European Commission's Directorate-General for Environment

Fiscal Measures to Reduce CO2 Emissions from New Passenger Cars

Main Report

Final Report

A study contract undertaken by COWI A/S

January 2002

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Prepared	JJD, AO, MSJ, NKR (COWI), MF (IEEP)
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A	Austria
ACEA	Association de Constructeurs Européens d'Automobiles
ATS	Austria Schillings
AVG	Average
B	Belgium
BEF	Belgium Francs
CO_2	Carbon Dioxide
CRTS	Community Reference Tax System
CT	Circulation Tax
D	Germany
DEM	Germany Deutsche Marks
DG-ENV	Directorate-General for Environment
DG-TAXUD	Directorate-General for Taxation and the Customs Union
DK	Denmark
DKK	Denmark Kroner
E	Spain
ECE	Standard for measurement of fuel consumption (litre/100 km)
EEV	Enhanced Environmentally friendly Vehicles
ESP	Spain Pesetas
EU	European Union
EUR	Euro
F	France
FIFRAM	Fiscal Framework Measures
FIM	Finnish Mark
FRF	France Francs
GBP	United Kingdom Pounds
GRD	Greece Drachmae
GVW	Gross Vehicle Weight
HE	Greece
I	Italy
IEP	Ireland Punt
IRL	Ireland
ITL	Italy Lira
JAMA	Japan Automobile Manufacturers Association, Inc.
KAMA	Korea Automobile Manufacturers Association
L	Luxembourg
LUF	Luxembourg Francs
MPV	Multi Purpose Vehicles
NL	Netherlands
NLG	Netherlands Guilder
P	Portugal
PTE	Portugal Escudos
RON	Research Octane Number
S	Sweden
SEK	Sweden Kronor
SF	Finland
ToR	Terms of Reference (the Technical Annex)
VAT	Value Added Tax
UK	United Kingdom

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1 Executive Summary

1.1 Conclusions

Model based calculations constitute the core output of this study. The calculations assess the extent to which vehicle related taxes (mainly acquisition taxes and ownership taxes) can be effective means to reduce CO_2 emissions from new cars. More specifically, the model calculations have assessed the ability of vehicle taxes to support the target to reduce average CO_2 emissions from new cars down to a level of 120 g/km. This is the agreed target of the Community Strategy to reduce CO_2 emissions from passenger cars. The calculations point to the following conclusions:

- It is essential to apply a tax scheme, which is directly or indirectly CO_2 related in order to provide for significant reductions in the average CO_2 emissions from new cars.

- It is essential to differentiate the taxes in such a way that taxes for very energy effective cars are significantly lower than taxes for cars with poor energy efficiency.

- Replacing the existing taxes with purely and directly CO_2 related taxes that are sufficiently differentiated provide the largest reductions.

- Adding a differentiated CO_2 element to existing taxes provides smaller, but still quite large, CO_2 reductions. If allowance were made for a subsidy to the most energy efficient vehicles, this would however increase the rate of progression and thus lead to even more CO_2 reduction.

- Merely enhancing the differentiation of existing taxes also provides significant CO_2 reductions, although the reductions are smaller than in the above two cases.

- The level of the potential CO_2 reductions does not depend on the type of taxes, e.g. registration or circulation tax, but more on the CO_2 specificality and the level of the tax differentiation.

- Simple increases of the tax that do not involve changes to neither the tax base, i.e. the parameter(s), which determine the tax, nor the differentiation schemes provide only very small CO_2 reductions.

- It is essential to modify national taxes that are of a significant size and where there is scope for improving the CO_2 relation of that tax in order to harvest the full potentials of CO_2 reductions within the boundary conditions.

- Fuel tax increases provide only very small reductions of the average CO_2 emissions of new cars compared to vehicle taxes. Fuel taxes may however still be a very effective means of controlling the total CO_2 emissions that are attributable to passenger car transport.

The model calculations have been subject to three important boundary conditions. All model-based assessments are thus done under the condition that there should be no downsizing of the vehicle sales. Furthermore, there should be no change to the overall revenue from vehicle related taxes from new cars (i.e. the total of registration taxes, circulation taxes and fuel taxes). Lastly, the proportion of diesel vehicles should remain constant at today's level. Respecting these conditions, the calculations show that:

- While it is possible to reduce the average emissions of new passenger cars in EU by about 5% on average, it is not possible to achieve the target of 120 g/km on average and avoid an increase of the proportion of diesel cars and/or downsizing of vehicle sales. The accomplishment of the target would require an additional 5.5%. The picture would look different, if increases of the proportion of diesel vehicles and/or downsizing were accepted. Moreover, it might be possible to achieve additional reductions if the fiscal measures are closely linked to the labelling scheme established under Directive 1999/24/EC. Increasing the proportion of diesel vehicles brings the estimated CO_2 emissions closer to the target. Nevertheless, it needs to be combined with downsizing if the model calculations are to result in a reduction down to 120 g/km.

- On the other hand though, the calculations show that budget neutrality is not the binding constraint in most cases. Thus, the requirement about unchanged revenue can be fulfilled without major implications for the achieved reductions in most cases.

- The achieved reductions depend on the particular conditions that apply in the individual Member State and are affected by for example the existing tax systems and the existing composition of vehicle sales.

This executive summary first summarises the background and purpose of the study, followed by an outline of the study contents. Lastly, it contains a summary of the results of the study.

1.2 Background and purpose

The study has been prepared by COWI A/S in accordance with the contractual arrangements governing the "Study of the potential effects of fiscal framework measures to reduce CO_2 emissions of new passenger cars". The European

Commission's Directorate-General for Environment (DG-ENV) in co-operation with the Directorate-General for Taxation and Customs Union (DG-TAXUD) launched the study in the summer of the year 2000. COWI A/S was awarded the contract later that year. The study commenced in late 2000, and was completed in late 2001.

In addition to this main report, the study has also resulted in nine separate annex reports. These reports provide a detailed summary of the in-depth calculations that have been performed for the nine selected EU Member States[1].

1.2.1 Background

The Expert Group

In 2000 the Expert Group on Fiscal Framework Measures was established with the objective of contributing to the "third pillar" of the Community's programme on CO_2 emissions from passenger cars. The three pillars are:

1. Agreements with the auto industry on fuel economy improvements.
2. Fuel-economy labelling of cars
3. Fiscal measures

Thus, an immediate objective of the Expert Group is to assist the Commission in studying the possibility of establishing a reference framework for fiscal measures to reduce CO2 emissions.

The target

The European Council and the European Parliament have adopted a target of reducing CO_2 emissions from new passenger cars to 120 gram per kilometre by 2005, or by 2010 at the latest. In the year 1999, the average level of CO_2 emissions from newly registered cars produced by members of ACEA, JAMA and KAMA was 175.9 grams per kilometre in 1999, and the corresponding figure in 2000 was 172.0. Hence, the 120 g/km target adopted by the Commission may indicate yet a long way to go with respect to reducing CO_2 emissions.

The agreement with the auto industry

However, an important step in this process is the agreements between the Commission and ACEA, KAMA and JAMA respectively. The agreement aims to reduce average CO_2 emissions from new cars to 140 g/km by 2008/2009. This is to be achieved mainly through technical developments and market changes linked to these developments.

Fiscal measures

Still, the quantitative target of the agreement with the industry on achieving 140 g/km for new cars by 2008/09 does leave a "gap" of 20 g/km in order to accomplish the EU target of 120 g/km.

1.2.2 Purpose

CO_2 effectiveness of national taxation systems

The overall purpose of this study is to assist the Expert Group on Fiscal Framework Measures in considering the potentials of fiscal measures in achieving the target of 120 g/km. More specifically, the purpose of the study is

[1] Belgium, Denmark, Finland, Germany, Italy, Netherlands, Portugal, Sweden, UK

to analyse at expert level the CO_2 efficiency of the national taxation systems using a "common yardstick", and thereby enabling individual Member States to review their national taxation systems in the light of the results of this analysis. The "common yardstick" is the computer model developed by COWI A/S which is used to model the existing national taxation systems and to assess their CO_2 efficiency.

Boundary conditions

The CO_2 efficiency of the national taxation system is studied with a view to support the demand for (more) CO_2 efficient cars while at the same time taking into consideration certain specified boundary conditions. The study therefore also includes scenario runs in order to illustrate the efficiency of the identified fiscal options. The boundary conditions were agreed upon at Expert Group level in order to focus the scope of the model runs. The boundary conditions include considerations as regards the below issues:

- Revenue neutrality *(motivated in concerns expressed by Member States)*
- The proportion of diesel cars *(applied for environmental purposes in order to avoid that CO_2 reductions are achieved at the expense of increased emissions of particles and of NO_x)*
- Fleet composition neutrality (i.e. downsizing) *(requested by the car manufacturing industry in order to minimise market distortions)*

1.2.3 Study organisation

Client and stakeholders

The study was carried out under the supervision and guidance of the Client, EU DG-ENV in collaboration with EU DG-TAXUD. The Consultant also consulted regularly with the Sub-Group on Fiscal Framework Measures to Reduce CO_2 emissions from new Passenger Cars. A total of six full-day meetings have been held with this group. The Consultant participated in the second and third meetings of the Expert Group on Fiscal Framework Measures (31 May and 17 October 2001 respectively) at which the results of the study were presented and discussed.

Consultant team

The Consultant established a small key team composed of senior consultants with specific expertise in the fields of transport policy framing, fiscal measures and transport demand modelling. Furthermore, the Consultant joined together with the UK based Institute for European Environmental Policy and the Germany based Marketing Systems. The former provided specific expertise in the field of company cars whereas the latter provided data on sales and technical features of new cars in the EU Member States.

1.3 Study contents

1.3.1 Study approach

What-if model

In meeting the study objectives, and to produce the requested outputs, a model-based approach is applied. The model is a "what-if" model. It is thus *not* a projection model. The implications of that are further outlined below together with a brief description of the scope and contents of the model.

The model is used to assess the CO_2 effectiveness of current tax systems and to analyse the implications of scenarios, which introduce changes to the current system. The effectiveness of existing systems and the scenarios are analysed with a particular view to the possible impact on the above mentioned pre-defined boundary conditions. Furthermore, sensitivity analyses are carried out for selected key assumptions.

Outputs

The ultimate output of the analyses is a set of country specific model-based analyses, one for each of the nine Member States for whom the analyses are conducted. The analyses are conducted according to a common and pre-defined structure.

Based on these analyses, the study identifies key conclusions in regard to the feasibility of accomplishing the EU target by means of vehicle related fiscal measures.

1.3.2 Study delineation

Vehicle sales and taxes

New petrol- or diesel fuelled passenger cars are considered in the study. The study considers all main taxes related to these vehicles. It focuses on registration and circulation taxes. CO_2 incentives are also included, but at a less detailed level. The study also includes fuel taxes, but for modelling purposes these taxes are fixed at today's levels and structures[2].

Target year

Year 2008 is applied as the target year. Thus, 2008 is assumed to be the year when the target of 120 g/km of CO_2 is accomplished. The target adopted by the European Council and the Parliament applies a target year of 2005, and 2010 at the latest.

Data

Data are applied on existing fiscal regimes for the year 2000 including possible measures that are adopted for implementation in the period up to year 2008[3]. The data on vehicle sales and features are the most recent complete data and cover the period July 1999 to July 2000. Data on incomes and household structures apply to the most recent year for which such data could be obtained or constructed at the national level.

Average emissions from new cars

It should also be underlined that this study solely addresses the issue of the extent to which the target of 120 g/km on *average* for *new* cars can be accomplished. Thus, the study does not at all consider the possible development of, and means of controlling, the total amount of CO_2 emissions that can be attributed to the use of passenger cars or to vehicle transport as such. Reaching the target of 120 g/km on average for new cars is by no means an indication that total CO_2 emissions caused by new cars or by the vehicle fleet as such have declined. The decline in average values may namely be more than offset by for example increases in the total number of cars sold.

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[2] Although sensitivity analyses are conducted to illustrate the effects from increased fuel taxes

[3] Information gathered until September 2001

1.3.3 The model

A what-if model

The COWI Cross Country Car Choice Model is used for the model-based calculations. This model is a further development of the already existing Danish Car Choice Model. The model can be termed a "what if" model in the sense that it does not perform projections nor forecasts. It is thus *not* a prognostic model. Rather, the model merely calculates what would happen to today's car demand if certain characteristics of today's tax systems were changed, all other things being equal.

The 2008 baseline

However, the agreement with the car manufacturing industry implies that an average of 140 g/km CO_2 is to be achieved by 2008/09. Thus, the above "today's" situation is assumed to be one, where the target of 140 g/km is achieved. In constructing the 2008 baseline, it is assumed that the costs of an overall 25% CO_2 reduction amount to 5% of the production costs with a lower limit of 1,000 EUR/car and an upper limit of 2,000 EUR/car. The 25% have been calculated as the necessary reduction to provide the 140 g/km when comparing the target to the situation in 1995. It should be noted that the establishment of the 2008 baseline also takes into account the rebound effect. The rebound effect occurs because demand patterns change as a result of improved fuel economy of cars. Roughly speaking, the improved fuel economy incites consumers to buy bigger cars, which in turn increases average CO_2 emissions. This in turn calls for a more than 25% technologically driven reduction in order to provide the target of 140 g/km. As a result of the rebound effect, the required reduction to reach 140 g/km has thus been calculated to be around 27.2% in the case of petrol cars and around 21.5% in the case of diesel cars.

