

Part II: Summaries of the sub reports

Contents:

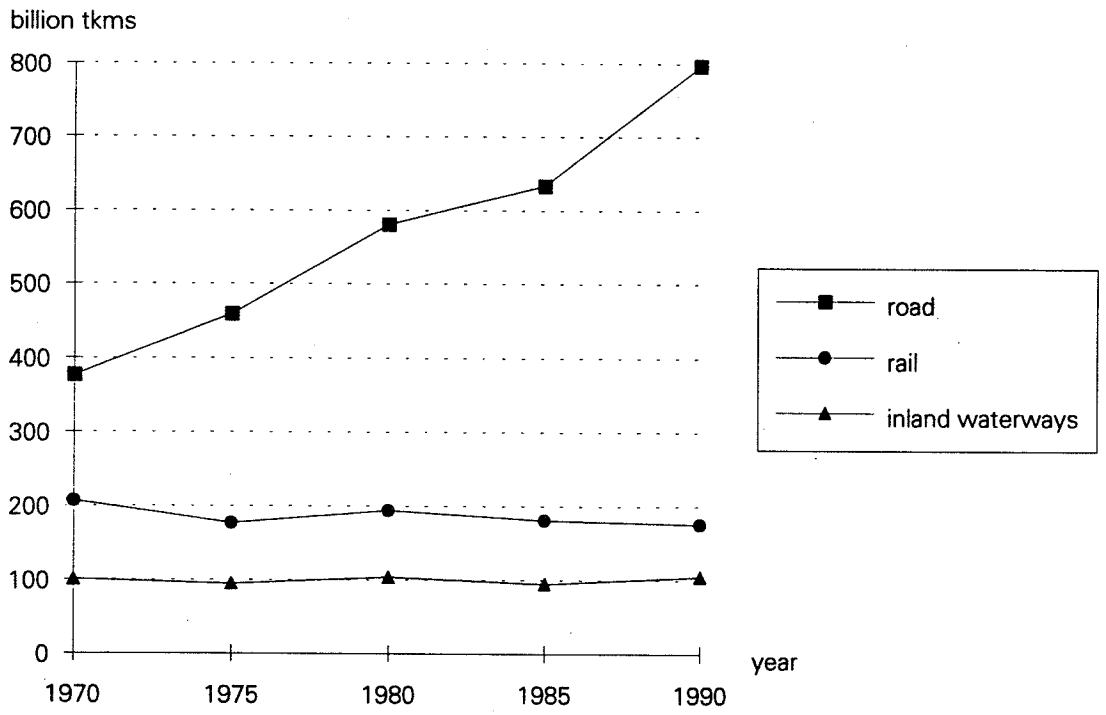
4 A mileage tax for European road freight transport

Summary of sub report "A mileage tax for European road freight transport", ECOPLAN

4.1 Introduction

In the last two decades freight transport has substantially grown: Between 1970 and 1990 the volume of tonne-kilometres (tkm) has increased by more than 50%. Figure 4-1 shows that first of all road freight transport has profited from this growth .

Figure 4-1: Freight transport in the EU, 1970 - 1990



Source: Commission of the European Community (1993), The future Development of the Common Transport Policy - A Global Approach to the Construction of a Community Framework for Sustainable Development (White Paper on Transport), Annex I.

The completion of the internal market will cause a further growth of freight transport. According to the White Book of the Commission an enormous increase is expected: "As to the future, forecasts of growth in transport demand show that in a "business as usual" scenario with a reasonably favourable economic climate the expansion of the road sector is likely to be buoyant: a near doubling of road transport demand for both passengers and freight seems likely." Without policy measures to reduce the harmful emissions most serious effects on the environment and on human health are to be expected. One such measure could be a mileage charge as described in the following sections.

4.2 Overview of the proposal

Table 4-2: Summary of the main features of the proposed mileage tax

features of the tax	description	comments
basic idea	variable tax for heavy goods vehicles (HGV) to internalise external costs	based on the territorial principle
object of the tax	HGV, permissible total weight > 3.5 t	
field of application	whole road network of the Member States	
tax base	permissible total weight and kilometre driven	
tax rate: "basic version"	lower bound: 0.006 ECU/t_{tw}km upper bound: 0.012 ECU/t_{tw}km	based on estimates of external costs that are available at present, to be adjusted in the course of time
tax payer	owner of the HGV (haulage companies)	
differentiation of the tax rate	– "extended version": differentiation according to emissions of air pollutants and noise of vehicle type – "sophisticated version": taking account of spatially different levels of pollution and of congestion	Three emission classes for air pollutants: EURO I, II and III; based on avoidance costs or on external (damage) costs e.g. a doubling of the tax rate in urban areas and higher tax levels during rush hours and for bottlenecks in the transport system
metering system	– electronic road pricing system – two-way data communication between vehicle and a vehicle identification system	first best solution is based on a global positioning system or on an electronic impulse of the speedometer
implementation	– EU: defining main features and minimum requirements (lower bound tax rate) – Member State: introduction	new Directive of the Council in compliance with the Directive
introduction scheme	– gradual increase of the tax rate – transitional period for "first mover" initiatives of the Member States	starting tax rate: lower bound
use of the revenues	– stage 1: earmarking for less polluting transport modes, financing of rescue packages for the environment – stage 2: redistribution of the revenues to the economy	at EU level: only recommendations => national solutions stage 1: only as interim solution reduction of labour costs, probably in the frame of an ecological tax reform

Comment:

a) Tax base

Key parameter of every mileage tax will be the number of kilometres driven. Furthermore, the tax base takes into account the weight of the vehicles. Here it was decided to base on permissible total weight of the vehicles due to two reasons:

- The permissible total weight is given in the vehicle documents
- With this tax base it would be possible to integrate infrastructure costs of road freight transport in the mileage tax (user-pays-principle)

b) Tax rate

In the **"basic version"** the tax rate is only differentiated according to the permissible weight of the vehicles. The basic tax rate was calculated using existing conservative estimates of external damage costs for noise, air pollution and accidents (lower bound 20 ECU per 1'000 tkm, upper bound 40 ECU per 1'000 tkm). Not included are the external costs of CO_2-emissions (greenhouse effect). Assumptions on the payload and the average load per vehicle category had to be made to calculate the average mileage tax per tonne of permissible total weight and kilometre, which is

- Upper bound: 0.012 ECU/t_{tw}km
- Lower bound: 0.006 ECU/t_{tw}km

In the **"extended version"** the level of the mileage tax is differentiated according to emissions of air pollutants. As main criterion for this differentiation, future emission limits of the EU for diesel driven HGV were used. Based on these limits **three classes of HGV with different emission factors** were defined. The differentiated tax rate was then calculated with avoidance costs (estimated additional costs to introduce the cleaner technology) and with external damage costs (estimated reduction of the damages due to the cleaner technology). The results of both calculations are summarised in table 4-3 and 4-4, respectively:

Table 4-3: Differentiated tax rate in ECU/t_{tw}km (per tonne of permissible total weight and kilometre driven)
With avoidance cost approach

Type of HGV	Upper bound in ECU	in %	Lower bound in ECU	in %
Class 1	0.0109	91%	0.0049	83%
Class 2	0.0116	97%	0.0056	94%
Class 3	0.012	100%	0.006	100%

Table 4-4: Differentiated tax rate in ECU/t_{tw}km (per tonne of permissible total weight and kilometre driven) With damage cost approach

Type of HGV	Upper bound in ECU	in %	Lower bound in ECU	in %
Class 1	0.0088	74%	0.0044	74%
Class 2	0.0108	90%	0.0054	90%
Class 3	0.012	100%	0.006	100%

Air pollution, noise and congestion often concentrate in urban areas and at particular times and the same holds therefore for the external costs. Correspondingly, a mileage tax intending to internalise the external costs of HGV should vary between areas with different air qualities and noise levels. We call the version of the mileage tax meeting these requirements "**sophisticated version**". Although it would not make sense to fix a specific extra charge for all urban areas in Europe (the transport problems vary from town to town) existing studies show that external costs of air pollution, noise and congestion are at least doubled (this is a very conservative value) in urban areas compared to rural areas.

c) Metering systems

After discussing the requirements which a metering system designed to implement the mileage tax has to meet, the following conclusions could be drawn: To meet the demands of the proposed mileage tax (applicable on the whole road network, differentiation according to emission standards, space and time) only an **electronic road pricing system** is possible. Metering systems fulfilling all the requirements are not yet available. But there are large ongoing efforts to develop such systems at national and European level. It can be expected that in the next five years standards for such systems will be defined.
Already now, the choice of possible metering systems can be limited to **only a few**, even if the ideal metering system is not yet determinable:

- Basically, a two-way data communication between the vehicle and an electronic system unit outside of the car (beacons, global positioning system) is necessary. As kilometres driven must be registered on the whole road network this registration must be possible without expensive new infrastructure needs. This means in our view that **registration systems based on beacons are out of question** as the costs of building such beacons for the whole network would be enormous.
- There are at least two categories of registration systems that are not dependent on additional infrastructure investments and could therefore build the base for the implementation of the mileage tax:
  - Firstly, the kilometres driven could be registered on the base of an **electronic impulse of the speedometer**. Acceleration and rotation signals serve as a control and to prevent manipulation. With such a system beacons would only be necessary between areas with different tax levels and at national borders.
  - Secondly, the registration can be based on a receiver/transmitter unit receiving **signals of the global positioning system** (GPS). In this case the speedometer im-

pulse is used to control plausibility of GPS-signals. This solution has the advantage that no investments for new communication infrastructure are needed as the spatial identification of the vehicle is very precise. Therefore, it would also be possible to vary the tax level in different areas and for different times. Already now, the GPS-system is used by private hauliers to optimise the logistics of the fleet. This private use of GPS-systems will rise substantially in the next years.