In other words, the model applies a baseline where the 140 g/km target is assumed to be achieved by year 2008, but where the situation in all other respects is assumed to be similar to today's situation (i.e. 1999/2000). This relates for example to purchasing behaviours of income groups and household groups, tax systems, macro-economy, income distribution and -level, fuel price developments and social structures.

In undertaking the assessments and the scenario analyses, the model simply compares this baseline with the hypothetical situation where the tax structure and/or the tax levels are changed.

Coverage and delineation

Car purchase decisions are based on a number of parameters. Apart from those that relate to the car (technical and financial including taxes) the model also considers the income, household structure and age of the purchaser of the car. These socio-economic features of the population or car purchasers in the individual Member States are accounted for at the model calibration stage. The model however does not consider aspects that relate to for example, weather conditions, urbanisation, overall road quality, landscape features or other external factors that may influence the car choice of individual EU citizens. To some extent though, these features are captured indirectly by the country specific model calibrations that have been done, but only at the very aggregated level. The model does not take into account that demand patterns may change in the future as a result of for example, changes in fashion, changes in production costs and pricing policies of manufacturers and innovation.

Model output

Important outputs of the model are the demand for new passenger cars in each of nine selected Member States and the associated average energy consumption and CO_2-emissions. New fiscal measures can be introduced into the model and the consequential effects on the demand for new cars can be calculated acknowledging the above limitations. The nine selected countries are Belgium; Denmark; Finland; Germany; Italy; Netherlands; Portugal; Sweden and UK. These countries represent a wide range of various regimes for vehicle taxation both with regard to types, design and levels. Additionally, the countries were selected to provide a wide representation of important geographical and economic features characterising EU Member States.

The structure of the model is illustrated in the figure overleaf.

Input data

The input data are the variables to be analysed (i.e. vehicle related taxes and taxation systems)[4]. The baseline is based on existing taxes and tax structures for 2000 including those that are planned for implementation in the period up to 2008. This part of the database is constructed mainly on basis of the information contained in ACEA's tax guides for 1999 and 2000 supplemented with additional information provided by the countries themselves.

As regards taxation systems and taxes that apply especially to company cars, the ACEA guide is less informative. Therefore, this information derives from other sources. This includes a questionnaire survey among the EU countries[5].

Database

The database includes observed data on sales of new vehicles (prices, numbers and technical features). This part of the database consists solely of observed data, with the sole exemption of the proportion made up by company cars. In the existing database it is not possible to distinguish between company cars and private cars. This information was provided separately for some countries. For the rest, estimates are applied. The database also includes the socio-economic features of car buyers. This information could only be fully obtained for a few countries. For the remaining countries, the socio-economic features of car buyers were estimated from the overall socio-economic data that could be obtained for the country in question combined with other relevant and available information on the country as well as on other relevant countries.

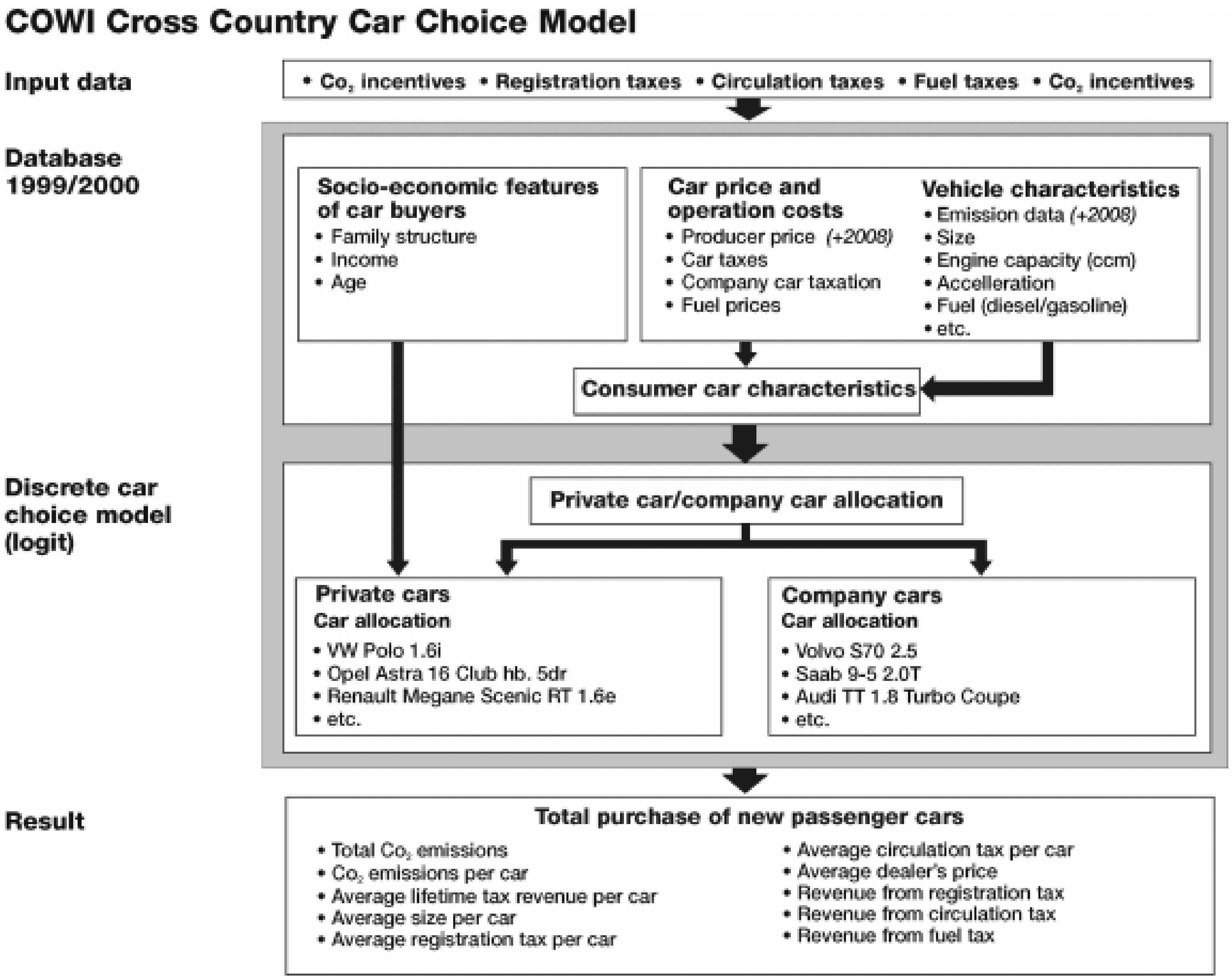
The model

Technically, the model is constructed as a logit-model. The model estimates its country-specific parameters based on elasticities derived from the original Danish model, and through a calibration and validation process, which takes

[4] For this project it was decided not to analyse the effects of changing fuel taxes and EEV incentives. While these data are inputs to the model with their country specific values, they are thus kept fixed within the analysis. Sensitivity analyses however do illustrate the implications of fuel tax increases.

[5] This information proved not to be available in some countries, and in others it proved impossible to obtain all the requested data. The methods used to derive estimates in these cases are further described in chapter 2.

into account the above socio-economic features and other country specific aspects disclosed during the process. The model uses these parameters to calculate the vehicle sales that will result from a certain set of input data and assuming that the 140 g/km target has been met. This is done by means of a two-step procedure. First, a distribution is performed of the car sales to allocate it between company cars and private cars. Secondly, the model calculates the specific allocation of the sales in these two groups. It should be noted that the total number of cars sold remains unaltered, i.e. the model does not allow for the total car sales to increase or decline as a result of the fiscal measures. This feature has no implications in relation to the ultimate objective of the study, which is concerned with the *average* CO_2 emissions from new cars. However, if the boundary conditions are substantially violated, in particular the one that requires no downsizing, this may have implications for such results as the average dealer's price, the total turnover of the car manufacturing sector, and the average taxation of cars.


COWI Cross Country Car Choice Model
Input data
• Co2 incentives • Registration taxes • Circulation taxes • Fuel taxes • Co2 incentives
Database 1999/2000
Socio-economic features of car buyers
• Family structure
• Income
• Age
Car price and operation costs
• Producer price (+2008)
• Car taxes
• Company car taxation
• Fuel prices
Vehicle characteristics
• Emission data (+2008)
• Size
• Engine capacity (ccm)
• Accelleration
• Fuel (diesel/gasoline)
• etc.
Consumer car characteristics
Discrete car choice model (logit)
Private car/company car allocation
Private cars
Car allocation
• VW Polo 1.6i
• Opel Astra 16 Club hb. 5dr
• Renault Megane Scenic RT 1.6e
• etc.
Company cars
Car allocation
• Volvo S70 2.5
• Saab 9-5 2.0T
• Audi TT 1.8 Turbo Coupe
• etc.
Result
Total purchase of new passenger cars
• Total Co2 emissions
• Co2 emissions per car
• Average lifetime tax revenue per car
• Average size per car
• Average registration tax per car
• Average circulation tax per car
• Average dealer's price
• Revenue from registration tax
• Revenue from circulation tax
• Revenue from fuel tax

1.3.4 Assessing the CO_2 effectiveness of national taxation systems

The table below provides an illustration of the operational approach that is used to assess the CO_2 effectiveness of national taxation systems. Inherent in the approach is a movement away from the existing system and into scenarios that involve more radical changes.

All calculations are subject to the boundary conditions:

- **Budget neutrality** which implies that any changes should be budget neutral compared to the base scenario for 1999, i.e. the scenario which assumes no changes in taxes and tax structures. Budget neutrality is assessed in terms of an indicator of the total revenue from the new vehicles, which includes registration tax revenue, circulation tax revenue and fuel tax revenue. The revenues are calculated for the average life time of the vehicle.

- **Unchanged proportion of diesel cars,** which means that the proportion of diesel cars in the total sales of new cars should not change. However, alternative calculations illustrate the implications of allowing for a doubling of the diesel proportion with an upper limit though of 50%.

- **No downsizing**, which implies that the CO_2 reductions should be achieved without major implications for the demand structure in terms of moving demand downwards towards smaller, and hence, more energy effective cars. As an indicator of compliance with this condition, the study has developed a size indicator based on a grouping of the cars into eight categories.

In all countries, a significant proportion of the cars sold is company cars. In most cases, the proportion of company cars lies between 10% and 45%. These cars are, on average, bigger than private cars, and the demand for them is affected by the country specific taxation schemes that apply to company cars. To take this properly into account, the model contains a separate module that splits the demand for cars between private cars and company cars. The model further contains separate demand modules, one for private cars and one for company cars. The split is determined by the taxation schemes for company cars and for private cars respectively and by the features of the various vehicles.

Table 1.1: Fiscal measures scenarios

Scenario types	Specific assumptions	Registration tax	Circulation tax	CO_2 - incentive	Comments
CO_2 effective-ness of the ex-isting national taxation systems	Differentiated registration tax based on national parameters	variable	constant	constant	Existing national tax system will be held constant. Rele-vant for countries with regis-tration tax.
	Differentiated circulation tax based on national parameters	constant	variable	constant	Existing national tax system will be held constant
Adding CO_2 differentiation	Existing national tax system plus differentiated CO_2 element into regis-tration tax	variable	constant	constant	Existing national tax system will be held constant. Rele-vant for countries with regis-tration tax.
	Existing national tax system plus differentiated CO2 element into circu-lation tax	constant	variable	constant	Existing national tax system will be held constant
CO_2 based tax structure	CO_2 differentiated regis-tration tax	variable	constant	constant	Relevant for countries with registration tax
	CO_2 differentiated circu-lation tax	constant	variable	constant	
	Mixed CO_2 differentiated scenario	variable	variable	(variable)	

Initial calculations

Prior to the scenario analyses, preparatory calculations considered whether the target would be technically feasible in a hypothetical sense. Further, it was assessed whether the target could be achieved merely by means of - hypothetically - just increasing the proportion of diesel cars, and to what extent simple increases of the current taxes would bring significant CO_2 reductions. These calculations indicated that:

- The target can be achieved if all cars within a given category (there is a total of eight categories including for example mini cars, luxury cars and MPVs) become as energy efficient as the most energy effective one within that specific category.

- Merely increasing the sales of diesel driven vehicles is not at the overall level a means of attaining the target. In some countries, notably those that have small current proportions of diesel cars, significant CO_2 reductions may admittedly be gained through such an increase in the proportion of diesel cars, but it will require very radical increases compared to today. This is further illustrated in the following section on model results.

- Simple increases in the current level of taxation (i.e. without changing the tax structure, the tax base or the size of tax differentiation) can provide only very small CO_2 reductions. Thus, it would require unrealistically high levels of taxation to reach any significant reduction. Simple tax increases are thus not an option in an effort to reduce average CO_2 emissions from new passenger cars.

Countries covered by calculations

The model based scenario analyses were conducted for the following nine Member States:

- Belgium
- Denmark
- Finland
- Germany
- Italy
- Netherlands
- Portugal
- Sweden
- UK

These countries were assessed to be sufficiently representative with regard to relevant background features (GDP, population density, family structures and urbanisation) as well as with regard to taxation systems, income levels, income distribution, and whether there is a domestic production of cars or not. Furthermore, they provide a broad geographical representation of the EU ranging from the Northern to the Southern countries. Lastly, data and/or relevant qualitative information could be obtained to a sufficiently high degree for these countries.

1.3.5 Applicability of study results

The "what-if" approach

The "what if" approach that is inherent in the model implies that the model provides a fairly transparent means of analysing the effects of changes in the level and structure of relevant fiscal measures.

In other words, the "what if" model based calculations provide a means of undertaking quite isolated analyses of the CO_2 effectiveness of existing taxation systems and fiscal measures scenarios. The results achieved from the calculations are, to a large extent, directly related to the applied input data and to the assumptions made. They are not affected by the inclusion of for example macro-economic projections, modelling of future car production costs, forecasts of fuel prices, development in car pricing policies, and modelling of future consumer car preferences.

This merit arises exactly because of the "what-if" nature of the model. However, the complementary feature of this approach is that the results of the model cannot be interpreted as projections of what would actually happen in 2008. In reality, actual developments will namely be affected by a number of factors that are not taken into account in the model calculations. These factors include, but are not limited to, the above mentioned issues.

1.4 Taxes and tax systems

The table below provides an overview of the types of taxes that are in effect in Member States. The specific design of the taxes differs substantially among Member States. This relates both to the level of taxation, the extent to which differentiation is applied and the tax base in use (e.g. the dominating parameter such as value, cylinder capacity, and horsepower). The major taxes of relevance to this study are the first five of those listed in the table. The registration charge and the insurance tax are quite small in most countries. The major revenue contributors are registration taxes, fuel taxes, and circulation taxes together with VAT. From a CO_2 reduction perspective, the company car taxation schemes are also of utmost relevance. The model calculations however do not assume changes in the existing systems for company cars.

Table.1.2: Types of vehicle related taxes in effect in Member States

	A	B	D	DK	E	F	HE	I	IRL	L	NL	P	S	SF	UK	#
Registration tax	●	●		●	●		●	●	●		●	●		●		10
Circulation tax	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15
Fuel tax	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15
Company car taxation	●	●	●	●	●	○	○	●	●	○	●	●	●	●	●	15
EEV incentive	●		●	●						●						4
Reg. charge	●	●	●	●	●	●		●		●	●	●			●	11
Insurance tax	●	●	●	●		●		●		●			●			8
VAT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15

● = Tax in use; ○ = Default values established in absence of data/information.

Registration taxes

Denmark and to some extent also Finland, the Netherlands and Portugal applies very high levels of registration taxes whereas the Italian level is insignificant. In all the former countries, the registration tax is of a significant size compared to the circulation tax. Five countries do not have registration taxes, namely Germany, France, Luxembourg, Sweden and UK. Germany however has a small CO_2 incentive, which is related to the purchase of a car. The registration tax is typically value based, but often with an element of differentiation incorporated. Typically, the differentiation relates to cm^3, but in Denmark it is purely value-defined with the exception of highly energy efficient vehicles, which are awarded a deduction. In the Netherlands, there is a differentiation in favour of petrol driven vehicles, and in Austria the registration tax is based on both fuel consumption and value.

Circulation taxes

Circulation taxes are applied in all countries except France. In France, circulation taxes are a regional measure rather than a national one. The tax base varies and includes HP, KW, cm^3, cylinder capacity, weight of the car, and engine size. In Denmark, fuel consumption and fuel type determines the tax, and in Germany, emission technology is one of the parameters used to calculate the tax. More specifically, the tax base is made up of the combination of emissions of conventional pollutants combined with cylinder capacity. Furthermore, the UK applies CO_2 as the explicit tax base.

Company car taxes

Company cars are subject to some form of taxation in all countries. While the study did manage to collect substantive amounts of country specific information on this, the database on this issue remains incomplete due to a lack of information from some countries. Still, the available information shows that an annual tax is typically imposed on the owner based on the value of the car. This level ranges from 9% in Sweden and 12% in Germany and up to a level of 25.5% in Ireland. In the UK the tax might be as high as 35%. Furthermore, several countries have schemes for modifications depending on use level and three countries have reported imposition of charges on the supply of free fuels for private use (Ireland, Finland and the UK). In the UK, a new company car taxation schemes enters into force in 2002 according to which company car taxation will be based mainly on CO_2 emissions.

1.5 Results from model calculation

Base scenario and value of boundary conditions

Prior to presenting the results from the scenario analyses, the table below summarises the key features of the base scenario. The table also shows the values of the boundary conditions for the nine countries. These values are shown in bold.

The table illustrates the substantial variation that can be observed when comparing the various countries. For example, some countries do not have registration taxes, while others have very high registration taxes. The average circulation tax also exhibits substantial variation among countries. The average size provides a rough indication of the average size of the new cars in the nine countries. This indicator varies substantially: from a level of 2.28 in Italy and up to 3.69 in Sweden. The values of the size indicator also illustrate that diesel cars are typically larger than petrol cars on average. This observation applies in all countries except Sweden. Similarly, the proportion of diesel vehicles also exhibits substantial variation ranging from below 10% and up above 50% in Belgium where the proportion is 54.5%. In this regard, it should be noted that there is currently a general trend of increasing diesel proportions in most countries. For example Germany has experienced significant increases since 1999/2000. The average lifetime revenue contribution per car also varies quite a lot from one country to the other. This revenue consists of the total taxes that are paid on average per car during the whole lifetime of the car and it includes fuel taxes, registration taxes and circulation taxes. The lifetime tax revenue range from more than 30,000 EUR and down to around 5,000 EUR.

Table 1.3 Overview of base scenario values

Base scenario values. 1999/2000	B	D	DK	I	NL	P	S	SF	UK
Average life time tax revenue per car									
- petrol, EUR/car	**7,845**	**6,950**	**29,286**	**5,696**	**16,661**	**5.348**	**7.814**	**13,539**	**11,824**
- diesel, EUR/car	**9,916**	**7,845**	**34,753**	**6,545**	**23,248**	**9,200**	**12,248**	**19,920**	**12,248**
Average value of size indicator									
- petrol	**2.78**	**3.18**	**2.98**	**2.28**	**2.82**	**2.54**	**3.69**	**3.26**	**3.10**
- diesel	**3.42**	**3.62**	**3.29**	**3.32**	**3.43**	**3.67**	**3.60**	**3.45**	**3.60**
Average registration tax									
- petrol, EUR/car	208	-3	16,025	151	3,726	2.236	-	7,863	-
- diesel, EUR/car	291	-11	22,530	151	6,032	6.583	-	10,410	-
Average circulation tax									
- petrol, EUR/car/year	177	88	404	151	433	35	150	118	231
- diesel, EUR/car/year	384	282	574	190	986	31	236	572	236
Proportion of diesel cars, %	**54.5**	**21.2**	**10.6**	**29.3**	**22.9**	**22.6**	**7.1**	**7.4**	**13.9**

1.5.1 Scenario analyses

Purely CO_2 differentiated taxes

The model-based calculations show that the largest CO2 reductions can be achieved when the existing system is replaced by a CO_2 dependent registration tax and circulation tax. The calculations that have been undertaken follow the steps shown in *Table 1.1*. The table below illustrates the achievable reduction from these new, and more radical, measures. It should be noted that the country specific targets that are contained in all of the tables are purely hypothetically defined targets[6]. The calculations thus relate to a situation, where all countries are assumed to provide the same relative reduction compared to 1995. As mentioned, this assumption is purely hypothetical and presumably not very realistic given the fact that such a similar relative reduction could be claimed to impose very strict and difficult requirements onto the countries that already in 1995 had small average emissions compared to the EU average.

[6] The strategy to reduce average CO_2 emissions from new cars does not define national targets. The theoretical targets listed in all the tables were calculated as points of comparison. They assume that the reduction from 1995 to 2008 is to be of the same relative size in all Member States. The resulting theoretical targets that are contained in the tables divert a little from each other. The reason for this is the development in specific emissions is the development of the proportion of diesel cars in the period from 1995 to 2000.

Table 1.4 Calculated maximum CO_2 reduction from a replacement of existing taxes [1)]

	B	D	DK	I	NL	P	S	SF	UK
Target CO_2 reduction, %	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Reduction for petrol cars, %	*5.4*	*5.5*	*8.6*	*4.3*	*6.5*	*2.9*	*3.9*	*4.1*	*4.9*
Reduction for diesel cars, %	*4.8*	*3.4*	*7.7*	*3.7*	*4.3*	*4.6*	*4.4*	*7.0*	*4.5*
Total CO_2 reduction achieved, %	5.1	5.0	8.5	4.1	6.0	3.3	3.9	4.3	4.8
Distance from target, percent-age points	5.7	5.5	1.4	7.3	4.2	7.5	6.3	6.4	5.5
Average registration tax									
petrol cars, '000 EUR/car	*323*	*-*	*21,113*	*151*	*4,629*	*2,868*	*-*	*9,086*	*-*
diesel cars, '000 EUR/car	*3,287*	*-6*	*25,324*	*241*	*6,554*	*7095*	*-*	*10,260*	*-*
Average circulation tax									
petrol cars, '000 EUR/car/year	*304*	*232*	*188*	*151*	*556*	*44*	*300*	*118*	*451*
diesel cars, '000 EUR/car/year	*231*	*369*	*451*	*269*	*1,062*	*33*	*415*	*646*	*415*
Diesel share, %	54.5	21.2	10.6	29.3	22.9	22.6	7.1	7.4	13.9

[1)] The maximum CO_2 reduction is generally obtained by combining purely CO_2 differentiated registration and circulation taxes. Exceptions from this rule are D, I and S (purely CO_2 circulation tax) and UK (circulation, increased progression).

In interpreting the results, it should be noted that the UK circulation tax is already explicitly related to CO_2 emissions. Therefore, the results provided from the calculations serve to illustrate the order-of-magnitude additional CO_2 reductions that could be provided by strengthening the relation and the progression of the tax in the UK. Given the existing CO_2 relation of the tax system in the UK, the results from the various scenarios for the UK simply presents the implications of applying the three different underlying functional relations.

The table shows that significant CO_2 reductions could be achieved within the boundary conditions if the national taxation systems were modified in such a way that CO_2 specific aspects were better considered. This conclusion applies to all the Member States that were analysed. The table however also shows that it is not possible to achieve the theoretically defined targeted CO_2 reduction *and* at the same time avoid violating the boundary conditions. In this regard it should be noted that there are some possible effects that have not been included in the calculations. Thus, there is likely to be a synergy effect from a combined launching of changes to the tax schemes and supporting other measures. For example the combination of information campaigns, labelling of cars according to CO_2 performance and a tax system that relates liable taxes to the CO2 performance. Furthermore, an increase of the proportion of alternatively fuelled vehicles (such as LGP or CNG) can reduce the target that must be fulfilled by the petrol and diesel vehicles in order to achieve the overall target of 120 g/km. In addition, the calculations have not involved any changes to the existing company car taxation schemes. Such modifications may also lead to reductions in the average CO_2 emissions from new cars, in particular if they involve more CO_2 dependency of the taxes and abolishment of schemes that provide for free fuel. In this regard, it is important to note though that company cars are typically bought on behalf of the more affluent parts of the population. If they were to replace the company car by a private car, the private car would probably continue to be larger than average. Company cars are 8-10% bigger than private cars, and while modifications to company car tax systems may reduce their size somewhat, the replacement cars are still likely to remain above average. Lastly, diesel fuelled vehicles emit about 10% less of CO_2 than petrol fuelled vehicles.

The table below provides rough estimates of the possible further reductions, compared to the above results that could be achieved if the proportion of diesel vehicles was allowed to increase.

Table 1.5 *Calculated CO_2 reduction from a replacement of existing taxes with purely CO_2 differentiated registration and circulation taxes. Allowing diesel share to increase.*

Doubling of diesel share (maximum share: 50%)									
	B	D	DK	I	NL	P	S	SF	UK
CO_2 reduction	5.1	6.6	9.4	6.0	7.6	5.8	5.2	5.2	6.1
Difference from target	5.7	3.9	0.5	5.4	2.6	5.0	5.0	5.5	4.2
New diesel share, %	54.5	42.4	21.2	50.0	45.8	45.2	14.2	14.8	27.8
Diesel share = 50%									
	B	D	DK	I	NL	P	S	SF	UK
CO_2 reduction		7.2	11.8		7.9	6.4	8.2	9.5	8.1
Difference from target		3.3			2.3	4.4	2.0	1.2	2.2
New diesel share	54.5	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0

The first part of the table shows the results from a mere doubling of the current diesel proportion applying however an upper limit of 50%. This can be seen to bring further reductions in all cases. In relative terms, the additional reduction in Portugal would be the largest comparing the original 3.3% to the 5.8% that could be provided if the diesel share was allowed to double.

A doubling, however, still results in very large discrepancies between the various countries, with respect to the proportion of diesel vehicles of the total vehicle sales. Therefore, the second part of the table illustrates the implications of having a diesel proportion of 50% in all countries. This calculation is purely theoretical and highly hypothetical as it involves very substantial increases in some countries. Nevertheless it serves to illustrate that even in this case the target cannot be achieved, with the exception of Denmark. In most of the cases where the assumed increase up to 50% constitutes a substantial change to the current situation, it does result in significant additional CO_2 reductions. It should be noted that the above calculations assume that any replacement is effectuated as a pure fuel replacement. Thus any other features of the cars in question are assumed to remain unaltered.

Adding a CO_2 element

The model based calculations show that it is also possible to reach significant reductions simply from adding a CO_2 element to the existing taxes. This is further illustrated in *Table 1.6*.