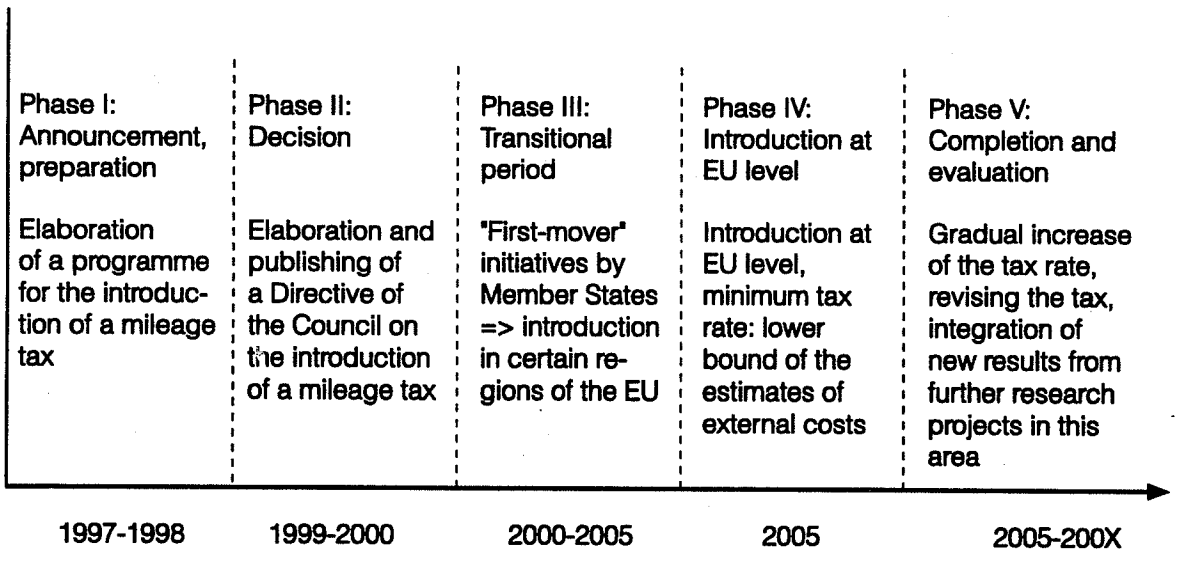
d) Implementation and Introduction

In many respects, the introduction of a mileage tax for road freight transport calls for policy measures at community level:

- **Distorting effect on competition**: A national mileage tax without an appropriate degree of co-ordination and harmonisation may influence the competitiveness of the economy in the respective country.
- **Global and/or transboundary character of environmental problems caused by road transport**: Especially in the case of air pollution the emissions of transport do not respect national boundaries. National action may not result in a substantial improvement of the air quality.
- **Compatibility of the metering system**: Community action will ensure the development of compatible systems and prevent the emergence of new barriers of trade at national borders. Furthermore, the development of such a system at EU level will cause less costs than uncoordinated national actions.

Therefore, a proposal for a gradual introduction at EU-level was developed. Figure 4-5 summarises a conceivable introduction scheme for a mileage tax at EU level that distinguishes between five different phases. It has to be emphasised that in this proposal the introduction of the mileage tax itself is left to the Member States. The time schedule assigned to each phase is of course only one possibility among others.

Figure 4-5: Proposal for an introduction scheme



e) Use of the revenues

Based on a review of different ways how to use the revenues of a mileage tax, a proposal was developed that takes into consideration criteria like political acceptance, revenue neutrality, administrative costs and the requirement that the use of the revenues does not weaken the incentive effect of the tax. The proposal is as follows:

- **Stage 1**: In a first stage which is clearly defined as an interim solution we suggest a mix of earmarking for investments in environmentally more compatible transport modes (e.g. TEN-projects for rail and inland waterways) and of rescue packages for the environment and/or of measures to reduce the negative impacts of road transport on human life. The first way to use the revenues is especially justified as long as the rate of the mileage tax hasn't reached its final level.
- **Stage 2**: In a second stage we propose to implement a refunding system. If, at that time, the Member States will still intend to introduce a harmonised CO_2/energy tax, the implementation of the two refunding systems will have to be closely co-ordinated. This could happen in the context of larger reorganisation of the existing taxation system, i.e. in the context of an ecological tax reform. The objective would be to reduce labour costs.

It is conceivable that at EU level it is only determined that the revenues must not be refunded to the transport sector. In addition, the EU would only make recommendations but would leave it to the Member States to define the use of the revenues in detail.

4.3 Assessment of the mileage tax

Regarding the main impacts of the mileage tax the analysis has to distinguish between the impacts on the transport sector, on the other sectors of the economy and on the environment. Additionally, a technical assessment including a comparison of the mileage and the diesel tax was carried out. At last, the political aspects of a mileage tax were assessed.

a) Impacts on the transport sector

- Given the various assumptions[1] the expected **increase of average road transport prices** is around 13% in the case of the lower bound tax rate and around 26% if the upper bound of the tax rate is applied.
- The proposed mileage tax will cause a rather **modest reduction of the road freight transport volume** of about 2-6%. Compared to the expected growth of road freight transport (see figure 4-1), the mileage tax will only lead to a small decrease of the annual growth rate.

1 Some of these assumptions are of rather speculative character. Therefore, the results derived from the estimates should be considered as orders of magnitudes and not as exact figures.

- Approximately three-fourth of the reduction of road freight transport will be achieved by a **shift of freight transport to rail**. Due to differences in total capacity this shift would correspond to an increase of rail transport by about 7-17%.
- The **shift to inland shipping** is expected to be modest. Geographical reasons, transportation time and the rather different characteristics of the goods transported by ships (i.e. bulk goods) and HGV prevent a large shift from road transport to inland shipping.
- In the **road transport sector** itself probable impacts of the mileage tax are:
  - raise of average occupancy rate
  - adjustments in the vehicle fleet (cleaner and smaller HGV)
  - strengthening of the trend towards larger haulage companies
  - positive effect on combined transport
  - improving competitiveness of haulage firms with a modern vehicle fleet.

b) Impact on other sectors of the economy

The influence of the mileage tax on the cost structure and thereby on product prices of the other sectors was assessed on the base of the transport intensity of the sectors (the transport intensity being defined as the ratio between the sector specific road freight transport costs and the value of the gross production of the sector).
From the calculations of the direct and indirect effects[2] of the mileage tax on the production costs of the sectors with a high (road freight) transport intensity the following conclusions can be drawn:

- The proposed mileage tax will only have a **very moderate influence on the production costs of other sectors**. Compared to other influences (the exchange rates, the wage level or technical progress) the impact is nearly negligible.
- The calculations show that for the lower bound of the proposed mileage tax the **maximum increase of the production costs comes to 0.2 - 0.5% for almost every sector with a high transport intensity**. Only for two sectors (cement, lime, building materials and petroleum products, refineries) it is conceivable that the cost effect will be above 0.5%. For all other sectors, particularly the whole services sectors, the cost effect amounts to less than 0.3%. Taking the upper bound of the mileage tax, approximately doubled cost effects compared to the lower bound mileage tax have to be expected.
- On account of the above results the proposed mileage tax will **not have a noticeable impact on the competitiveness and on the growth rate of the European economy**. This is true all the more as the revenues of the mileage tax are not lost but would be refunded to the economy (e.g. through a reduction of the social security contributions or through a wage sum bonus).

2 The **direct effect** corresponds to the impacts of the mileage tax on the cost and price structure of all other sectors. The higher costs of road freight transport will partly be transferred to ancillary sectors and to customers of other sectors (**indirect effect**).

- At last, it must be remembered that the introduction of the mileage tax sets an incentive for adjustment processes towards a **more efficient and welfare optimising road freight transport system**.

c) Ecological impact

Two effects determine the ecological impact of the mileage tax:

- The **reduction of the transport volume** and therefore of the road performance of road freight transport reduces total emissions. Due to the low reduction of the transport volumes this effect is rather modest. This is also a consequence of the very low values of external costs that were used to define the basic tax rate.
- More important than the first effect is the **incentive set by the tax to improve the emission abatement technology** as the potential of improved technologies is considerable. The proposed differentiation of the tax rate will accelerate the use of less polluting trucks. If the differentiation is adjusted in the course of time a lasting incentive for truck manufacturers to develop emission abatement technologies beyond today's knowledge will be set.

d) Technical assessment

The technical assessment of the mileage tax shows that the development and running costs of an electronic metering system to implement the mileage tax can be justified by the positive effects of the mileage tax on the environment and human health.

- Although the "extended" and the "sophisticated" version of the mileage tax cause higher classification costs (the HGV have to be classified in different categories corresponding to their emission factors) the **welfare gains of a differentiation of the mileage tax are remarkable** and seem to justify these higher implementation costs.
- Out of the different electronic metering systems those based on the **global positioning system** are most suitable to realise this kind of differentiation at low additional costs. One can therefore conclude that the "sophisticated" and not only the "extended version" of the mileage tax should be the final objective of an introduction of this instrument.
- Automatic debiting systems are mainly developed and tested due to other reasons than the internalisation of external costs (charging for infrastructure costs, control of traffic flow, fleet navigation). As a consequence, the **additional costs to use such systems for the implementation of a mileage tax may be substantially lowered**. Therefore it is important, that the choice of a specific automatic debiting system is also based on criteria that are important from the point of view of an internalisation of external costs (e.g. the spatial differentiation).

e) Mileage or diesel tax?

In this sub report it was not possible to carry out a full scale cost-benefit analysis of the mileage and the diesel tax. But, based on a **qualitative comparison**, the following conclusions can be drawn:

- From the point of view of the **incentive** to reduce external effects of air pollution and noise the mileage tax has marked advantages compared to the diesel tax because only the mileage tax can be differentiated according to emission factors.
- It is not obvious which tax has the better **cost-benefit ratio**. Actually, the two instruments can hardly be compared because they pursue different objectives and have not the same incentive effects. In many respects they are rather complements than substitutes.
- A more useful comparison would have to base on **packages of instruments** to internalise external costs of road freight transport. The packages would consist of the mileage tax or the diesel tax plus useful accompanying policy measures. The core of the two packages could, for example, consist of the following instruments:
  - Core of package 1: CO_2/energy tax as global incentive charge and a differentiated mileage tax ("sophisticated version")
  - Core of package 2: Diesel tax, annual vehicle and/or sales taxes and urban road pricing schemes

  Both packages can take into account the most important external cost elements and influencing parameters (technology, spatial and temporal differences, way of driving). Again, it is not obvious which package is more cost-efficient.
- Compared to a general CO_2/energy tax, a diesel tax is only a second best solution because with a CO_2/energy tax there are no price distortions between different kinds of fuel and no corresponding negative incentive effects. Additionally, if diesel driven cars do not have to pay the diesel tax, different diesel pumps at the filling stations are necessary. As it may be difficult to introduce a diesel tax independently of the political discussion about a CO_2/energy tax it seems to be the advantageous strategy to promote first of all the introduction of a CO_2/energy tax.
- An argument in favour of a transport policy strategy basing on a differentiated mileage tax is the fact that such a strategy would fit the current Common Transport Policy (key words: user charges, tolls) and the development in road freight transport (key word in this context: telematics).

f) Political assessment

Based on an analysis of the major obstacles to introduce a mileage tax several policy measures are proposed to overcome potential opposition against the mileage tax.

The proposed measures are

- **to improve and harmonise the evaluation of external costs** in order to increase the comparability and robustness of the findings. The research work within the 4th Framework programme will probably contribute to this objective.

- **to improve the transparency of internalisation measures** in order to reduce misunderstandings of the objectives of an internalisation of external costs.
- **to develop a convincing concept for the use of revenues** because distributive effects often dominate in the political debate. Therefore, the way the revenues of the internalisation instruments are used can considerably contribute to an increase of political acceptance. Ways have been found to ensure revenue neutrality.
- **to implement a concise communication strategy** in order to include all major actors in the discussion on the objectives and introduction of the internalisation strategy.

4.4 Conclusions and recommendations

Based on the analysis of the mileage tax for European road freight transport in this sub report we come to the following general conclusions:

- The mileage tax corresponds to one of the main objectives of the environmental policy of the EU, the realisation of the **polluter-pays principle**. From a theoretical point of view, the mileage tax is a convincing approach to reduce the negative impacts of road transport on the environment and on human life.
- The tax is an efficient instrument for **one of the most important and most growing polluters** of the environment in Europe.
- The tax would be a useful **completion of the CO_2/energy** that is still planned to be introduced by the Member States.
- Even with conservative values for the external costs the internalisation leads to a **substantial rise in costs of road freight transport**.
- The tax **improves the efficiency of the whole transport system** and gives room for manoeuvre for alternative, less polluting transport modes.
- The tax will **not reduce competitiveness of the European economy**. On the contrary, "first-mover" advantages may result from innovations of European firms in the field of emission abatement technologies for HGV and of metering systems for electronic road pricing schemes.

Therefore, we recommend to set up a detailed programme for the introduction of a mileage tax to internalise external costs of road freight transport at EU level.
Ongoing and further research work will yield additional results that can be integrated in the programme. The results will allow to deepen and complete knowledge especially in the fields of the assessment of external costs and of the technical feasibility of metering systems and to overcome many of the difficulties connected with the introduction of a mileage tax. The fact that the tax will have to be introduced gradually is an additional reason to start as soon as possible with the introduction process.

5 Differentiated sales and vehicle taxes

Summary of the sub report "Differentiated sales and vehicle taxes", ECN Policy Studies

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 did not pay the full price of the effects of our transport activities like air pollution, noise and accidents. Nowadays market prices only reflect the private costs[1] and not the marginal external costs of transport. As a consequence, activities with negative external effects, such as driving passenger cars, take place in a too large degree. This leads to distortions in the economy in the sense of a misallocation of resources and non-optimised 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. Which instrument or package of instruments would be the best for internalisation of environmental costs depends on several criteria like the effectiveness, the efficiency, technical feasibility and acceptability.

The objective of this sub report is to evaluate a system of differentiated sales and 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 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, 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 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 get revenues rather than to influence the purchase decision in the direction of the purchase of more environmental 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, air pollutants 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 coun-

1 The European countries levy taxes on private cars but these taxes are rarely based on environmental costs.

tries 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 type of vehicle.

In order to internalise the external cost of transport the level of the external cost has to be determined. In this report the avoidance cost is used as a shadow price of the external cost of transport. In this report only the avoidance cost for passenger cars, based on Kram (1995), will be discussed, because this report focusses 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 proposal for a further tightening of the emission limit would be 74 dB(A) per passenger car; the so-called 1996 limit. In Kram (1995) 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).

Table S-1 shows an example of a differentiation of the sales tax and the annual vehicle tax for air pollution and for noise which is based on the avoidance cost estimates and the average emissions per vehicle technology.

Table S-1: Differentiation of the sales and annual vehicle tax

Air pollution					
Transport technology	NO_x mg/vkm	Particulates mg/vkm	Mileage vkm/y	Sales tax ECU/vehicle	Vehicle tax ECU/y
car on petrol	2'294	750	12'007	1'238	136
car petrol lean burn	392	28	12'007	286	31
car petrol catalyst	473	30	12'007	333	36
car on diesel	750	240	25'241	2'286	252
car diesel fuel modified	750	192	25'241	2'000	219
car diesel direct injection	688	200	25'241	1'976	217
car on LPG	1'400	20	23'655	1'595	164
car LPG lean burn	239	17	23'655	340	37
car LPG catalyst	289	19	23'655	393	43
truck on diesel	13'926	996	60'000	35'238	5'442

Noise		
Noise emissions of a passenger car	Sales tax ECU/vehicle	Vehicle tax ECU/y
74 dB (A)	0	0
75 dB (A)	67	7
76 dB (A)	134	15
77 db (A)	201	22

The differentiation of the sales tax and the annual vehicle tax for internalisation of avoidance cost of air pollution lies between 1.4% and 9.9% of the total costs of a passenger car and differs per technology. Of course, it is a positive point for the society that these avoidance cost are so low. But for governments it is very difficult to internalise these low avoidance cost and in 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 the consumers two products are complete substitutes of each other, a small difference in price of the substitutes would be enough for consumers to buy the more environmental friendly product if this product is cheaper than the more polluting product.

Under the assumption of growth in transport demand and a maximal penetration scenario of emission reduction technologies as described in Kram (1995) the following emission reduction of passenger cars will be achieved for the Netherlands (see table S-2)

Table S-2: Total emission reduction per pollutant in 2005 compared to 1990 (in %)

Pollutant	Reduction
NO_X	12%
CO	22%
VOC	16%
SO_2	0%
PM	-31%
CO_2	-38%

This means that, although the penetration of emission reduction technologies, the total emission of PM and CO_2 will still grow due to the higher growth in transport demand than the emission reduction. In this report the total emission reduction is only estimated for passenger cars. The emission reduction of SO_2 will be higher as the emission reduction of trucks is included.

However, the total emission reduction presented in table S-2 will only be achieved if the non-marginal reduction technologies will also be implemented. The non-marginal reduction technologies are often technologies which improve the energy-efficiency. These measures can lower the cost of the marginal reduction technologies. In order to achieve the desired reduction levels, additional measures can be taken to support the implementation of this non-marginal reduction technologies. A good example of an additional measure is an energy tax or CO_2 tax, which will stimulate the implementation of the main non-marginal reduction technologies, namely those which will increase energy efficiency. However, it is the question if a CO_2 tax alone will be enough for the implementation of

these technologies which improve energy efficiency, because although many non-marginal reduction technologies are already cost-effective, they are hardly implemented yet. This is possibly due to institutional or social barriers as 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.

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
- 0 the instrument is neutral
- + the instrument has a low positive impact
- ++ the instrument has a strong positive impact

Table S-3: Rating of instruments on several criteria

Type of assessment	Instrument	
	Sales tax	Annual veh. tax
ECONOMIC		
– efficiency transport system	+	+
– transport quality	-	-
– impact on economy	0	0
– impact on innovative behaviour	+	+
– effectiveness	+/0	+/0
ECOLOGICAL		
– incentives to switch to less polluting modes	0	0
– impact on emissions and pollution	+	+
TECHNICAL		
– feasibility	+	+
– implementation and running costs	+	+
– flexibility towards further technical progress	+	+
– co-ordination with regulation and existing policy	++	++
– reliability or fraud proof	++	+
POLITICAL		
– juridical and institutional aspects	++	++
– acceptability	+	+
– impact on national budgets	0	0
– distributive effects	+	+

Although this evaluation scheme has a strong indicative character, it is obvious that these instruments have no strong negative impacts, but have also 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 effectiveness of the instruments depends on the level of the price differences and on the order of magnitude the consumers assess the technologies as substitutes. Obviously, the instruments are probably 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.

For a successful introduction of the instruments the following requirements can be defined from the economical, ecological, technical and juridical assessment:

- 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 on a European level.

It is already an issue in the EU to base the fiscal instruments more on environmental criteria. 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 should adopt the internalisation measures, like differentiated sales and vehicle taxes. Because if only a few Member States had these charges, there would 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 models.
The new tax system should not lead to too much disruption of the car market at once, whether for the motorist or the manufacturer. This means that these measures should be introduced so as gradually to replace existing annual car or sales taxes or other such charges.

It can be concluded that the differentiated sales or annual vehicle tax is a useful additional instrument to a CO_2 or fuel tax for these environmental aspects which are not completely correlated with fuel consumption such as the effects of a three-way catalyst. Also the annual mileage tax is a suitable additional instrument to a CO_2 or energy tax in this respect. The mileage tax is also more usage 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.

6 Variable track charge for railway noise

Summary of the sub report "Variable track charge for railway noise", COWIconsult

6.1 Introduction

The following is an extended summary of the sub-report "Variable track charge for railway noise". The main objective for the sub-report has been to make an assessment of a variable track charge as an instrument for reducing railway noise. The background comes from two recognition's:

- Railway noise is a relatively important external effect of rail transport.
- There are very few assessments of instruments for reducing railway noise.

The importance of the institutional set-up for the railway sector combined with the fact that there are few studies on the regulation of external effects from railways implies that the ambition level of this analysis is to identify and describe the most important issues and problems of defining a suitable policy strategy for reducing railway noise.

6.2 Background

As background information for the internalisation analysis, data on noise annoyance and the avoidance cost estimates from the topic A report will be presented briefly.
In order to simplify the assessment of the noise problem, a one-dimensional value, a noise annoyance index (SBT), has been calculated. By this index, the noise situation in different countries can be compared. Table 6-1 illustrates relative noise annoyance index values. A noise annoyance index (SBT) at 100% would indicate a situation where all dwelling units were exposed to rail noise above 70 dB(A).

Table 6-1: Relative noise annoyance using SBT values.

	Train kilometres	Total SBT value (1000)	Relative SBT value	SBT per 1000 train km
Germany	604	490	2.0	0.8
The Netherlands	117	70	1.2	0.6
Switzerland	137	53	2.5	0.4
Denmark	57	14	0.6	0.2

The relative noise annoyance seems to be worst in Switzerland, with Germany as second and with the situation in the Netherlands and Denmark significantly less annoying. Related to the number of train kilometres, the largest annoyance per train km can be found

in Germany. It is important to note that measured either way, there is large difference between the countries, indicating that the need for policy actions will be different. There is one thing to note in the comparison between countries. In Denmark, rail noise is given a "bonus" of 5 dB(A) implying that the size of annoyance as well as the avoidance costs are significantly lower. For Germany, it has been estimated that excluding the noise level 55 to 60 dB(A) will reduce the avoidance costs of total avoidance by approximately 50%. Avoidance cost curves have been estimated for railway noise (see Topic A report) based on the cost of sound insulation of buildings. The total avoidance costs can be related to the number of train kilometres. Such calculation gives the average avoidance cost per train km. The calculations have been performed for the avoidance cost of reducing the annoyance to 0. In doing that, the crucial element is how to weight passenger trains compared to freight train. The contribution by each type of train to the total noise level (measures as L_{eq}) depends on the conditions prevailing for each section of the line. In general, the freight trains are longer and heavier, but running at a lower speed compared to passenger trains. It is not possible to make any general assessment and instead it is assumed that freight trains and passenger trains account for the same noise emissions per kilometre.

The marginal noise cost has been estimated by calculating the effect of 1% reduction in total number of train kilometres. The effect measured in dB results in a decrease in the annoyance index and thereby in the total avoidance costs. It is implicitly assumed that the reduction is uniformly on all part of the rail network.

Table 6-2: Avoidance costs for rail noise, average and marginal costs

	Average noise costs	Marginal noise costs
Germany	1.5	0.03
The Netherlands	1.1	0.02
Switzerland	0.5	0.01
Denmark	0.3	0.01

The figures illustrate that the marginal costs are much lower than the average due to decreasing marginal effect on the noise level of increasing traffic volumes.