Table 1.6 *Calculated CO_2 reduction from adding a CO_2 element to existing taxes.*

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline), %	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Adding CO_2 element to registration tax									
- petrol, CO_2 reduction, %	*4.3*	*-*	*4.9*	*3.0*	*3.9*	*2.0*	*-*	*2.9*	*-*
- diesel, CO_2 reduction, %	*2.5*	*-*	*1.6*	*3.0*	*1.7*	*2.4*	*-*	*2.1*	*-*
Total reduction, %	3.3	-	4.6	3.0	3.4	2.1	-	2.8	-
Distance to target, % points	7.5	-	5.3	8.4	6.8	8.7	-	7.9	-
Average registration tax									
- petrol, EUR/car	1,786		20,816	1,135	5,823	2,955	-	9,046	-
- diesel, EUR/car	1,418		25,784	1,036	7,207	7,077	-	10,991	-
Average circulation tax									
- petrol, EUR/car/year	174		193	153	436	35	-	118	-
- diesel, EUR/car/year	384		389	191	988	31	-	573	-
Adding CO_2 element to circulation tax									
- petrol, CO_2 reduction, %	*4.0*	*5.0*	*5.4*	*3.6*	*4.7*	*1.9*	*3.1*	*3.2*	*4.6*
- diesel, CO_2 reduction, %	*2.0*	*2.4*	*1.9*	*2.7*	*1.9*	*2.7*	*4.3*	*2.5*	*4.3*
Total reduction, %	2.9	4.4	5.0	3.3	4.0	2.1	3.2	3.1	-
Distance to target, % point	7.9	6.1	4.9	8.1	6.2	8.7	7.0	7.6	-
Average registration tax									
- petrol, EUR/car	197	-	18,330	151	4,189	2,327	-	7,034	-
- diesel, EUR/car	287	-8	24,346	151	7,327	6,909	-	10,996	-
Average circulation tax									
- petrol, EUR/car/year	310	230	411	151	581	89	297	292	-
- diesel, EUR/car/year	480	366	513	266	979	46	414	573	-

Calculations were also undertaken to illustrate the effects from simply increasing the differentiation within the existing tax systems. The results are shown in *Table 1.7*. These calculations show that this more moderate change to the existing system in the sense of not introducing new tax bases, can provide CO_2 reductions that are quite significant, but smaller than in the above scenario of adding a CO_2 element to the existing tax base.

Table 1.7 Calculated CO_2 reduction from increasing the progression of existing taxes.

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline), %	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Increased differentiation of registration tax									
- petrol, CO_2 reduction,	*3.7*	*-*	*3.6*	*-*	*4.4*	*1.5*	*-*	*2.6*	*-*
- diesel, CO_2 reduction, %	*1.5*	*-*	*1.0*	*-*	*1.2*	*3.0*	*-*	*1.3*	*-*
Total reduction, %	2.5	-	3.3	-	3.6	1.8	-	2.5	-
Distance to target, % points	8.3	-	7.7	-	6.6	9.0	-	8.2	-
Average registration tax									
- petrol, EUR/car	1,891	-	20,702	-	5,910	2,955	-	9,040	-
- diesel, EUR/car	1,563	-	25,662	-	7,212	7,102	-	10,977	-
Average circulation tax									
- petrol, EUR/car/year	163	-	197	-	431	34	-	118	-
- diesel, EUR/car/year	369	-	396	-	986	30	-	572	-
Increased differentiation of circulation tax									
- petrol, CO_2 reduction, %	*3.7*	*5.1*	*5.8*	*3.3*	*4.3*	*1.7*	*2.2*	*-*	*4.9*
- diesel, CO_2 reduction, %	*1.3*	*1.8*	*2.3*	*1.2*	*1.4*	*2.6*	*4.5*	*1.7*	*4.5*
Total reduction, %	2.4	4.4	5.4	2.7	3.6	1.9	2.4	0.1	4.8
Distance to target, % points	8.4	5.5	5.6	8.7	6.6	8.9	7.8	10.6	5.1
Average registration tax									
- petrol, EUR/car	153	-	17,938	151	4,135	2,254	-	-	
- diesel, EUR/car	275	-6	24,169	151	7,304	6,741	-	10,971	
Average circulation tax									
- petrol, EUR/car/year	313	231	449	239	584	95	294	-	451
- diesel, EUR/car/year	479	364	536	262	965	60	415	573	415

The table below summarises the reductions in average CO_2 emissions from new passenger cars that can be achieved in each of the above scenarios by year 2008. The results shown in the table are all within the boundary conditions.

The table illustrates the conclusion that the replacement of existing taxes by purely CO_2 dependent taxes in most cases provides the largest CO_2 reduction. It is however noteworthy also that in the UK a simple enhancement of the differentiation of the current circulation tax performs even better. This is due to the recently implemented CO_2 dependency into the UK tax system. Thus, the calculations indicate that UK can actually provide a reduction in the order of 5.7% simply by means of further enhancing this differentiation.

Table 1.8 Summary of main results

	B	D	DK	I	NL	P	S	SF	UK
Calculated reductions, %	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Enhanced differentiation of existing taxes									
- registration tax	2.5	-	3.3	-	3.6	1.8	-	2.5	-
- circulation tax	2.4	4.4	5.4	2.7	3.6	1.9	2.4	0.1	4.8
Adding a CO_2 element to existing taxes									
- registration tax	3.3	-	4.6	3.0	3.4	2.1	-	2.8	-
- circulation tax	2.9	4.4	5.0	3.3	4.0	2.1	3.2	3.1	4.6
Purely CO_2 differentiated taxes									
- registration tax	3.5	-	8.4	1.8	5.5	3.2	-	4.3	-
- circulation tax	4.2	5.0	5.5	4.1	6.0	2.3	3.9	3.5	4.7
- combination	5.1	4.9	8.5	4.0	7.0	3.3	3.8	4.3	4.5

Comparing the results from the table, it can be seen that the potentials of fiscal measures to provide the requested CO_2 reductions are largest in Denmark and the Netherlands. Purely CO_2 differentiated circulation *and* registration taxes would provide 8.5% and 7% reductions respectively. For Belgium, Germany and the UK, the potentials lie in the range of 4.5%-5%, whereas between 4% and 4.5% could be provided in Italy, Sweden and Finland. Portugal has the smallest reduction potentials from fiscal measures, namely 3.3% at the maximum. One should note that part of the explanation for the small reduction potentials in Portugal are likely to lie in the small average size of vehicles in Portugal. While a similar feature applies in Italy, the variation is likely to be much larger in Italy than in Portugal.

Denmark, Portugal and Finland are all countries with a relatively high registration tax. In all these countries, the replacement of taxes by CO_2 dependent taxes provides significant results in the cases where this replacement involves the registration tax. In the case of the Netherlands where the registration tax is also significant, both of the existing taxes are not originally very CO_2 related. Therefore, the replacement of both taxes with a purely CO_2 differentiated tax performs better than the individual cases. Similarly, in Belgium there is a large increase when comparing the replacement of the registration tax alone (3.5%) to the situation where both taxes are replaced (5.1%). In the latter case, the counterproductive effect from the circulation tax is removed. The effect from modifying only the registration tax is namely reduced due to the large impact from the circulation tax, which is relatively weakly related to CO_2 emissions.

Calculations have also been undertaken to assess the extent to which results would be affected by alternative formulations of the budget boundary condition. Two alternatives are investigated. First, it is assumed that the revenue from fuel taxes is not to be included in the definition of the constraint, and second, it is assumed that the constraint is only to consider the revenue from the tax in question, i.e. the one that is subject to modification. These calculations show only little sensitivity of results to such changed formulations of the budget. In the majority of cases, the effect is between 0.1 and 0.3 percentage points.

Furthermore, the implications of allowing for an increase in the fuel tax of 25% have been analysed. The calculations show that fuel tax increases alone will only provide for reductions of the average CO_2 emissions from new cars in the order of less than 1%. Only in a very few cases is the reduction more than 1%, and never above 2%. Combining the fuel tax increase with the scenario that changes the progression of the taxes, involves very small changes to the original results, typically in the order of 0.1% to 0.5%.

1.5.2 Benchmarks and differentiation levels

The above scenario calculations all result in an implicit level of differentiation, and the below table serve to illustrate the order of magnitude of these differentiation levels. In order to allow for comparisons, the country specific differentiation levels have been normalised in the table to apply to the accomplishment of emissions reduction of one percentage point in all cases. However, it is still important to note that inter-country comparisons should be done with the utmost care since the total achievable level of CO_2 emissions reductions (within the boundary conditions) varies from one country to the other. Similarly, the table shows the levels of differentiation for two scenarios, viz. adding a CO_2 element to the existing tax and replacing the existing tax with a purely CO_2 dependent tax. In the vast majority of cases the latter provides for the largest total reductions, and in addition it is important to note that the two scenarios apply very different underlying functional tax relations. Regarding registration taxes, the table disregards the results for Belgium and Italy, as the existing registration tax is very low in these countries.

It should be underlined that the table merely summarises the levels of differentiation. The figures stated in the table ***cannot*** be used to calculate the resulting tax burden as all the underlying functional relations include a negative constant, which should be included in such calculations. It should also be repeated that the calculations have been subject to the boundary conditions, and consequently they also respect the requirement that any tax change should be budget neutral.

Table 1.9 Normalised levels of differentiation (tax differentiation to provide for 1% reduction), EUR/g CO_2 [7]

Tax scenario	Adding a CO_2 dependent tax to the existing tax				Replacing the existing tax with a fully CO_2 dependent tax			
	Registration tax		Circulation tax		Registration tax		Circulation tax	
Country	petrol	diesel	petrol	diesel	petrol	diesel	petrol	diesel
Belgium	163	54	1.0	2.6	11	17	4.1	8.8
Germany	not relevant		0.7	1.1	not relevant		1.4	2.0
Denmark	41	67	2.6	5.9	75	116	4.9	17.3
Italy	93	41	1.1	1.5	38	12	3.9	2.0
Netherlands	34	55	1.3	3.6	36	55	4.1	10.3
Portugal	44	13	1.8	0.5	51	19	6.5	1.2
Sweden	not relevant		1.5	1.1	not relevant		2.1	2.2
Finland	48	44	1.3	1.4	60	58	1.8	2.8
UK	not relevant		1.2	0.9	not relevant		1.6	1.2

[7] It should be noted that all the underlying tax functions include a negative constant, and therefore the shown differentiation levels ***cannot*** be used to calculate the resulting tax.

2 Introduction

This report was prepared in accordance with the contractual arrangements governing the "Study of the potential effects of fiscal framework measures to reduce CO_2 emissions of new passenger cars" including the Technical Annex of the Invitation to Tender. The Study was launched by the European Commission’s Directorate-General for Environment (DG-ENV) in co-operation with the Directorate-General for Taxation and Customs Union (DG-TAXUD). COWI A/S has undertaken the Study. It commenced in late 2000 and was completed one year later.

In carrying out the study, the Consultant has consulted regularly with the Sub Group on Fiscal Framework Measures to Reduce CO_2 Emissions from new Passenger Cars" (henceforth: "the Sub Group"). The Consultant strongly appreciates the fruitful and very professional discussions that have taken place at these meetings as well as more concrete inputs, comments and proposals provided by the individual members of the Sub Group. Nevertheless it should be underlined that the contents of this report remains the sole responsibility of the Consultant.

2.1 Background and purpose of the study

2.1.1 Background

The Expert Group on Fiscal Framework Measures

In 2000 the Expert Group on Fiscal Framework Measures was established with the objective of contributing to the “third pillar” of the Community’s programme on CO_2 emissions from passenger cars. The three pillars are:

- Agreements with the auto industry on fuel economy improvements.
- Fuel-economy labelling of cars
- Fiscal measures

An immediate objective of the Expert Group is thus to assist the Commission in studying the possibility of establishing a reference framework for fiscal measures to reduce CO2 emissions.

The target

The European Council and the European Parliament have adopted a target of reducing CO_2 emissions from new passenger cars to 120 gram per kilometre by 2005, or by 2010 at the latest. In the year 1999, the average level of CO_2 emissions from newly registered cars produced by members of ACEA, JAMA and KAMA was 175.9 grams per kilometre. Hence, the 120 g/km target adopted by the Commission may indicate yet a long way to go with respect to reducing CO_2 emissions.

The agreement with the auto industry

However, an important step in the right direction is the agreement between the Commission and ACEA, KAMA and JAMA respectively. The agreement aims to reduce average CO_2 emissions from new passenger cars down to a level of 140 g/km by 2008/2009. This is to be achieved mainly through technical developments and market changes linked to these developments in the car manufacturing.

Fuel-economy labelling of cars

Another pillar is the completed work on the labelling of cars with information on fuel economy.

Fiscal measures

Still, the quantitative target of the agreement with the industry on achieving 140 g/km for new cars by year 2008/09 does leave a “gap” of another 20 g/km in order to accomplish the EU target of 120 g/km.

To address this issue, the Environment Council in October 1999 reiterated the need to study the possibility of establishing a reference framework for fiscal incentives. To this end, the Commission established an Expert Group, which assists the Commission in this work. The present study is to assist this Expert Group in fulfilling its mandate.

2.1.2 Purpose

Overall purpose

In line with the above, the overall purpose of the study is to assist the Expert Group in accomplishing its task. More specifically, the purpose of the study is to analyse at expert level the CO_2 efficiency of the national taxation systems using a "common yardstick", and thereby enabling individual Member States to review their national taxation systems in the light of the results of this analysis. The "common yardstick" is the "Community Reference Tax System" (CRTS). In practical terms, this is the computer model previously developed by COWI A/S which can be used to model the existing national taxation systems for new cars and to assess their CO_2 efficiency. This model has been further developed in the context of this study to respond to the specific needs of the study.