6.2.1 Cost-effectiveness of different measures for reducing rail noise

In order to evaluate the benefits of a variable track charge, it is necessary to defined the possible avoidance measure with respect to their effect. In Table 6.3, a number of avoidance measures as well as other factors that influence the noise emission from rail transport are presented.

Table 6-3: Avoidance measures for rail noise

Type of measure	Reduction effect of measure or factor
Insulation of buildings	Reduces the in-door level of noise to non-annoyance
Noise barriers	5 - 10 dB
Improvement in rolling stock	approx. 5 - 10 dB
Speed reducing speed to half level	7 dB
Maintenance of tracks and rolling stock	5 - 15 dB

The estimation of costs related to the measures is very complicated, as the costs relate to different dimensions:

- insulation of houses relate to the number of residential units being exposed
- noise barriers relate to the length of the track
- rolling stock relate to the number of rolling stock units

In order to make comparable figures, assumptions about local conditions must be made. The range of variation for local parameters such as number of residential units per length of track, volume of traffic at the track, composition of traffic on type of train, speed for individual trains just to mention the most important, prevents making general conclusions about cost-effectiveness.

The additional price of new less noisy rolling stock is the most interesting element. The problem is that railway material is not a mass produced good, but it is often designed or adapted the demands of to each customer (railway company). The price is determined by the interaction of many design factors. In general, all new equipment has a lower noise emission level than previous versions. For freight wagons, it has been indicated that the price of wagons with disc breaks which have a significant impact on noise emissions is twice the price of wagons with traditional brake blocks (Jäger, 1994).

Another problem with the rolling stock is the very long life time of the equipment; 25 to 30 year for passenger wagons and locomotives and 40 to 60 years for certain type of freight wagons is not unusual. The cost of accelerated replacement of old rolling stock depends on the price of second-hand equipment. As the freight wagons are used internationally, all operators would have to replace the old wagons and then the cost would be substantial and likely preventive. There are measures that can be used to modify existing rolling stock; e.g. change of material for brake blocks (Jäger, 1994).

A very rough assessment has been made. Based on the total number of freight wagons (approximately 275.000 for Germany, the Netherlands and Denmark), an average cost of 70.000 ECU per wagon and assuming that the price of less noisy wagons is twice the normal cost, a total figure can be estimated. It is in the order of 1150 million ECU per year. This figure can be compared with the avoidance cost of 1000 million for reducing

the SBT value to 0. Taking into account that the insulation of building only reduce the indoor level of noise, and that reducing noise from the rolling stock will also have an effect in areas where the official limit for noise annoyance (55 or 60 dB(A)) is not exceeded and that it might not be necessary to change all units. Thus, this assessment indicates that the possibilities of improving the rolling stock need more attention; although the costs are larger than the avoidance based on sound insulation, it does not appear to be a prohibitive level for reducing the noise emissions.

It possible to define three different strategies with respect to avoidance measures among which the choice must be made:

- reducing the noise annoyance by local measures (sound insulation and noise barriers) which will have an immediate effect on the annoyance but the quality of the reduction is not high especially in the case of sound insulation.
- reducing the noise annoyance be improvement in the rolling stock. There will be no large immediate effect but in the long run the quality of the reduction is high.
- reducing the noise annoyance by a mixed strategy where local measures are used at the "hot spots" while the improvement of the rolling stock will achieve a general reduction in the long run.

Due to the uncertainty attached to the cost assessment, no exact conclusion about cost effectiveness can be made. The cost of last strategy might be highest, but as the benefit also will be higher the cost-benefit ratio could be in favour the last strategy.

6.2.2 The institutional framework

The railway services are in most of the European countries are provided by a state own company which is in a monopoly situation. The situation in Switzerland is different in this respect. In addition to the Schweizerische Bundesbahnen there are approximately 60 private (or local public) rail companies of which the majority are small with only local or regional traffic.

The main requirement for enabling a more competitive and deregulated railway sector is the separation of infrastructure and operations. The process is just in the initial phase, but the Directive 91/440 (Directive on the development of the Community's railways) specifies that each country must before 1995 indicate how the Directive will be implemented in the country.

The implementation of a variable track charge is linked to the development of the organisational situation. As the variable track charge is a differentiation of an infrastructure fee, it is basically when a separate infrastructure company has been established that the charge could be relevant.

6.3 Variable track charge

The basis question for the formulation of an internalisation strategy for railway noise is the determination and choice of policy instruments at two levels:

- actions at the international level of EU
- national or local actions against rail noise.

As different avoidance measures can be divided in a similar way, infrastructure measures which are local and reduction from the rolling stock which to at large extent need to be an international regulation, the choice of policy level and the choice of the cost-effective avoidance measure are the same.

This is a very important recognition. Unfortunately, the result of the cost assessment is that it is not possible to make a general conclusion about the most cost-effective measures without making a huge analysis including all the local factors in all the countries. The implication for the evaluation of policy strategies can be stated as the following question:

- is it possible to define at policy strategy at the EU level which can incorporate the cost-effectiveness aspect without making the extremely large investigation on the cost of different avoidance measures incorporating local specific conditions from all EU countries..

This is in fact one of the most fundamental issues for defining a policy strategy on noise, as the various avoidance measures relate to either very local conditions or the actions at an international level. An internalisation strategy that can adapt to the information on cost-effectiveness when the information becomes available and allows for decentralised decision making will be superior to other strategies.

For the present analysis on internalisation of the noise effect, the basis question to be answered in the following is:

- could a variable track charge be a component of an efficient policy strategy on railway noise and what are the requirements that the charge has to fulfil?

6.3.1 Alternative versions of a charge

In order to answer the above mentioned question a number of alternative versions of the charge will be defined. In the elaboration of the track charge two aspects must be considered:

- the differentiation of the charge
- the institutional set-up

a) Differentiation of charge

Approaching the definition of a variable track charge differentiated according to noise emissions from rolling stock, the two main alternatives comprise:

- a simple version where the charge depends only the type of rolling stock, i.e. each kind of rolling stock is grouped according to noise emissions and the number of kilometres for each kind of rolling stock..
- the charge is differentiated according to both rolling stock and one or more parameters related to each rail line section.

The reason for a further differentiation is that the annoyance along any railway line depends on large number of conditions where the characteristic of the rolling stock is only one. The most important parameters for the resulting noise annoyance are:

- the extent of residential areas along the section:
- the degree of noise barriers (natural or constructed)
- the total traffic at section
- the distribution of the traffic on various type of trains
- the speed of the trains
- the maintenance of the rolling stock
- the maintenance of the tracks

Taking all the parameters into consideration implies a system which would be a rail equivalent to road pricing.

b) Institutional framework

The influence of the institutional framework depends on how the development within the railway sector will proceed. With the EC Directive on free access to the rail infrastructure by a separation of the infrastructure and the operations the process and the resulting situation have been defined. To which extent, however, the deregulation and free access can be achieved as foreseen, is difficult to predict at this moment.

There could thus be two distinct situations with respect to the institutional or organisation set-up:

- a continuation of the present with state owned companies
- a separation of infrastructure (one manger) and several operators (private or public owned)

In the present situation with most of the rail sector as public monopolies, a track charge will not be the most reasonable instrument to use. In principle, it could be elaborated so the rail companies should pay according the use of the rolling stock and differentiated to local conditions.

In the case of separate unit for infrastructure and operations, it will be more complicated. The proposals for infrastructure charges imply that the user of the infrastructure pay to the administrator of the infrastructure. These payments are suggested to vary according to the extent of traffic and differentiated according to primarily type of train. In some cases, it is suggested that the infrastructure fee should also solve problem of assigning track capacity to the operators. It is here important how a variable track charge can be implemented as a differentiation of the proposed infrastructure fee.

6.3.2 Definition of alternative instruments

The discussion in the subsequent sections will be focused on the evaluation of the variable track charge. The discussion of the instrument will benefit from a comparison with some alternative instruments. There will be four alternatives:

- variable track charge
- simple version related to type of rolling stock
- differentiated version where the charge levied on the infrastructure users vary according to the train kilometres at each track with each kind of rolling stock
- requirements imposed on the infrastructure manager which is assigned with the responsibility for the noise situation
- standards for noise emissions from rolling stock; equivalent to the case of road vehicles

6.4 Evaluation of variable track charge

The variable track charge will be evaluated based on the following criteria:

- economic aspects comprising: efficiency of railway system, cost-effectiveness of noise abatement, and impact on innovative behaviour
- the ecological criteria which comprises the incentives to reduce the noise emissions
- the technical criteria comprising: technical feasibility, implementation and running cost of instrument, and relation to other form of regulation within the railway sector
- the political criteria comprising: institutional aspects, and acceptability.

6.4.1 Economic assessment

a) Efficiency of railway transport

To which extent, any of the alternatives will influence the efficiency of the railway system is difficult to predict. What should be mentioned here is question of the overall objectives of and constraints on railway transport.

In most European countries, where rail transport has been carried out by state owned monopolies, it has been subsidised. On average 40% of the total costs have been paid in some form by the government. The economic factors that can justify such subsidisation are:

- provision of transport services with respect to geographical areas and population groups where other forms of transport are not available. The obligation to maintain service at lines where it is not financial sustainable demand some form of support.
- public transportation in large cities. Although the competitiveness of rail transport might be high in areas with a very high population density, the willingness to pay of the users might not equal the total social benefit of sustaining a transport system. The difference could be the non-user benefit, the increased accessibility for e.g. the road users.

As it can be expected that the present market price on many rail transport services does not reflect even the total financial cost of the operations, it is difficult to predict how the effect of a noise charge will be on the price facing the transport users. This conclusion is valid for all form of regulation which increased the cost of operation railways.

If a charge on railway noise is compensated by increased subsidisation, there will not be an effect on the average price of rail transport. If the railway company (the operator) finds no profitable improvement for the rolling stock with a given level of the variable track charge, there will be no effect on noise and the payment of the noise charge will be equalised by the increased subsidisation implying that the net subsidisation will remain constant. In the case that improvements take place, the public will have paid for these improvements.

If there is no compensation, the total cost of rail transport will increase and the influence on the competition between modes depends on what form of regulation being imposed on the other modes. The complexity of noise emission makes it difficult to calculate the noise cost per passenger or tonne kilometre. Also, for such comparisons an analysis of whole transport systems is needed as the cost per passenger or tonne kilometre depends on the utilisation of each mode.

With respect to the advantages and disadvantages of a variable track charge compared to alternative instrument no conclusion can be made.

b) Cost-effectiveness of noise reductions

The variable charge provides only an incentive for the reducing the noise from the rolling stock. Thus, the charge can not promote cost-effective avoidance measures if that includes also the local measures. However, assuming that reduction of the noise emission at least to some extent is part of the cost-effectiveness reduction strategy using a variable track charge has a number of advantages.