With these results at hand, individual Member States should thus evaluate their national tax systems in order to assess the following characteristics:

- Completeness of the tax system
- Sufficient differentiation in vehicle taxes for low and high consuming vehicles
- Incentives for best performing vehicles

In providing the requested outputs, the Consultant worked under the guidance and supervision of EU DG-ENV (the Client), EU DG-TAXUD and the Sub Group.

The CO_2 efficiency of the national taxation system is studied with a view to support the demand for (more) CO_2 efficient cars while at the same time taking into consideration certain specified boundary conditions. The study therefore includes scenario runs in order to illustrate the efficiency of the identified fiscal options. The boundary conditions include considerations as regards the below issues:

- Revenue neutrality,
- The proportion of diesel cars,
- Fleet composition neutrality (i.e. downsizing)

Outputs

The final outputs of the study consist of:

- A final report, which is made up by this report (the main report) and an annex report. The latter provides detailed summaries of the results from the country-specific model based calculations.

- An access-based ready-to-use version[8] of the model that enables the further analyses of fiscal measures scenarios in respect of course of the inherent limitations that result from the applied approach and underlying input data.

Approach

A model based approach is applied to meet the study objectives. The scope and contents of this approach are further out-sketched below, and a more detailed description is contained in chapter 3.

Delineation

In the study, all taxes related to the purchase and operation of new vehicles are considered focusing however on registration and circulation taxes. The study also considers, but at a less detailed level, fiscal incentives for CO_2 reductions, which may be part of EEV incentives. In line with the Terms of Reference, the study does not consider fuel taxes as an option. Rather, the current level of fuel taxation is considered as given. The study will consider the following taxes and fees in more detail.[9]

The study draws on data (vehicle fleets, socio-economic variables and tax systems) from late 1999 and early 2000, the latest period consistently available. For the sake of simplicity, this report hereinafter quotes the study's base year as 1999. In the case of socio-economic data, the database applies to the most recent year for which such data could be obtained. In some cases this is earlier than 1999.

[8] Noting that the delivery will *not* consist of user guided software, and the use of it will therefore assume prior knowledge and familiarity with access.

[9] Noting that instruments that relate to second hand cars will be dealt with mainly in qualitative terms.

Table 2.1 Taxes, incentives and tax deductions and their coverage by the "Community Reference Tax System".

Relevant taxes, incentives and deductions	Not considered	Considered, but as a fixed parameter	Considered as a variable parameter
VAT for car purchase		x	
Registration tax for new cars			x
Registration tax for second hand cars	x		
Circulation tax			x
CO_2 incentive			x
Scrapping incentive		x	
Fuel/lubricant tax (VAT and excise duties)		x	
Insurance tax	x		
Tolls	x		
Tax reductions for business related use of private cars		x	
Tax reductions for commercial cars		x	
Corporate taxation related to company car acquisition		x	

The Terms of Reference for the study define the target year as 2008. It is thus assumed that (i) all planned changes in Member State fiscal regimes will be implemented by then, and (ii) no additional changes will be implemented to achieve the 120 g/km target in the period up to 2008.

2.2 Approach and methodology

The use of a model-based tool for identifying and assessing various fiscal policy options constitutes the methodological core of the study. The computer model itself is used to assess the effects from various policy options (scenarios) that are established beforehand. The outputs of model calculations thus provide the major inputs into the task of identifying the appropriate policy options when considering the CO_2 effectiveness of the various options.

The model

The basis for developing this model-based tool is the already existing Danish Car Choice Model. In the context of the present study, the applicability of this model at the EU level is tested and the emerging needs for calibration are identified and implemented.

Inputs

Essential inputs to the model consist of information on:

- National sales of new vehicles
- National taxes and tax systems related to vehicles
- National socio-economic data on car purchasers

Data on the above issues are collected and used in the model. Before the conduct of the country specific calculations and analyses, the model has been subject to extensive calibration and validation based on these data as well.

In the process of data collection, The Sub-Group, the Expert Group and the Commission assisted where possible. Furthermore, national experts and institutions were approached when relevant.

Input assumptions

In addition to the above factual information, the definition of the base scenario also required essential assumptions to be made[10]. These assumptions concern:

- the costs involved in achieving the 140 g/km assumed efficiency gain;
- the envisaged implementation of 140 g/km target (given that the 140 g/km is an average, it is necessary to establish operational assumptions as to the achieved reduction for the various vehicle types);
- the corresponding Member State average percentage reductions to be applied (for example, 35 % for the period 1995-2008);
- taxes and structures that will prevail in 2008 in the absence of any specific measures to support the 120 g/km target.

2.3 Structure of this report

This report first provides an in-depth description of the model-based approach that underlies and governs the work conducted under this contract. The results of the data collection are presented in the following chapters on the taxes, the vehicle data and the socio-economic data. The next chapter describes in more detail the fiscal policy measures scenarios, i.e. the operational approach to assessing the CO_2 effectiveness of national taxation systems. This chapter also includes a discussion of the boundary conditions. Lastly, the report provides a summary of the results and conclusions from the model based calculations. This includes also sensitivity analyses, a discussion of the implications of important constraints and assumptions and a summary of the major points for discussion, which have arisen from this study.

The detailed summaries for the country specific model calculations are issued as a separate annex consisting of nine papers - one for each country.

[10] Noting that it was decided at a relatively early stage of the project to apply 1999 as the base year and to assume that the year of achieving the 140 g/km and the 120 g/km targets was to be year 2008.

3 The passenger car model

3.1 Model scope and approach

Model background and overall approach

The COWI Cross Country Car Choice Model is used in this study to do the model-based calculations. This model was developed based on the already existing Danish Car Choice Model.

The model can be termed a "what if" model in the sense that it does not perform projections nor forecasts. It is thus *not* a prognostic model. Rather, the model merely calculates what would happen to today's car demand if certain characteristics of today's tax systems were changed, all other things being equal.

Acknowledging however, that the voluntary agreement implies that an average of 140 g/km CO_2 is to be achieved by 2008/09, the above "today's" situation is assumed to be one, where the target of 140 g/km has been achieved.

In other words, the model applies a baseline where the 140 g/km target is assumed to be achieved, but where the situation in the target year of 2008 in all other respects is assumed to be similar to today's situation (i.e. 1999/2000). This relates for example to purchasing behaviours of income and household groups, tax systems, macro-economy, income distribution and social structures.

In undertaking the assessments and the scenario analyses, the model simply compares this baseline with the hypothetical situation where the tax structure and/or the tax levels is assumed to be different.

Coverage and delineation

The study is only to consider new cars. Consequently, second hand cars are excluded from the analysis. The model thus assumes that buying behaviour as regards second-hand cars remains similar to the behaviour that was valid upon the time of the collection of the socio-economic data (see chapter 4), and the model cannot provide any information as to the characteristics on that market.

Furthermore, the model-based calculations only consider passenger cars with petrol and diesel engines. Other technologies could in principle be included as well, as long as they are in supply today. The major motivation underlying this delineation is the scarce current supply of cars equipped for alternative fuels, which renders estimations on these cars less robust. An estimate on the implications of assuming that a certain share of the new cars use alternative fuels has been calculated for Italy in response to a specific request.

Car purchase decisions are based on a number of parameters. Apart from those that relate to the car (technical and financial including taxes) the model also considers the income, household structure and age of the purchaser of the car. These socio-economic features of the individual Member States are accounted for at the model calibration stage. The model however does not consider aspects that relate to for example weather conditions, urbanisation, overall road quality, landscape features or other external factors that may influence the car choice of individual EU citizens. To some extent though, these features are captured indirectly by the country specific model calibrations that have been done, but only at the very aggregated level. The model does not take into account that demand patterns may change in the future as a result of for example changes in fashion, changes in production costs and pricing policies of manufacturers and innovation.

Model output

Important outputs of the model are the structure of demand for new passenger cars in each of the EU Member States that are analysed[11] and the associated average energy consumption and CO_2-emissions. New fiscal measures can be introduced into the model and the consequential effects on the structure of demand for new cars can be calculated acknowledging the above limitations.

Applicability of results

The "what if" approach that is inherent in the model implies that the model provides a fairly robust means of analysing the effects of changes in the level and structure of relevant fiscal measures. However, it should be noted that the approach also implies that the model can by no means be used to assess the actual fulfilment of the CO_2 target of 120 g/km on average for new cars in 2008.

3.2 Model framework

The overall model set-up is illustrated in the figure overleaf. As shown, the model structure consists of four parts: The input data, the database, the model and the results/outputs:

- **The input data** are the variables to be analysed in terms of their effect on car purchase (i.e. the fiscal measures).
- **The database** contains observed data from the market, such as prices and the technical characteristics of sold cars, plus assumptions made outside the model (relating to the above voluntary agreement and other necessary technical assumptions such as the annual mileage). The database also includes socio-economic information enabling a characterisation of car buyers according to income level, household structure and age).
- **The model** combines the estimated relations between the objective conditions (database and input data) and subjective consumer behaviour (the elasticities).

[11] This study performs model-based calculations for nine countries (Belgium, Denmark, Germany, Italy, Netherlands, Finland, Sweden, Portugal, UK)

- **The results/outputs** are the calculated car purchases given the above input data, the database and the model. Based thereupon, the results/outputs part can provide information on for example the resulting tax revenues, energy use, average car prices, composition of the resulting sales of new vehicles, and the consequent CO_2 emissions from new cars.

The input data consist of the taxes that are of relevance to car purchases and car ownership. More specifically, the input data consist of registration taxes, circulation taxes, fuel taxes, and CO_2 incentives.[12] In this study, the term CO_2 incentive is used for fiscal measures that aim to encourage the purchase of less energy consuming vehicles. Typically this is in the form of deductions from the general tax, but it can also be in the form of actual subsidisation.

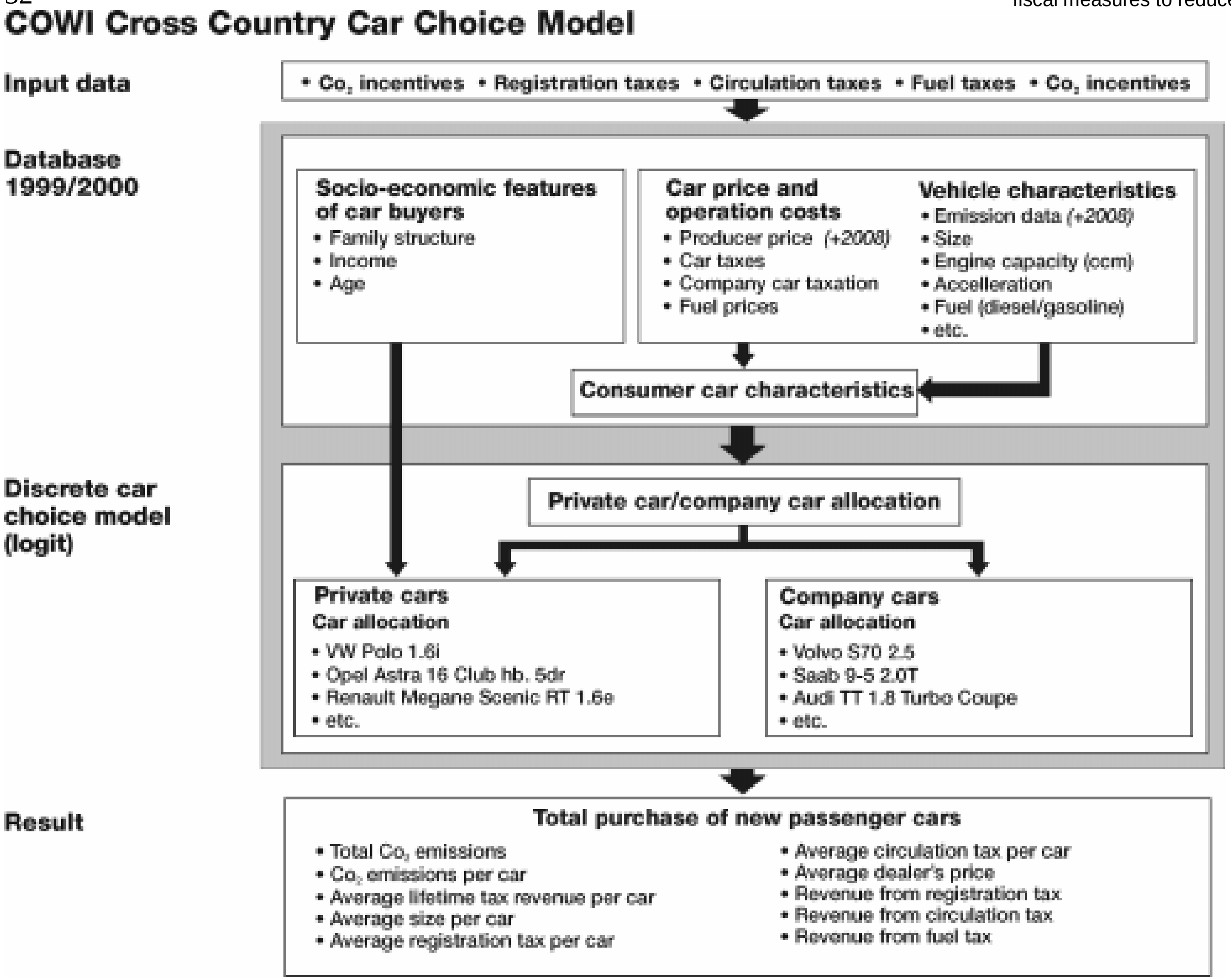
While the registration tax is the only tax that directly affects the purchase price of a car, other taxes and incentives also influence indirectly the decision on car purchase. Such taxes relate to the ownership and use of a car and include circulation taxes and fuel taxes. The model only considers the former of those (the circulation tax) as variable whereas the fuel tax is considered as fixed at today's level. This is in line with the overall scope and delineation of the study. CO_2 incentives may be designed to affect either the purchase price or the running cost of the vehicle.

The model includes both private cars and company cars. The demand for private cars and company cars are calculated separately and then combined taking the proportion of company cars into account. It should be noted that company cars are less sensitive to price changes relative to private cars. This is taken account of in the model calculations and the effects will of course be most predominant in countries with a high proportion of company cars.

In terms of output, the model provides information on the distribution of the total purchase of new passenger cars and the associated average CO_2-emissions in the 9 EU countries that are analysed given the established assumptions about the fiscal policy measures (expressed by the input data). The output may be decomposed in various ways and dimensions as illustrated in the figure.

The applied elasticities are shown in the annexes.

[12] CO_2 incentives will be accounted for as exemptions to the registration tax.


COWI Cross Country Car Choice Model
Input data
• Co2 incentives • Registration taxes • Circulation taxes • Fuel taxes • Co2 incentives
Database 1999/2000
Socio-economic features of car buyers
• Family structure
• Income
• Age
Car price and operation costs
• Producer price (+2008)
• Car taxes
• Company car taxation
• Fuel prices
Vehicle characteristics
• Emission data (+2008)
• Size
• Engine capacity (ccm)
• Accelleration
• Fuel (diesel/gasoline)
• etc.
Consumer car characteristics
Discrete car choice model (logit)
Private car/company car allocation
Private cars
Car allocation
• VW Polo 1.6i
• Opel Astra 16 Club hb. 5dr
• Renault Megane Scenic RT 1.6e
• etc.
Company cars
Car allocation
• Volvo S70 2.5
• Saab 9-5 2.0T
• Audi TT 1.8 Turbo Coupe
• etc.
Result
Total purchase of new passenger cars
• Total Co2 emissions
• Co2 emissions per car
• Average lifetime tax revenue per car
• Average size per car
• Average registration tax per car
• Average circulation tax per car
• Average dealer's price
• Revenue from registration tax
• Revenue from circulation tax
• Revenue from fuel tax

3.3 Database

The database includes three types of information on the purchases of new cars:

- Socio-economic features of buyers of new cars
- Information on car price and running cost
- Other vehicle characteristics

4 The base year has been established as 1999/2000. Comprehensive and consistent sets of data on cars and car purchase are available for the last half of 1999 and the first half of 2000. It has been decided to use these sets of data because they provide the most up to date information. The only modification to this is the assumed fulfilment of the target of 140g CO_2/km in 2008. This in turn also necessitates that assumptions are established on the resulting dealer's price and the average CO_2 emissions of new cars sold in 2008.

5 Marketing Systems GmbH has provided the data on car purchases and the associated car prices and car characteristics. Data on fiscal measures have been obtained through ACEA's annual tax guides. This information has been updated or amended based on information provided through the questionnaire survey, which the Commission facilitated in late 1999. The Consultant has reviewed the responses and revised the data base accordingly. Socio-economic data have been gathered using national statistics and information provided by individual focal points.

6 Company cars constitute a significant share of the total number of purchases of new cars in most Member States. The factors that affect decisions on the purchase of company cars differ from those that affect the decisions on private cars. To improve the accuracy of the model it is therefore essential to collect specific information on the purchases of new company cars and the taxation systems that govern this part of the market. To collect this information, the consultant conducted a questionnaire based data collection.

The data on the vehicles among other things include the prices for the registered new cars. This, combined with information on taxation including VAT, is used to calculate the dealer's price (excl. VAT) and the associated car taxes. The exact derivation of the price at purchase is done in a separate module. Another separate module derives the running costs per 100 km.

The cost increase that will result from the car producers' efforts to achieve the target of 140g CO_2/km is a core issue in setting the dealer's price. This issue was thoroughly discussed at meetings in the Sub Group and at a workshop organised by ACEA-workshop. It was decided to assume that the resulting cost increase per car amounts to between 1,000 and 2,000 EUR - plus VAT (with a linear increase from small to large cars). A sensitive run has been made for Italy, which assumes lower costs in order to assess possible distortions on less expensive cars. This cost increase is assumed to be associated with achieving a 25% reduction in the energy consumption of the cars.

The reduction of 25% corresponds to assuming that the 140g CO_2/km is achieved in 2008 taking 1995 as the base year for comparison. It has been assumed that the small cars reduce less than 25% while the bigger cars will reduce by more than 25%, reflecting the hypothesis that the technical progress has a lower limit close to the very energy-efficient cars of today.

Data on vehicle purchases across household structures and income levels are used also to calibrate the model in order to take properly into account the specific socio-economic features of each of the 9 Member States that are analysed.

The car costs and the vehicle characteristics together with the socio-economic data form the "consumer car characteristics", which are used as the basis for the model calculations.

3.4 The logit model

The logit model combines the information about the consumer car characteristics with the observed market data for car purchase in order to establish reliable relations (and thereby elasticities) for consumer behaviour on the car market. Hence, the first step of the model calibration is to establish a model set-up that provides calculated results/outputs for today's situation which are reasonably similar to the situation as it can be actually observed.

The car choice model consists of three sub-models. The first model determines whether the consumer buys a private car or a company car. Secondly two models are used to determine the choice of car for the private car buyers and the company car buyers, respectively. Thus, there are separate modules covering both private cars and company cars respectively, although it should be noted that the latter is more roughly dealt with. The models are logit models that build on the assumption that the consumer maximises his or her utility.

The output of the model calculations is a large number of individual car choices, summarised as the relative change (probability-based) in the purchase of each car. The relative change will be applied to the present number of cars purchased, in order to arrive at the estimated number of specific cars purchased in each country.

The most interesting result in the context of this study is the average CO_2 emissions that result from the alternative assumptions about the fiscal measures (input data) and the consequent structure of car purchases. This overall result may be decomposed and illustrated in various ways and dimensions, as shown in figure 1.

The model set-up and model considerations are described in more detail in the Technical Annex.

1.1 Model validation

A series of tests has been carried out in order to validate the model and its use in the EU Member States. The tests have compared results from model based calculations with observed data in order to validate the ability of the model to calculate the actual demand within a tolerable level of uncertainty.

During the project, the Consultant has performed detailed validation tests for all countries before the model was applied. This section shows examples of the validation tests for Denmark and for Germany. The validation tests for the other countries show results that are quite similar to the examples shown here.

The validation has considered the following three parameters:

- Levels of CO_2 emissions
- Registrations of new cars
- Estimates of parameters (elasticities).

The validity of the parameter estimates was tested at detailed level combining demand data with car characteristics for 11 Member States (as many as there were data available for at the time of testing). These tests, and the detailed validation tests for Denmark and Germany illustrates and confirm the overall accuracy of the model calculations, albeit with minor country specific adjustments proved necessary in some cases.

CO_2 emission levels

Figure 3.1 and Figure 3.2 below show the results of the validation tests for both petrol- and diesel-fuelled cars, respectively. The calculations have been done separately for company cars and private cars because of the difference in emission levels among these two groups.

Figure 3.1 Modelled CO_2 emissions compared to observed CO_2 emissions for petrol cars in Germany and Denmark (1999/2000)

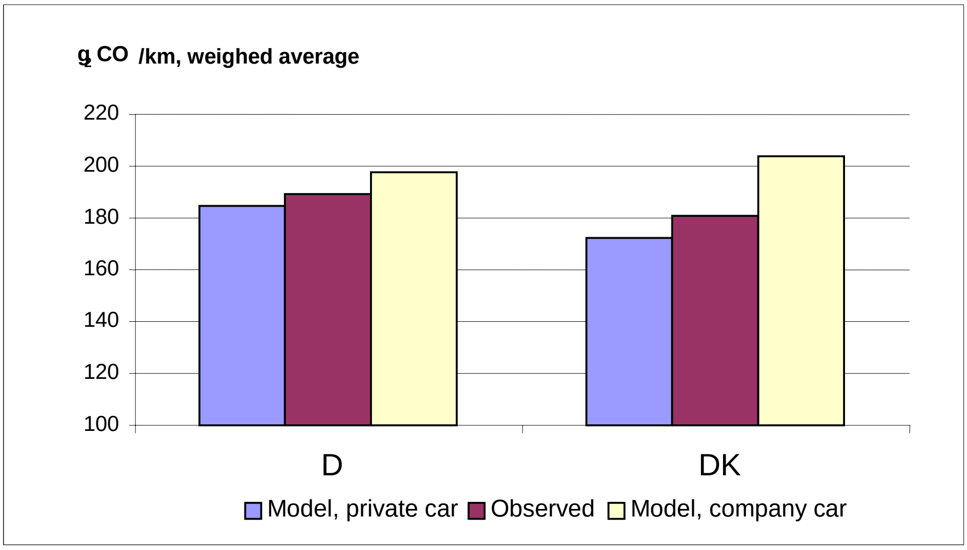
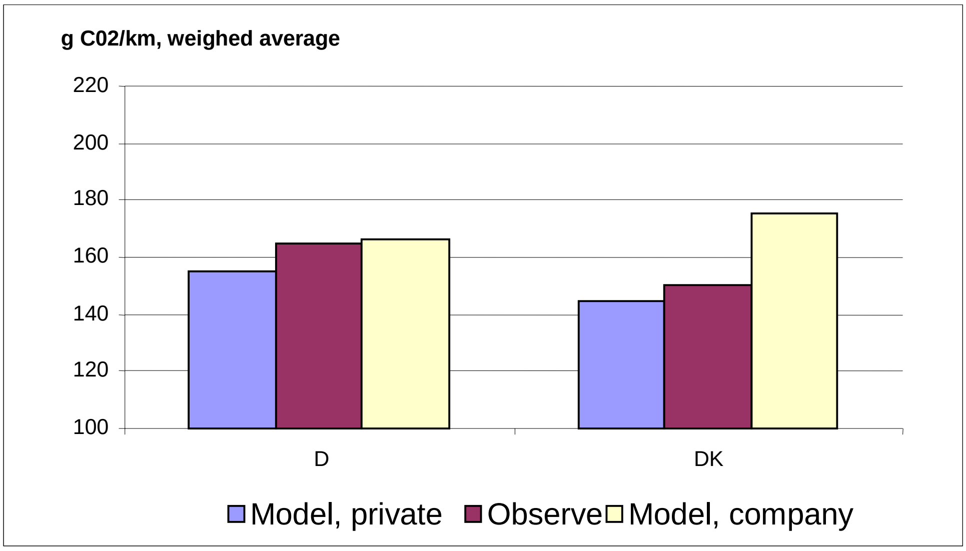


Figure 3.2 Modelled CO_2 emissions compared to observed CO_2 emissions for diesel cars in Germany and Denmark (1999/2000)



As shown, the model calculates larger CO_2 emissions from company cars relative to private cars. This correlates very well with the fact that company vehicles generally tend to have relatively lower rates of energy efficiency). The observed CO_2 emission levels lie between the calculated level for company cars and the calculated level for private cars. This applies both in Denmark and in Germany, and is in line with what could be expected.

In Denmark the observed emission levels are closer to those that are calculated for private cars than for those calculated for company cars. This is well in line with the fact that private cars account for most of the registrations of new cars in Denmark.

In Germany, company cars constituted about 41% of the total number of registrations of new petrol cars in 1999/2000. The corresponding share for diesel cars was 55%. These shares are substantially larger than in Denmark. Not surprisingly therefore, the observed CO_2 emission levels in Germany are closer to those that have been calculated for company cars than for private cars. This observation is most outspoken in the case of diesel cars.

New car registrations

Figure 3.3, Figure 3.4 and Figure 3.5 show the results of the validation tests. The figures compare model results with actual data for CO_2 emission levels, engine size volumes and engine size classes respectively. All the figures show the results for petrol cars in Germany (similar figures for diesel cars in Germany are given in annexes).

At the overall level, the number of registrations calculated by the model correlate well with the observed data. However, there are also some deviations from the observed data that cannot be explained by the model. For example, Figure 3.3 shows that the model calculates too many registrations in the region of 165g CO_2 per km. Such unexplained deviations are largely caused by country-specific preferences that the model cannot capture. However, the effects from such country specific preferences are assessed to be minor in the context of this study.