If the charge is fixed based on the avoidance cost estimates from topic A, the costs of sound insulation, there will only be investment in rolling stock improvement if these im-

provements are cheaper. Compared to a quantitative regulation, e.g. standards for the noise emission, the advantage of the charge is that only if the investments in rolling stock improvements are efficient they will be made. As there is uncertainty about the ranking of measures with respect to cost-effectiveness, a charge will reduce the risk of making excessive investments in noise reductions related to the rolling stock. It should be noted that due to the complexity of noise, it is not possible to calculate an exact price on noise emissions which will ensure that the effect of reduced emission equal the effect of sound insulation.

There is another and more important complication. In order to create an incentive, the charge related to the oldest part of the rolling stock should be sufficiently high for a longer period in order to make new investments profitable. The problem is that the effect of investment in rolling stock improvement is game strategic, especially for the freight wagons. Only if all operators invest in noise reduction (improvement or new wagons) there will be an effect on the level of noise annoyance. If the track charge is differentiated to the individual sections of a line, the charge is likely not be reduced when only one operator changes to better rolling stock. Thus, too much differentiation on local conditions will decrease the incentive or make it a part of strategic situation if several independent operators are active.

It should be remarked with respect to cost-effective avoidance measures against noise, that in addition to measures which reduces the impact of the noise, reductions in the emission from the sources will always have some benefit. Even if the noise level measured as L_{eq}, indicates that no dwelling units are exposed to noise levels above 55 dB(A), the individual noise events, the passage of a train, could be annoying and thus the traditional measures of noise underestimate the true annoyance.

For rail noise, the cost-effectiveness aspect of avoidance is a question of whether there is a willingness to pay what might turn out to be a higher cost for reducing the noise from the source compared to just improving the situation at the most annoyed areas.

The conclusion with respect to the comparison of a variable track charge with other instruments is that the simple version of a track charge seems to provide the strongest incentive for reducing the noise from the rolling stock. The variable track charge will also minimise the risk that too much investments in rolling stock are carried out. Imposing requirement on the infrastructure manager will not provide a strong incentive for charging according to the rolling stock as the other avoidance measures are likely to be cost-effective in the short run. An administrative regulation demanding specific noise emission limits observed for new rolling stock will have an effect but not on the possibilities for reducing the noise from the existing rolling stock and it will not incorporate the cost-effectiveness aspect.

c) Impact on innovation behaviour

The variable track charge will very likely exert an influence on the development of new rail equipment. The magnitude of such influence depends on the size of the charge. Pre-

diction in more detailed the effect of charge is not possible. Even if no technical options would be profitable with a given level of noise charge, there would still be a pressure to develop cheaper measures.

Introduction of noise emission limits for new rolling stock will exercise a pressure for improvement until the requirements are meet. Afterwards, there will be no incentive. Opposite to the noise charge, there will be no incentive for improving on existing rolling stock which could be more cost-effective than substitution with new equipment. The variable track charge is thus superior with respect to innovation incentives.

6.4.2 Ecological assessment

Evaluating a variable track charge, the most important criterion is to which extent the charge will influence the choice of rolling stock and thereby contribute to the reduction of the noise eternality. Unfortunately, it is very difficult to assess the intensity of the incentive.

If the level of infrastructure and operational costs for Denmark can be used to indicate the level of rail transport costs in general, the following relation between noise costs and production costs for rail transport can be estimated.

Table 6-4: Average avoidance costs compared to production costs

%	The avoidance cost for noise as a percentages of production costs for rail transport services		
	Infrastructure	Operation	Rolling stock[1)]
Germany	16	10	60 - 125
The Netherlands	12	7	45 - 90
Switzerland	6	3	20 - 40
Denmark	3	2	10 - 25

1) The depreciation and interest payment on rolling stock is roughly estimated at 5 to 10% of total production costs.

Compared to total production costs, the noise costs amount to at most 6%. Related to the infrastructure costs which could be the base for the noise charge, the noise costs are between 3 and 16%. If the noise costs are compared to the estimated costs of the rolling stock, it is to close to be in a comparable magnitude.

The implication is difficult to assess. If the variable track charge would be calculated on the basis of average avoidance costs or even at a willingness to pay estimate for the "true" external costs, the influence would be significant.

It should be noted here, that the effect on the noise level measure at the rail track might be very low from substituting only a small part of the rolling stock used at that specific track. If then the noise charge would be differentiated to the actual situation at each track, a strategic situation could emerge. Only if all operators at the track would shift to the less noisy rolling stock, the noise charge for all operators would decrease, but if only one changes his rolling stock, no effect would appear and the change in the variable track charge would accordingly not decrease.

Especially for freight transport, this problem could be significant. The number or wagons are very large. Many are not used very much and they are often so old that they might not cause any depreciation costs and interest payments and thus they are very cheap to use. The freight train operator will also often use wagons owned by other operators (national and international) and private companies. The effect of purchasing new freight wagons could be expected to be very low implying that the costs of new freight wagons as avoidance measure will be substantial.

Therefore, it can be expected that it is mainly on lines where a limited number of rolling stock units are used, like local or regional passenger traffic and subway/metro systems where the benefit of changing to less noisy rolling stock would exceed the costs.

The extent of the incentive for innovation depends on the size of the charge and it should be reduced when the noise emission from individual units of rolling stock is reduced regardless of the overall noise situation.

In the strategic situations, a simple form of the track charge relating the charge only to the type of rolling stock and the number of kilometres will have a larger incentive than the more differentiated system. This indicates that they might be a trade off between the ability of the instrument to promote the cost-effectiveness avoidance measures and to provide incentive for improvements in the rolling stock (both replacement and investment in noise reducing modifications).

6.4.3 Technical assessment

a) Technical feasibility

There is no immediate condition which could make a variable track charge impossible. On the other hand, it substantial amount of measuring and calculation will be needed. As mentioned in section 2.3 regarding the German experience with infrastructure fee, the German Railways has already a very detailed manual for calculation the infrastructure fee for individual tracks according to a large number of parameters. More investigations for the noise emissions from different type and age of rolling stock may be needed. Also, the mapping of noise annoyance related to each track need to be carried out.

b) Implementation and running cost of instrument

Although technical feasible, the implementation cost could be high if a very detailed system is considered. It will be possible to initiate the system on a more pragmatic base using average values instead of measuring all parameters.

While, the implementation cost could be high, the running cost should be expected to be moderate. Only when new rolling stock is put into use and when abatement equipment like noise barriers are being constructed new measurements need to be carried out. Especially, in a situation where there will be a general scheme for infrastructure fees the additional cost of differentiating such fees with respect to noise should not create substantial implementation costs.

c) Relation to other form of environmental regulation

As the railways most often are public monopolies they are not subject to many forms of economic instruments specifically addressed at railway sector. In Denmark, the railway receives a large annual subsidy and there has been no political willingness to impose any economic instruments as it will be giving and taking at the same time. The efficiency argument has not been very prominent part in the discussions.

With respect to noise, there are in all the four countries' requirement for construction of new rail tracks and extending existing lines. Comparing the alternatives, clearly an extension of these noise limits to be valid for existing residential areas along existing lines and/or tightening the requirement would be administratively simple. If a system of infrastructure fees is to be introduced, the administrative cost of including noise as an extra parameter will not be preventive.

6.4.4 Political criteria

a) Institutional aspects

The institutional aspect is extremely important for the assessment of the variable track charge. Firstly, the deregulation within the rail sector which eventually will have to mean separation between the infrastructure part and the operations is necessary if a variable track charge should be implemented. Secondly, the institutional situation for rail transport with a vertically integrated business structure implies that the possibility of achieving cost-effective reductions of noise is better than within the road transport sector.

If the rail company continue to be state owned monopolies, a variable track charge would be possible, however not the best solution. One of the advantages of economic instruments is that it is often more simple to employ a charge when the number of actors which need to influenced are high. As the number of railway companies is limited, mak-

ing an agreement of replacement or improvements in the rolling stock for international could be an alternative. As there are especially many private freight wagons, a variable track charge could also be relevant in case the organisational structure remains unchanged.

A general noise charge related to the number of people being annoyed would be another relevant alternative that could achieve the same end allowing for static efficiency. Alternatively, the noise limits could be lower and the railway company required to carry out a cost-effectiveness analysis of possible avoidance measures. The company could also just be required to carry out cost-benefit analysis before purchasing new equipment and in relation to existing line to determine the need for abatement constructions.

Assuming that the present EU Directives on deregulation of the sector is implemented, the variable track charge can be seen as a differentiation of the infrastructure fee. One problem could emerge. The distribution of access to the tracks will become a very complicated process.

In the process of making agreement for the access to the infrastructure, any requirement like noise limits or noise charges could be used to exclude specific operators and vice versa, the operators would claim that they were treated unfair if they were to pay extra for using noisy equipment. Such disputes could be avoided if the charge were defined in simple and transparent way. As discussed previously, the local conditions determine the noise level. Using old rolling stock may not be a problem on a not very used line and with few departures per day. Another situation: the operation of two services at one line where the use of one old set of rolling stock and one less noisy would result in a total noise situation below the critical limit. If both operators want to use noisy equipment the noise cost will increase. These examples illustrate some of the conflicts which could emerge.

b) Acceptability

The question of acceptability can not be answered before the different "players" in the railway sector are defined. Compared to the situation within the road sector, the most relevant players with respect to a variable track charge are only very few and today it is more or less different bodies within the public sector. As discussed in connection with the efficiency of the rail business, it is not clear how any form of noise regulation will affect the price of rail transport and accordingly, the political element can not be assessed.
The international dimension could be a problem. Although the EU has passed the directives on deregulation and free access, some countries might not be very enthusiastic about the implementation. Making agreements on a common principle for differentiating the infrastructure fee according to noise could thus be a difficult task. In the past, the relationship between the national railway companies has often been characterised by disputes about the prising of border crossing traffic.
If the companies look at the deregulation process with some resentment, the possibilities of making agreements about a further complication of the system by introducing the differentiation according to noise, could be limited.

6.5 Conclusion and recommendations

The most interesting result is that reducing the noise emission from the rolling stock seems to imply costs in the same order as other measures and taking the higher quality of the reduction of noise emissions into account, it appears that actions towards the rolling stock need more attention. As railway noise up till now has been subject to rather few studies there seem a need for research to validate the result. If it turns out that reducing noise from the rolling stock will give the largest social benefit the next step is the definition and implementing of a policy strategy.

The effect of the local measures, building insulation and noise barriers, and reducing noise emissions are to some extent complementary. The local measures could reduce the annoyance at the worst part of the network, the "hot spots" sections while the improvements in the rolling stock has the same effect everywhere and thus ensure a general reduction in the noise level.

The assessment of the variable track charge has revealed the following advantages of charge as an internalisation instrument:

- Subject to the constraint that only an average noise charge can be calculated, it can achieve the end of promoting noise reduction from the rolling stock with a low risk of making non-efficient investments. The reason is the traditional static efficiency argument for economic instruments. Only investments cheaper than the imposed tax will be carried out. Thus, if the noise reductions related to the rolling stock turns out to be more expensive and therefore not cost-effective than indicated, they will not be carried out if a charge is used.
- If the charge is based on the average avoidance costs, it is likely to have an impact on the quality of the rolling stock. The incentive for improvement will be larger if the charge is not differentiated according to the actual noise annoyance at the lines where the rolling stock is used.
- A charge will raise a revenue, which could be used to finance some of the local measures, in particular at the sections of the rail network where the annoyance is high.

In defining an variable track charge a number of difficulties and complications need to be considered:

- Introducing policy measures for reducing rail noise could affect the competitiveness of rail transport (depending on how the noise problem is solved in the road transport sector) and therefore there could be a trade-off between reducing noise and encouraging to mode shift.
- The complexity of noise annoyance implies that it will only be possible to calculate an average noise charge based on the avoidance cost estimates and that further analysis is needed before the charge can be defined in detail, e.g. how the charge should be differentiated according the noise emissions, the measurement procedure for noise emissions from the rolling stock etc.
- If the variable track charge should create an incentive of reducing the noise emissions from the rolling stock it should not be differentiated to local conditions but only relate to the characteristics of the rolling stock and the extent to which rolling stock is used.

Thus, there is a trade-off between the incentive to replace or improve on existing rolling stock and the incentive to use the existing stock differently. The last option requires that the charge is differentiated according to local conditions.

- The variable track charge will be most relevant if the rail sector is divided into infrastructure managers and operators.
- The fact that most rail operators are running a deficit and that improvements of the rolling stock implies substantial investments could make an acceptance from the rail operators difficult to obtain.

It is important to stress the tentative nature of these results. The cost assessment are complicated due to the complexity of noise annoyance where the emissions have a purely local effect and where the contribution of individual noise sources is not additive. Therefore, general conclusions about the cheapest avoidance measures are difficult to draw implying that the division between the regulation on a EU level and the national and local regulation is difficult to establish.

The analysis has demonstrated that a variable track charge could be an efficient instrument in a EU policy strategy on railway noise. A number of element could be further investigated, especially as there have been very few studies within this area.

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Part III: Main findings and conclusions

Contents:

7 Summary of the main findings

7.1 Introduction

The main objective of topic B of this research project was to discuss the theory of internalisation and selected transport policy instruments to internalise external costs at a European level. To summarise, we have chosen the following procedure to fulfil this task:

- In a first step the main findings of the **theory of internalisation** had to be summarised (chapter 2). In this chapter we also discuss the link between the different methodologies to assess external costs and the internalisation approaches.
- In a next step we had to chose those internalisation instruments that were to be analysed in detail (chapter 3). It should be noted that the objective of this research project was not to elaborate an optimal strategy of different instruments - economic instruments as well as regulations - for the different transport modes[1] but to analyse **some selected instruments** that could be part of an optimal strategy.
- The instruments chosen are analysed in the **three sub reports**. The summaries are part of this synthesis report:
  - a mileage tax for European road freight transport (chapter 4)
  - differentiated sales taxes and annual vehicle taxes (chapter 5).
  - a variable track charge for railway noise (chapter 6)

The objective of this chapter 7 is a **review of the main results of the research work carried out in topic B**. The following subjects will be discussed:

- In section 7.2 we deal with the question what problems emerge when the theoretical concept is to be applied under real world conditions. In other words we ask whether **internalisation is a feasible concept or not**.
- In the centre of the next step (section 7.3) are the possibilities and limits of the **use of avoidance costs for internalisation**.
- In section 7.4 the **main findings of the sub reports** on the three instruments are summarised.

7.2 From theory to practice

The basic idea of internalising external costs of transport is given in figure 2-1 of this synthesis report: **Internalisation** means that the external costs of an activity are integrated into the price of this activity according to the following rule: price equals marginal social

1 Such a package of instruments has been developed recently by Infras / IWW (1994), External Effects of Transport, for a summary see chapter 25.

(internal and external) costs of the activity. Already in chapter 2 it was argued that under real world conditions it will be difficult to realise the concept of internalisation.

- In topic A, the problems connected with an assessment of the external costs (damage costs and willingness-to-pay) and with the assessment of avoidance costs have become obvious: Lack of knowledge concerning the chain of cause and effect in the case of damage costs, imperfect information in the case of the willingness-to-pay approach and in the case of avoidance cost assessments the large variety of possible avoidance measures, only to mention some of them. Thus, we are far away from knowing where the optimal tax, i.e. the Pigouvian tax is. Therefore, any attempt to introduce "economically optimal" charges in transport sector will fail.

- Furthermore, the description of possible internalisation instruments in the sub reports showed that even if we knew where the external cost curve and the avoidance cost curve intersect it would still not be very useful to try to apply the pure concept of internalisation in actual transport policy: This concept implicitly assumes that taxes can be found being capable to take into account optimally all the parameters influencing the level of the respective external costs.

  To give an example: In the case of railway noise the following parameters should be taken into account by the tax:[2]

  - the extent of residential areas along the section
  - the degree of noise barriers (natural or constructed)
  - the total traffic on a specific section of the rail network
  - the distribution of the traffic on various types of trains
  - the speed of the trains
  - the maintenance of the rolling stock
  - the maintenance of the tracks

  It is obvious that no single tax is capable to meet all these requirements in a cost-minimising way because of the large uncertainties in the chain emission - transmission - damages - costs. It is possible that other instruments may be more cost-efficient.

Regarding these uncertainties and problems of practicability one could conclude that the concept of internalisation is unsuited for deriving transport policy measures. Our answer to the question whether the concept of internalisation is a feasible concept for the practice or not goes as follows:

- **It is not a feasible concept** if it is understood in a very narrow sense by assuming that
  - transport policy measures should mainly base on the amount of external costs caused by the different transport modes
  - taxes alone will lead to a cost efficient reduction of the negative impacts of transport.

2 See sub report "Variable track charge for railway noise", section 6.3 of this synthesis report.

- **It is a feasible concept** if it is understood in a broader sense namely a tool
  - to provide important information for the political discussion about transport policy measures
  - to emphasise the polluter-pays principle to be a main characteristic of an efficient transport policy and therefore
  - to promote the use of economic instruments to change price signals in the favour of a more environmentally compatible transport system
  - to define a useful range of the rate of internalisation taxes.

So far a very first assessment of the concept of internalisation. In the next section we will go a little bit more into detail by discussing the question of the use of avoidance cost assessments for internalisation.

7.3 Internalisation and avoidance cost

7.3.1 Internalisation without avoidance cost assessments

In order to show the possible use of avoidance cost assessments we first discuss how the internalisation approach can be applied if no estimates of avoidance costs are available.

In this case the internalisation approach can be used as a "global top-down approach". Broadly speaking, the basic idea then is that the responsible public authorities change price signals by introducing an internalisation tax without assessing reaction patterns of road users. It is assumed that the market will more or less react in an efficient way to the changes in the price signals. The main objective is to confront the road users with the internal and external cost caused by their transport activities. Behind this allocative point of view there is also some interpretation of justness: Road users may cause negative effects to the environment and human beings but at least they have to pay for it. Economically, it will also be better to charge a sector for its full social costs than not to charge it at all even if the tax structure may not be optimal at first.

From the last section we know that two major problems render it difficult to apply this approach in practice:

- the definition of the optimal tax level is not possible without knowing avoidance costs
- in practice it is rather impossible to design a tax taking into account all the relevant parameters.

Because of these problems a conceivable way to put this "top down approach" into practice would consist of the following procedure:

- The responsible authorities introduce a tax that does not claim to be optimal with regard to the tax level but still takes into account external cost assessments. This pro-

cedure was chosen in the sub report on the mileage tax for European road freight transport: Existing external cost assessments were used to define the tax rate but it was clear that the tax rate is not optimal in the sense of a Pigouvian tax.[3]

- Because the public authorities do not know whether there are more cost-efficient policy measures than the tax, they could announce that the design of the tax or the tax rate will be adjusted if the agents of transport sector propose more cost-efficient measures and agree with the implementation of these measures.
  To give an example: In the mileage tax for road freight transport also the external costs of accidents were used to define the tax rate. The public authorities could call upon the road transport associations to develop, together with insurance companies, a new form of insurance to internalise the external costs of accidents in a more efficient way than the mileage tax does. As soon as the new system is introduced and internalises the external costs of accidents the mileage tax would be adjusted. Otherwise the transport sector would have to face the less efficient solution. This procedure sets an incentive for agents of the transport sector to search cost-efficient measures to reduce the negative impact of transport.

7.3.2 Internalisation with avoidance cost assessments

In the political discussion it may be demanded that the public authorities do not simply implement a "global internalisation tax" but should present a cost-efficient strategy to internalise external costs or to achieve a certain environmental target. In this case the public authorities must have available **avoidance cost assessments**.

In contrast to the "top down approach" discussed above, the use of avoidance cost assessments represents a "bottom up approach". If avoidance cost assessments are used for internalisation of external costs the task of the internalisation instruments is to ensure that the cost-efficient avoidance measures are actually implemented.
Regarding the three sub reports we can make out different ways to use avoidance cost assessments for internalisation.

a) Surcharge on a fixed tax

In the case of the sales tax or the annual vehicle tax the additional costs of the cleaner technology were used to define the tax applied to the conventional technology. The resulting incentive effect depends on the level of the surcharge:

- If the surcharge exactly corresponds with the additional costs of the cleaner technologies potential buyers of new vehicles are not confronted with a price difference anymore: both technologies cost the same. The decision will then base on the environmental awareness, the image of the cleaner vehicles, other features of the vehicle that are influenced by the emission abatement technology (e.g. higher fuel consumption of cars with catalytic converters).

3 Such a procedure is also suggested in the proposal of a mileage tax for HGV in Switzerland.

- If the surcharge is higher than the additional costs of the cleaner technology and rational behaviour is assumed, there is a very strong incentive to buy cleaner vehicles, if the vehicles are perfect substitutes with regard to the other characteristics. In this case, the effect of the fixed tax is similar to regulations demanding the use of a certain technology but the transaction costs of regulations may be lower. However, the fixed tax works according to the market mechanism and consumers still have the choice.

b) Tax differentiation of a variable tax

In the cases of the variable track charge for railway noise and of the mileage tax for road freight transport avoidance costs estimates were used to differentiate the tax rate in order to promote the use of less noisy rolling stock and less polluting vehicles.