Figure 3.3 Number of registrations as a function of CO_2 emissions for petrol cars (g per km)

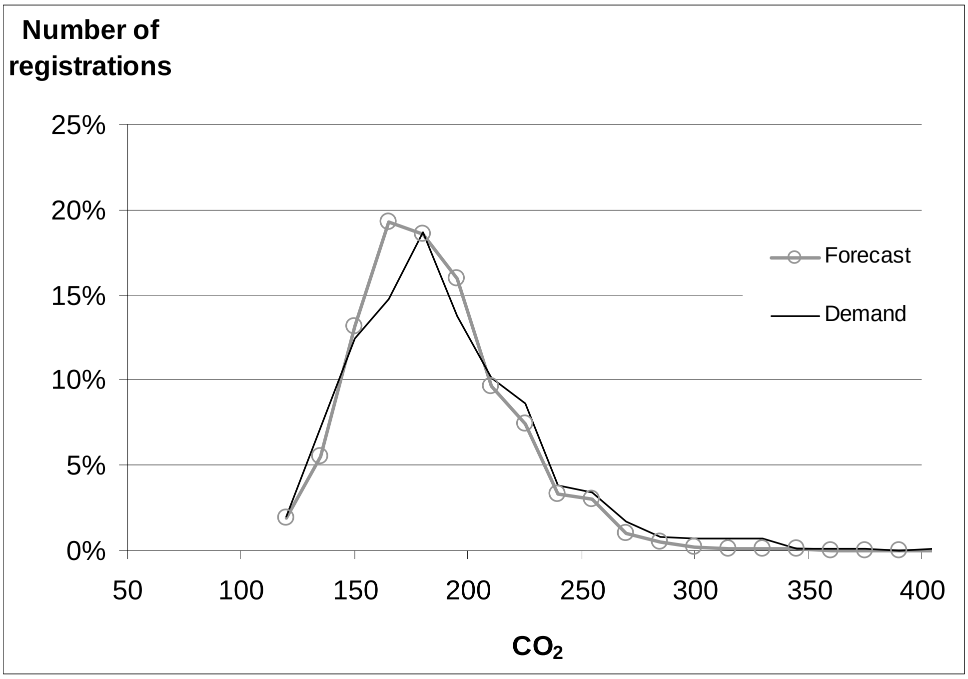


Figure 3.4 Number of registrations as a function of engine size volume (ccm) for petrol cars

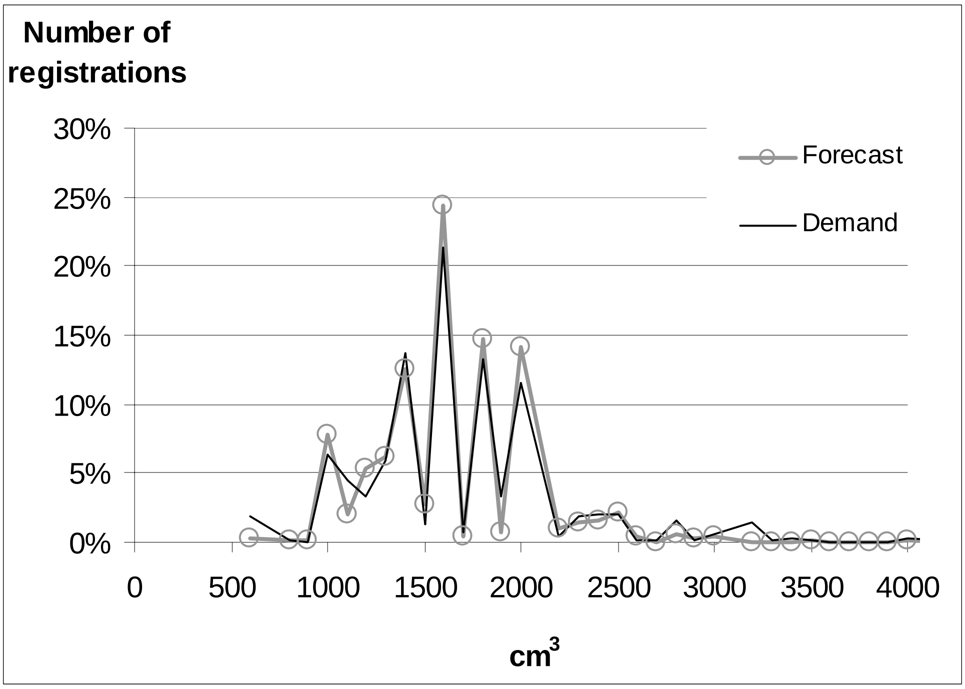
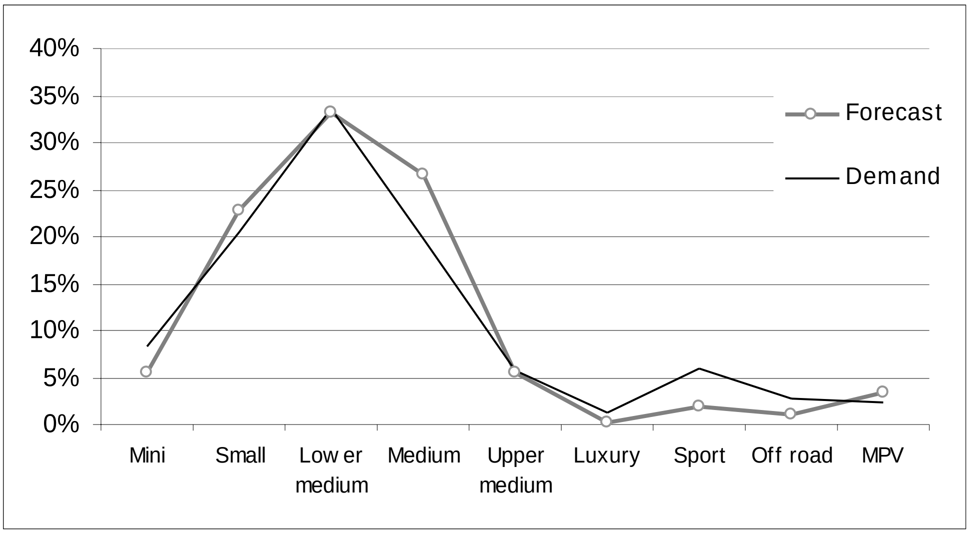


Figure 3.5 Number of registrations as a function of engine size class for petrol cars



Parameter estimates

Figure 3.6 and Figure 3.7 below show the validation results for both private cars and company cars with respect to an average for EU11[13], which was calculated for this purpose. The parameters reported here are "price" and "running costs", which are the most sensitive ones in this study.

Overall, the parameters estimated by the Danish model are in reasonable accordance with those estimated by the aggregated model. However, the calculation of a weighted average of all the parameters[14] shows that the Danish model (the original model) relies on figures that are above the levels estimated through the EU11 model (and this is true for all parameters estimated).

The major contributor to this difference is likely to be the socio-economic differences between the average car buyer in Denmark and elsewhere in the European Union. Simply stated, the average income level in Denmark is higher than in most of its other EU counterparts. Therefore, the profile of the average EU buyer correlates better with that of the lower income segments in Denmark (as corroborated by the validation test).

The parameter estimates are shown in the annex. In interpreting the tables, one should be aware that the model applies the logarithmic value of the car price (including the registration tax) rather than the absolute value.

[13] Data was available for 11 EU Member States only.

[14] The Danish model relies on a much larger set of parameters in relation with the EU11 model, including various socio-economic features of the purchaser of the vehicle.

Figure 3.6 Price parameter estimates, log(price in EUR) (1997 prices)

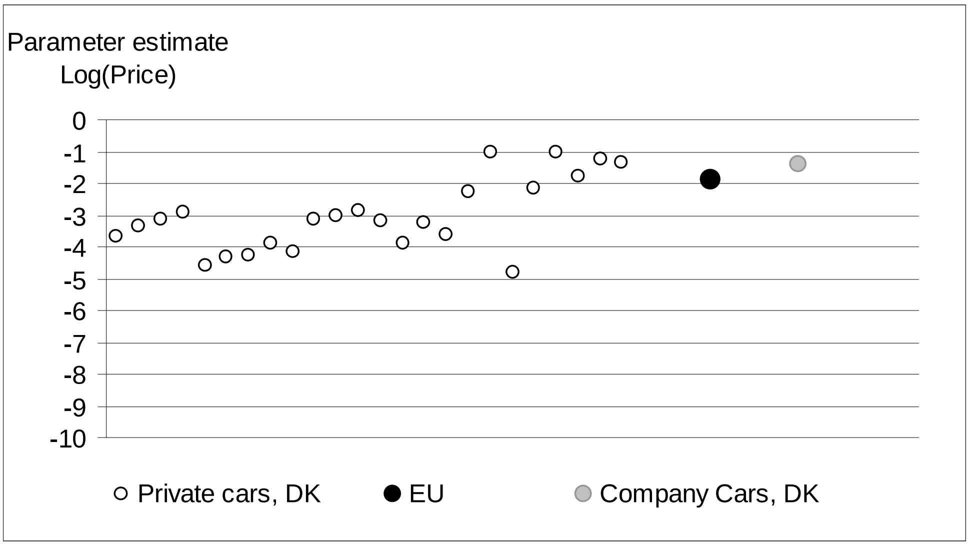
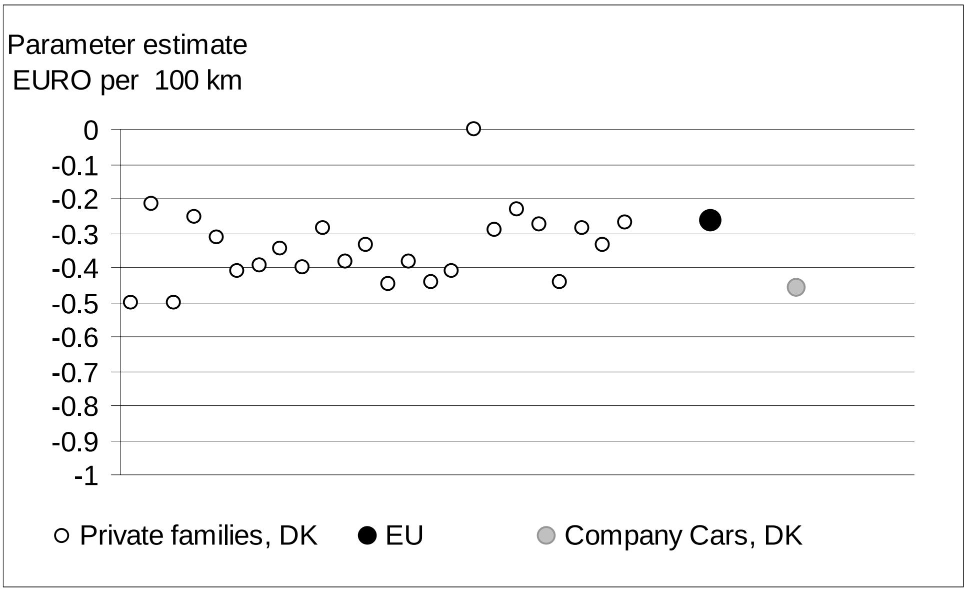


Figure 3.7 Running cost parameter estimates, DDK per 100 km (EUR / 100 km, in 1997 prices)



However, even if there are small differences, they will only have insignificant implications for the model calculations. If one corrects the Danish parameters for such differences, this only involves very marginal increases in the estimated energy consumption (0.6 % for petrol cars and 0.5 % for diesel cars). The reason for this small impact is that all parameters are adjusted in the same direction and more or less by the same factor.

The annexes provide figures similar to those shown in this section, which compare the parameter estimates for length, acceleration and luggage capacity. Furthermore, the annexes contain a table that shows the actual values for all the parameters. The applied 'parameter values are also given in annexes.

2 Data on taxes and tax systems

2.1 Passenger cars in general

Data on the structures of passenger car taxation were compiled from two sources: the ACEA 2000 Tax Guide and updates supplied by the Member States in the questionnaire survey initiated and conducted by the Commission in advance of this study. Personal contacts to individual country focal points constituted another important source of information and review.

Additionally, information on taxes and tax systems of relevance to the purchase of company cars was collected separately through the conduct of a questionnaire survey and extensive follow-up to this. This chapter first describes the overall features of the taxes and the tax systems followed by a separate section on the specific features that apply to company cars. All the information that is presented in this chapter applies to the year 2000 and includes both measures that are in effect and those that have been adopted for later implementation.

2.2 Taxes on acquisitions

In *Table 2.1*, an overview of the different tax systems in the Member states is provided.

Table 2.1 Taxes on acquisitions of passenger cars.

Country	VAT on car purchase	VAT rate, %	Registration tax	Registration charge
Belgium	*	21	*	*
Germany	*	16		*
Denmark	*	25	*	*
Spain	*	16	*	*
Greece	*	18	*	
France	*	19.6		*
Italy	*	20	*	*
Ireland	*	21	*	

Country	VAT on car purchase	VAT rate, %	Registration tax	Registration charge
Luxembourg	*	15		*
Netherlands	*	17.5	*	*
Austria	*	20	*	*
Portugal	*	17	*	*
Finland	*	22	*	
Sweden	*	25		
UK	*	17.5		*

All Member States impose VAT on the purchase of a new car and VAT-rates vary between 15% and 25%. However, not all Member States levy registration taxes and registration charges (the latter is a duty to be paid for obtaining a set of number plates and registration certificate). Furthermore, there is no uniformity across Member States with regard to the actual design of the registration tax. In some cases it is related to the physical properties of the car (e.g. cylinder capacity or fuel consumption) whereas in other cases it is related to the price of the car. A more detailed overview of the registration tax systems that are in force is provided in *Table 2.2* below.

2.2.1 Taxes on ownership and motoring

Ownership taxes include circulation tax and insurance tax. From the table below it can be seen that all Member States impose some kind of circulation tax on passenger cars. This tax is charged annually according to a variety of criteria among the Member States, e.g. fuel type, dead weight, cylinder capacity, fuel consumption and age of the vehicle. An overview of taxes on car ownership including motoring (fuel) is provided in *Table 2.3*.