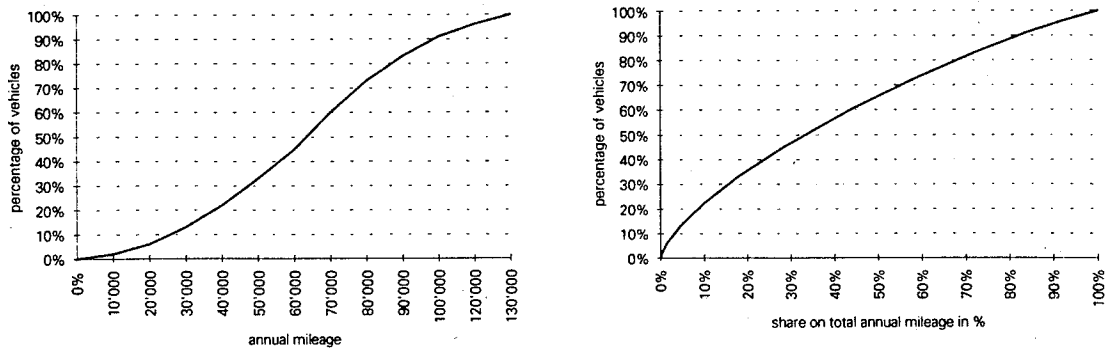
In the case of the mileage tax the base for the tax differentiation were the additional costs of the less polluting technology and the average mileage of the vehicles. The incentive effect of this differentiation is obvious: If the mileage of a vehicle is above the average it is cheaper to use the cleaner technology, if the mileage is below the average it is cheaper to use the conventional technology and pay the higher tax.

It should be noted that without defined environmental targets (e.g. a reduction of NO_x emissions of road freight transport by 30%) it is on principle not possible to determine a useful level of tax differentiation with the avoidance cost assessments alone.
To give an example: The differentiation of a mileage tax for road freight transport could be defined in a way that it pays to switch to the cleaner technology as soon as the yearly mileage of a vehicle is above 40'000 kms a year. But the differentiation could also be designed in a way that this break-even point is already at 30'000 kms. Without information about external cost curves or without an emission reduction target for road freight transport it is impossible to say at what yearly mileage the break-even point should be.

If an **environmental target** is given the tax differentiation must take into account how the average annual mileage is distributed on the HGV as given - in an illustrative sense - in the left side of figure 7-1. On the right side the share on total annual mileage is shown. With the figure it can be assessed where the break-even point of the tax must be in order to reach a certain emission reduction target. If, for example, the mileage of HGV with conventional technology is to be reduced by 20%, the break-even point of the mileage tax should be somewhat below an annual mileage of 100'000 kms.[4]

4 Under real world conditions one had furthermore to face the fact that the market value of HGV with the conventional technology would decrease after the mileage tax has been introduced. Because the owners of HGV with the conventional technology would take into account this loss of value when they decide on a replacement of the HGV the break-even point must be at a lower annual mileage than pointed out in figure 7-1.

Figure 7-1: Distribution of average annual mileage and share on total mileage



If **not an environmental target but external cost assessments** (damage costs or willingness-to-pay) are available, the differentiation should reflect the different environmental impact of the cleaner and of the conventional technologies. Not the additional costs of the cleaner technology but the differences in the external costs caused should be decisive for the tax differentiation. The conventional technology will then be used as long as the product of the annual mileage and of the higher tax rate (conventional technology) is lower than the product of the annual mileage and the lower tax rate (cleaner technology).
If external cost assessments are lower than avoidance cost assessments and one can assume that external costs have been substantially underestimated the differentiation could base on the avoidance cost assessment. Otherwise, the differentiated mileage tax would have almost no incentive to switch from the conventional to the cleaner technology.

c) Defining the level of a variable tax with avoidance costs

If the level of a tax should be determined with estimates of avoidance costs, the information requirements become rather high:

- It is essential that environmental policy defines environmental targets. However, from topic A and from chapter 2 of this synthesis report we know that **economically optimal** environmental targets cannot be defined without estimates of damage costs and/or willingness-to-pay and without comparing the costs of avoidance measures in the transport sector with those of other sectors.
- There are many different possibilities to reduce harmful emissions of transport and, on principle, the cost-effectiveness of all of them should be taken into account by the avoidance costs assessments. From topic A we know how difficult it is to include a **wide range of policy measures and all the relevant cost components** (including the implementation costs). If relatively cheap avoidance measures are not included in the assessment, the level of the tax rate required to achieve a defined emission reduction target is overestimated. Therefore, a step-by-step procedure to implement the tax would be useful to prevent an "overshooting" of the tax.

Nevertheless, this third way to use avoidance cost assessments has proved to be feasible:

- Environmental targets have been defined in different European countries (e.g. Switzerland) based on sustainability aspects, scientific knowledge about the negative impact of pollutants on the environment and on human health and on political consensus rather than on external cost assessments.
- large scale cost-effectiveness analysis are carried out at the national and at EU-level (e.g. topic A of this research project, the Auto/Oil-Programme of DG III).

We conclude that avoidance cost assessments can provide important and useful information for internalisation if

- defined emission reduction targets or external costs estimates do exist, and if
- a wide range of policy measures is analysed.

If these conditions are met the results can be used to differentiate a variable tax or to define the level of an internalisation tax.

7.3.3 Further possibilities to use avoidance cost assessments

Furthermore, avoidance cost assessments are not only useful to define tax rates but may also be used for other purposes:

- **Cost-effective mix of instruments**: Avoidance cost assessments can look at a wide range of measures and instruments whereas the internalisation concept concentrates on economic instruments.
- **Forecasting the impacts of the use of certain instruments**: Avoidance cost assessments allow to assess the impact of the implementation of certain instruments (e.g. a fuel tax) because reaction patterns are analysed.
- **Costs of environmental policy measures**: In the political process it is important that an answer can be given to the question what environmental policy measures cost. In this case avoidance cost assessments can be used to define the rate of a tax that is introduced to finance environmental policy measures (e.g. noise barriers) according to the polluter-pays-principle.
- **Definition of environmental targets**: If external cost assessments (damage costs or willingness-to-pay) are available economically optimal targets can be set by using avoidance cost assessments.

7.3.4 Conclusions

There is a rather wide range of potential benefits resulting from avoidance cost assessments, the use for internalisation only being one of them. With regard to internalisation the analysis has shown that - as in the case of external cost assessments by the use of the damage cost or willingness-to-pay approach - the information requirements are rather high.

Avoidance cost and external cost assessments are to be considered as complements. Therefore, whenever possible environmental policy should aim at a combination of both approaches. Nevertheless, both can also be used separately:

- If avoidance cost assessments are not available the "global top down approach" as described in section 7.3.1 can be applied.
- If external cost assessments are not available emission reduction targets must be defined based on scientific information (e.g. critical loads of pollutants) rather than based on a comparison of marginal avoidance costs and marginal external costs.

Because in both cases serious uncertainties emerge a **step-by-step procedure** to implement transport policy instruments can be recommended independently of what approach has been used to define a internalisation tax, starting with low tax levels.

7.4 Main findings from the sub reports on internalisation instruments

7.4.1 The three instruments analysed in detail

Table 7-2: Main features of the instruments analysed in detail

Features of the tax/charge	**Mileage tax for European road freight transport**	**Differentiated sales and vehicle taxes**	**Variable track charge for railway noise**
basic idea	variable tax for heavy goods vehicles (HGV) to internalise external costs	"once only" and annual tax to internalise external costs of air pollution and noise	variable tax for railway companies to internalise external cost of noise
object of the tax	HGV, permissible total weight > 3.5 t	passenger cars	rolling stock of railway companies
tax base	permissible total weight and kilometre driven	vehicle	train kilometres
tax rate	basic version: lower bound: 0.006 ECU/t_{tw}km upper bound: 0.012 ECU/t_{tw}km	**Air pollution** technology / sales t. / veh.t. petrol 1'238 136 petrol lean burn 286 31 petrol catalyst 333 36 diesel 2'286 252 diesel fuel mod. 2'000 219 diesel dir. inject. 1'976 217 LPG 1'595 164 LPG lean burn 340 37 LPG catalyst 393 43 **Noise** emissions / sales t. / veh.t. 74 dB (A) 0 0 75 dB (A) 67 7 76 dB (A) 134 15 77 dB (A) 201 22	if average avoidance costs are used: 0.3 ECU/train km if marginal avoidance costs are used: 0.01 ECU/train km

Features of the tax/charge	**Mileage tax for European road freight transport**	**Differentiated sales and vehicle taxes**	**Variable track charge for railway noise**
tax payer	owner of the HGV (haulage companies)	buyer/owner of the car	rail operators
field of application	whole road network of the Member States	new cars, registered cars	railway infrastructure, track
differentiation options	– "extended version": differentiation according to emissions of air pollutants and noise of vehicle type – "sophisticated version": taking account of spatially different levels of pollution and of congestion	fuel type, emission reduction technology	maybe according to specific sections and speed; there is a trade-off between incentive and efficiency
metering system	– electronic road pricing system – two-way data communication between vehicle and a vehicle identification system	– metering of emissions (or applied technology) – definition of different categories of the vehicles	probably electronic track pricing system
implementation	– EU: defining main features and minimum requirements (lower bound tax rate) – Member State: introduction	classification of cars at EU level	implementation in the frame of the deregulation within rail system (separation between infrastructure and operations)
introduction scheme	– gradual increase of the tax rate – transitional period for "first mover" initiatives of the Member States	information about the adjustment and objective of the new tax system	introduced in form of a differentiation of the infrastructure fee (deregulation as necessary condition)
use of the revenues	– stage 1: earmarking for less polluting transport modes, financing of rescue packages for the environment – stage 2: redistribution of the revenues to the economy	– subsidies for cleaner vehicles – improvements of public transport	use to cover the costs of sound insulation of buildings and/or noise barriers

From the designing of the main features the following general conclusions can be drawn:

- The more different parameters influence the external costs the more difficult it is to find **optimal leverage points** to base the tax on. The differences between the different types of external costs are considerable: Whereas it is rather easy to internalise the external costs caused by CO_2 emissions with a fuel tax, the difficulty to find a useful tax base especially emerges in the case of noise with the large variety of parameters influencing the resulting noise annoyance.
- Closely connected with the first point is the second: It proved difficult to find cheap ways to implement a tax without loosing too much of the "precision" of the internalisation instrument. Especially the variable track charge and the mileage tax were confronted with the problem that only a differentiated tax would be suitable for an internalisation tax claiming to realise the polluter-pays-principle. However, the more **differentiation options** are to be realised, the higher would be the **implementation costs**.

  In the case of the mileage tax a very rough assessment was carried out comparing the benefits (i.e. the potential welfare gains) of a certain differentiation of the tax with resulting additional implementation costs. It showed that under the assumptions taken, a spatial differentiation (e.g. higher tax level in urban areas, lower tax level in rural areas) yields a comparatively high benefits.
- The analysis showed that the three instruments should be **part of package of further policy measures**. To give a conceivable example for each tax analysed:
  - Mileage tax: If - as suggested - the tax is differentiated according to the emission abatement technology, regulations concerning maintenance and inspection should prevent a strong deterioration of the technology.
  - Sales tax and annual vehicle tax: The sales tax and the annual vehicle tax should be accompanied by a variable charge (e.g. a fuel tax) because of the limited incentive effect of a fixed charge.
  - Track charge: Because it was difficult to judge in conclusion whether emission avoidance measures related to the rolling stock are more cost-effective than other noise avoidance measures a useful policy mix would probably consist of reduction measures at the source of noise and related to the local conditions ("hot spots").
- All the three taxes had to solve the problem of the **adequate policy level to introduce the instrument**. Good reasons for Community action were found whenever the technology of the vehicle was concerned. The classification of the vehicles (sales taxes, annual vehicle taxes and mileage tax) and of the rolling stock (variable track charge) should take place at EU level. Furthermore, the task of the EU was seen to define the most important general features of the policy instrument to prevent national solutions to be incompatible with each other (e.g. in the case of the metering system for the mileage tax).

  For the introduction of the instruments themselves the national level was considered to be most appropriate.

7.4.2 Summary of the impact assessment

Each instrument has been assessed according to
- economic aspects
- ecological criteria
- technical criteria and
- political criteria.

The most important findings the evaluation of the instruments will briefly be summarised in the following paragraphs.

a) Economic impact assessment

The main conclusion was that the impact of the three instruments on the European economies would be low due to the following reasons:
- First of all one has to keep in mind that the main objective of the three instruments is to **redress an economic market failure**, namely to internalise external costs affecting public welfare. With the introduction of internalisation instruments the transport sector will at least partly pay for these external costs. Therefore, the three instruments create an incentive for adjustment processes towards a more efficient and welfare optimising transport system.
- In most sectors of the economy the taxes analysed would result in only very **modest increases of production costs**.
- The **revenues** from the taxes are not lost. Depending on the way they are used they may results in cost reductions (using the revenues to lower labour costs) or in higher demand of the public sector (using the revenues for environmental rescue packages, building of noise barriers).
- The three taxes increase the demand for less polluting vehicles and less noisy rolling stock by accelerating the replacement rate. Furthermore, they set incentives for the development of more environmental-friendly transport technologies and may therefore result in **innovations** that raise the competitiveness of European firms supplying transport technologies on international markets.

b) Ecological effects

For all taxes analysed in the sub reports the technology improvements seem to have a larger effect than the reduction of transport volumes. More important is that the instruments analysed set lasting incentives to reduce the negative effects of transport on the environment and on human beings. However, there are considerable differences between the three solutions:
- The short run effect of **fixed taxes** (sales and annual vehicle taxes) is comparatively low because their impact almost completely refers to technology improvements. The sales may even have an undesirable effect from an ecological point of view because it may induce people to postpone the replacement of old, polluting vehicles. If the reve-

nues of the tax are used to subsidise the cleaner vehicles this effect will be reduced. However, with the exemption of zero-emission-vehicles also cleaner vehicles (e.g. cars with catalytic converters) exhaust environmentally harmful pollutants. Therefore, there is not much reason for subsidies.

With regard to the incentive effect it is desirable that the two taxes are not related to a certain technology but to certain emission limits. There should be a direct relationship between the emission and the tax rate, otherwise the incentive effect will disappear as soon as all the vehicles are equipped with the technology required.

- On principle, the **variable taxes** (track charge and mileage tax) are more effective in the short and in the long run. In the case of noise however the short run effect is very small because a large part of the rolling stock must be replaced to achieve a noticeable reduction of the noise level and because of the long average lifetime of the rolling stock. However, the long term effect is high because noise is reduced at its source.

  As in the case of the fixed tax the differentiation of the tax should not be related to an emission reduction technology but to an emission limit.

For all three solutions the incentive of the taxes to develop new technologies beyond today's knowledge can be increased if the tax differentiation includes **a class "future technologies"**, i.e. technologies that reduce emissions more than the best available technology.

Regarding the relatively low short term effect (e.g. reduced driving) the following points should be taken into account:

- Obviously, a high reduction of the kilometres driven would result in substantial decreases of consumer benefits. The relatively low elasticities found in the transport sector reflect the **high social value of transport**. The fact that traffic volume does not decrease to a larger extent can therefore not be considered as a drawback of the instruments.
- For all three sub reports it was assumed that the external costs of **CO_2 emissions** will be internalised by a CO_2/energy at EU level. If the external costs of CO_2 emissions were also integrated in the taxes the tax rate would have to be increased substantially.
- Finally, the external cost and avoidance cost assessments used to define the level of the taxes can be considered as **lower bounds of the costs**. In both cases estimates do exist that are noticeably higher than the estimates used.

Nevertheless, one can conclude that the three taxes alone will not solve the environmental problems caused by transport. But this fact is not an argument against these taxes because the same argument applies to any other instrument if a reduction of transport volume must not be achieved at any costs.

c) Technical assessment

Differentiated sales taxes and annual vehicle taxes are feasible: they have already been introduced in European countries.

In the case of the two variable charges the situation is somehow different. However, both instruments may probably profit from efforts taken in another context:

- In the case of the **mileage tax** the intention of the EU to realise the territoriality principle in the charging of road transport for its infrastructure costs (i.e. infrastructure costs should be paid by those who use it) resulted in large research projects in the field of automatic debiting systems. Furthermore, the haulage firms themselves are interested in the development of electronic fleet navigation system. The implementation of the differentiated mileage tax requires a metering systems having very similar technical features as these systems (e.g. vehicle identification, vehicle positioning, automating debiting).
- The variable **track charge for railway noise** "profits" from the deregulation in the rail sector, namely from the probable introduction of an infrastructure fee for rail operators, because this fee could serve as base for the differentiated variable track charge.

In both cases it is too early to make reliable assessments about the costs of the different implementation options and therefore it was impossible to carry out cost-benefit analyses for different technical solutions.

d) Political assessment

For all three taxes it will be difficult to find political majorities:

- On the one hand many different "players" with different interests and attitudes are involved, including very strong pressure groups.
- The instruments require a certain minimum level of international co-operation. The example of the CO_2/energy tax has shown the difficulties that may arise from this fact. However, one should not forget that all three instruments leave room for initiatives of a single or a group of Member States.

The following potential measures to improve political acceptance have been made out:

- **Improving and harmonising the evaluation of external costs** in order to increase the comparability and robustness of the findings. The research work within the 4th Framework programme will probably contribute to this objective.
- **Transparency of internalisation measures** in order to reduce misunderstandings of the objectives of an internalisation of external costs (e.g. "internalisation taxes are simply another fiscal instrument of the state").
- **Use of the revenues**: Because distributive effects often dominate in the political debate the way the revenues of the internalisation instruments are used can considerably contribute to an increase of political acceptance. Ways have been found to ensure distributional neutrality.
- A **communication strategy** to inform about the objectives of internalisation strategy and to include all major actors in the discussion on the introduction of a internalisation instrument will be inevitable.

8 Conclusions and recommendations

Based on the main findings of topic B of this research project the conclusions and the recommendations for the further proceeding in this field of transport policy are the following:

- The **concept of internalisation** has proved to be a **feasible concept** if it is understood in a broader sense namely as a tool
  - to provide important information for the political discussion about transport policy measures
  - to emphasise the polluter-pays principle to be a main characteristic of an efficient transport policy and therefore
  - to promote the use of economic instruments to change price signals in the favour of a more environmentally compatible transport system
  - to define a useful range of the rate of internalisation taxes.
- The analysis has shown that **assessments of avoidance costs and of external costs** should rather be considered as complements than as substitutes. It can be concluded that further research work should aim at enlarging knowledge about both, external and avoidance costs.
- A wide range of useful **possibilities to use avoidance cost assessments** - as carried out in topic A of this research project - for internalisation and other purposes was identified:

use for internalisation	use for further purposes
– defining differentiation options for taxes – defining the level of taxes	– defining economically sensible environmental targets (together with external cost estimates) – defining a cost-effective mix of instruments to achieve environmental targets – forecasting the impacts of the introduction of certain instruments – showing the costs of environmental policy measures

- The analysis within topic B of this research project pointed out that **cost-benefit analysis of various differentiation options of the same instrument** are important. In general, the higher the "precision" of an instrument is, the higher are the implementation costs. Thus, only cost-benefit analysis can show what differentiation level can still be justified with the implementation costs. The analysis has shown that further information about implementation costs and potential welfare gains of additional differentiation options are needed to ensure that internalisation instruments do realise the polluter-pays-principle in an optimal way.
- Furthermore, it has become clear that only **packages of different instruments** will be suitable for making transport sustainable. The definition of such packages should be the next step as soon as all the promising internalisation instruments and further

transport policy measures are described in detail. Cost-benefit analysis should then be carried on the base of packages of different instruments too.

With regard to the **three instruments** the conclusions and recommendations are the following:

- **Mileage tax for European freight transport**: From the analysis in the sub report it can be concluded that this variable tax for HGV is a promising instrument for the future transport policy at EU level:
  - The tax would be a suitable complement to a CO_2/energy tax if it is differentiated according to emission limits. If the differentiation rewards technologies that reduce emissions even more than the best available technology, the tax will set strong incentives for innovations.
  - According to preliminary cost-benefit analysis, a spatial differentiation of the tax would probably yield additional net welfare gains.
  - The mileage tax can take profit from the current development of automatic metering systems to charge road freight transport for its infrastructure costs according to the territoriality principle. It should be ensured that these metering systems do also meet the requirements of a differentiated mileage tax aiming at an internalisation of external costs of transport.

- **Sales tax and annual vehicle tax**: Both taxes show the disadvantages of fixed taxes, i.e. they mainly "only" have a technological incentive effect but almost no impact on transport volume. In the case of the sales tax, undesirable effects, namely postponement of the purchase of new cars, may result. Nevertheless, there are good reasons in favour of the use of these differentiated fixed taxes:
  - If appropriately designed, the technology incentive effect can be strong. Entirely new technological concepts can be promoted effectively. Therefore, the fixed taxes can be considered as a useful accompanying instrument of a usage related tax that does not directly take into account the emission abatement technology (e.g. a fuel tax). If ever possible the differentiation of the fixed taxes should not base on a certain technology but on emission limits.
  - The implementation costs are comparatively low (classification, low enforcement costs).

- **Variable track charge for railway noise**: Despite the difficulties to internalise railway noise by a tax further investigations of this instrument can be recommended, mainly due to the following reasons:
  - In the context of the deregulation within the rail sector the introduction of infrastructure fees is planned. This fee could be a useful starting point for the implementation of this internalisation instrument.
  - Preliminary cost-effectiveness estimates have shown that reducing noise from the rolling stock seems to imply costs in the same order as other reduction measures (e.g. noise barriers) but results in a higher "quality" of noise reduction because

emissions are reduced at the source. Thus, a net social benefit can be expected from a track charge taking into account the characteristics of the rolling stock and therefore setting incentives to use less noisy rolling stock.

- In most European countries other measures than a reduction at the source (e.g. complementary local measures) will be necessary to reduce noise annoyances of rail. The track charge would guarantee a financing of these measures according to the polluter-pays-principle.

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