Table 2.2 Detailed overview of registration tax and registration charges for the purchase of new passenger cars

	Registration tax	Registration charge
Belgium	Tax base is cm^3, Rate is differentiated with cm^3 Range from BEF 2,500 to 200,000 (EUR 62 to 4,958)	BEF 2,500 (EUR 62)
Germany	None	DEM 50 (EUR 26)
Denmark	Tax base is price incl. VAT. Rate is differentiated with price 105% up to DKK 53,000 (EUR 7,122) & 180% of remainder	DKK 1,070 (EUR 144)
Spain	Tax base is base price excl. VAT. Rate is differentiated with cm^3 7% for small cars 12% for bigger cars	ESP 10,250 (EUR 62)
Greece	Tax base is base price excl. VAT. Rate is differentiated with cm^3 Range from 7% to 88%	None
France	None	Avr. FRF 167 (EUR 25) x horse power
Italy	Fixed amount, ITL 292,000 (EUR 151)	ITL 230,500 (EUR 118)
Ireland	Tax base is price incl. VAT. Rate is differentiated with cm^3 22.5% if $cm^3 < 1{,}400$. 25% if $1400 < cm^3 < 2000$. 30% if $cm^3 > 2000$.	None
Luxembourg	None	LUF 1,166 (EUR 29)
Netherlands	Tax base is base price excl. VAT. Rate is differentiated between petrol/diesel Petrol: 45.2% - NLG 3,394 (EUR 1,540) Diesel: 45.2% + NLG 772 (EUR 350)	NLG 90 (EUR 41)
Austria	Tax base is base price excl. VAT. Rate is differentiated with fuel consumption Maximum rate is 16%	ATS 1500 (EUR 109)
Portugal	Tax base is cm^3	PTE 5,000 (EUR 25)
Finland	Tax base is CIF price excl. VAT. Rate is 100% Fixed deduction in tax is FIM 4,600 (EUR 774)	None
Sweden	None	None
United Kingdom	None	GBP 25 (EUR 40)

Table 2.3 Taxes on ownership of passenger cars and motoring.

	Ownership taxes		Fuel taxes[1], EUR/litre	
	Circulation tax	Insurance Tax	Petrol (95 octane)	Diesel
Austria	*	*	0.406	0.283
Belgium	*	*	0.507	0.29
Denmark	*	*	0.514	0.33
Finland	*		0.559	0.304
France	*	*	0.59	0.392
Germany	*	*	0.562	0.378
Greece	*		0.3	0.254
Ireland	*		0.374	0.325
Italy	*	*	0.527	0.388
Luxembourg	*	*	0.372	0.253
Netherlands	*		0.6	0.353
Portugal	*		0.289	0.246
Spain	*	*	0.372	0.27
Sweden	*		0.52	0.34
United Kingdom	*		0.764	0.764
EU minimum			0,287	0,245

[1] ACEA guide 2000, Status april 2000, Source Denmark: Oliebranchens fællesråd, average July 1999 to June 2000.

All Member States apply fuel taxes. In most countries the diesel tax is lower than the petrol tax. The petrol tax ranges from 0.289 EUR/litre in Portugal and up to 0.764 EUR/litre in the United Kingdom. The diesel tax range from 0.254 EUR/litre in Greece up to 0.764 EUR/litre in United Kingdom. EU regulation stipulates the minimum tax to be 0.287 EUR/litre for petrol and 0.245 EUR/litre for diesel. Most countries have chosen to levy higher taxes than these minimum rates.

Diesel vehicles constitute an increasing share of the vehicle sales in most EU countries. Consequently, the favourable tax treatment of diesel fuels may be changed in the future.

A more detailed overview of the structure of the circulation tax (i.e. the tax that relates to car ownership) in the 15 EU countries are given in Table 2.4.

Table 2.4 Detailed overview of circulation tax

	Basis for circulation tax	Approximate range, annually (National currency)	Approximate range, annually (EUR)
Belgium	Tax base is Fiscal HP (cm^3) , Small supplementary tax for diesel cars	BEF 2,284 (HP = 4) to BEF 58,463 (HP = 20)	EUR 57 (HP = 4) to EUR 1,449 (HP = 20)
Germany	Tax base is cm^3 Differentiated petrol/diesel		
Denmark	Tax base is fuel consumption Differentiated petrol/diesel Increase 2% anually (in fixed prices)	DKK 460 (>20 km/l) to DKK 16,920 (< 4.5 km/l)	EUR 62 (>20 km/l) to EUR 2,272 (< 4.5 km/l)
Spain	Tax base is Fiscal HP (cm^3)	ESP 2,100 (0-8 HP) to ESP 18,635 (> 20 HP)	EUR 13 (0-8 HP) to EUR 112 (> 20 HP)
Greece	Tax base is Fiscal HP (cm^3)	GDR 25,000 (< 9 FHP) to GRD 130,000 (> 17 FHP)	EUR 73 (< 9 FHP) to EUR 382 (> 17 FHP)
France	Tax base is Fiscal HP Rates varies with county		
Italy	Tax base is kW (linear relationship)	ITL 55,000 (11 kW) to ITL 1,580,000 (316 kW)	EUR 28 (11 kW) to EUR 806 (316 kW)
Ireland	Tax base is cm^3	IEP 98 (< 1,000 cm^3) to IEP 849 (> 3,000 cm^3)	EUR 124 (< 1,000 cm^3) to EUR 1,078 (> 3,000 cm^3)
Luxembourg	Tax base is cm^3	E.g. LUX 1510 (< 1000 cm^3) to LUX 13,600 (8000 cm^3)	E.g. EUR 37 (< 1000 cm^3) to EUR 337 (8000 cm^3)
Netherlands	Tax base is Weight Differentiated petrol/diesel Vary between districts	E.g. 1,100 kg: NLG 848 (petrol) and NLG 1,676 (diesel)	E.g. 1,100 kg: EUR 385 (petrol) and EUR 761 (diesel)
Austria	Tax base is kW (12 x [kW – 24] x 0,55 EUR)	Min. EUR 66 (+ approx. EUR 73 road toll)	Min. EUR 66 (+ approx. EUR 73 road toll)
Portugal	Tax base is cm^3 Differentiated petrol/diesel	PTE 2,700 (< 1,000 cm^3) to PTE 59,700 (> 3,500 cm^3)	EUR 14 (< 1,000 cm^3) to EUR 298 (> 3,500 cm^3)
Finland	Tax base is total (max) weight for diesel cars, flat rate for petrol cars	FIM 700 E.g. 1,100 kg: FIM 1,650	EUR 118 E.g. 1,100 kg: EUR 277
Sweden	Tax base is weight Differentiated petrol/diesel	E.g. 1,000 kg: SEK 734 (petrol) and SEK 2814 (diesel)	E.g. 1,000 kg: EUR 78 (petrol) and EUR 299 (diesel)
United Kingdom untill Match 2001	Tax base is cm^3	GBP 100 (< 1.1 litre) and GBP 155 (> 1.1 litre)	EUR 159 (< 1.1 litre) and EUR 246 (> 1.1 litre)
United Kingdom after March 2001	Tax base is CO_2	GBP 100 (< 150 g CO_2) and increases gradually up to GBP 155 (> 185 g CO_2) for petrol cars. The tax is approx. GBP 10 higher for diesels	GBP 159 (< 150 g CO_2) and increases gradually up to GBP 246 (> 185 g CO_2) for petrol The tax is approx. GBP 15 higher for diesels

It is worth noting that UK has recently changed its system, so that the circulation tax is now determined by the CO_2 emissions.

2.2.2 Special tax incentives for low CO_2 emissions

Tax incentives with respect to vehicles with very low CO_2-emissions are in effect in Austria, Luxembourg, Germany and Denmark.

In Germany an exemption in the circulation tax is granted to cars that meet advanced emission standards or that have very low fuel consumption as can be seen in Table 2.5 below. The information contained in the table applies to year 2000.

Table 2.5 Tax exemptions in circulation tax, Germany

	Petrol Car DEM	Diesel Car DEM
Emission standards		
Euro 3 (first registered before 01.01.2000)	250	500
Euro 4	600	1,200
Low fuel consumption		
Less than 120 g CO2/km	500	500
Less than 90 g CO2/km	1,000	1,000

Note: By 2008 the 120g tax exemption is no longer in effect.

Denmark introduced tax reductions in the registration tax for the most efficient new cars with effect from 2000. The reduction rates are different for the periods 2000-2005 and 2006-2010, and higher during the first period. The reduction rates in registration tax for new passenger cars is as shown in the table below.

Table 2.6 Reductions in registration tax, Denmark.

Fuel consumption		Reduction in registration tax	
Petrol per kilometre	Diesel per kilometre	2000-2005	2006-2010
At least 40 km/l	At least 45 km/l	4/6	3/5
Less than 40 but not less than 33.3	Less than 45 but not less than 37.5	3/6	2/5
Less than 33.3 but not less than 28.6	Less than 37.5 but not less than 32.1	2/6	1/5
Less than 28,6 but not less than 25	Less than 32,1 but not less than 28,1	1/6	-

Both Austria and Luxembourg have incentives to encourage low emissions of CO_2 (in Austria the most energy efficient cars do not pay the tax). Electric vehicles are exempted from taxes in some Member States for example Sweden. Furthermore, Sweden awards a rebate to cars that fulfil the future EU requirements on air pollution.

2.2.3 Scrapping

No countries have informed that they use taxation or incentive schemes to encourage scrapping.

3.5 Company cars

3.5.1 Definitions and Distinguishing Characteristics

Definitions

No single definition is possible of what constitutes a 'company car', not least because circumstances and tax arrangements differ significantly from country to country. Broadly, however, they are cars purchased by a company and used to some degree for carrying out company business (eg in carrying merchandise or equipment, visiting clients, etc). In addition, however, they are available to their regular users for private purposes at other times. To reflect the business use of the car, corporate tax arrangements allow the company's purchase and running costs to be reflected in the calculation of company profits as with other equipment and costs. In addition, to reflect the private benefit to the user, national taxation and social insurance systems are adapted to tax the private use as a 'benefit in kind'.

There are also several important categories of car ownership or use which do *not* fall within the above definition, however, including the following.

- Cars purchased by rental companies, for long or short term rental to private individuals.
- Privately owned cars used for commuting to work but not in the course of work.
- Private cars used occasionally in the course of work, but primarily for private purposes.
- Company owned cars used solely for business purposes, typically by a number of different employees.

Corporate versus Private Behaviour

It is known that private individuals do not always place a great deal of importance on the environmental performance of the cars, which they purchase: other factors such as style, power and safety are likely to be given greater weight.

Companies could be expected to behave more rationally – or at least differently – when they have a major influence over car buying. They may also have internal environmental policies, which encourage them for example to buy cleaner or more economical cars, to use advanced or alternative fuels. Still, companies have to prioritise between the costs and environmental performance of company cars on the one hand and the benefits of powerful and large cars on the other hand, in order to secure that company business is carried out efficiently and in order to please their employees.

The modelling undertaken is designed to reflect the differences between corporate and private cars as far as possible, by applying different treatment to the two types of cars.

Patterns of Ownership and Use of Company Cars

For a number of reasons, including those set out above, there can be marked differences between the ownership and use patterns in the company car fleet and in the private car fleet. These too need to be reflected in the modelling used in this study.

In particular, company cars tend to be larger and more powerful than the fleet average. This is partly explained by the fact that many of them are used by more affluent motorists, such as professionals, managers and company executives who tend anyway to prefer larger and more expensive cars than the average. In addition, however, tax treatment and other financial arrangements may reduce the real costs to buyers or drivers, encouraging a trend towards the larger cars.

In addition, company cars are commonly driven much farther each year than the fleet average. They therefore make a disproportionate contribution to total traffic levels, emissions and fleet average fuel consumption. This second point, however, is not directly relevant to the outputs of this study.

The Extent of Company Car Ownership and Use

In the UK, company cars began to be offered as a benefit in kind on a large scale in the 1970s. Their numbers grew steadily from that time, encouraged by relatively favourable tax treatment. They are now an established feature of the UK system, to the extent that over half of all new cars purchased are registered to a company rather than a private individual (although not all of these are ‘company cars’ according to the definition above).

Most other EU Member States have followed a similar trend to one extent or another, generally from a later date. A few exhibit an equally marked pattern of company car ownership as the UK, while in others they are less prevalent. In general, however, there has been a steady increase in their numbers in most states, and this may well continue. Again this makes it important to understand the scale of company car use in the different Member States for the purposes of this study.

Typically, company cars remain in company ownership for a period of one to three years, and are then sold on to the private second-hand market. The type and number of company cars in some national fleets therefore have an enormous impact upon the size and composition of the car fleet as a whole, and hence upon its CO_2 emissions profile.

3.5.2 Data Sources

In order to model company cars realistically, two basic types of data are needed:

- Information on the distinctive characteristics of national taxation systems relevant to company car taxation; and
- Data on the numbers and distinctive fleet characteristics of company cars within the total new car fleet for each year.

Taxation Data

Some basic information is provided for some Member States in the *ACEA Tax Guide*. Additional sources provide some further details in a few cases. However, no documentary source which addresses company car taxation in a comprehensive way has been identified.

Data have therefore been compiled on the basis of a combination of the authors' own knowledge for our home countries; relevant material from the questionnaires circulated to FIFRAM members; and more detailed input from some members of the FIFRAM group, in particular the subgroup.

Company Car Fleet Characteristics

Ownership or registration details may not be the best guide to whether or not a car is a company car according to the provided definition above. It may for example be owned by the driver, but operated with significant financial support from the employer. Some company cars may also be leased from third parties, but used by employees for company and private business just as any other company car.

National data on the prevalence and character of the company car fleet may come from any or all of the following sources:

- national vehicle purchase and registration data;
- taxation and social insurance records;
- national travel surveys;
- motor trade surveys or other sources.

The completeness and reliability of any one of these sources differs significantly from country to country. Also, where several good sources are available, they may show significantly different figures owing to the definitional problems outlined above. In practice, therefore, a compromise figure is sometimes the best and most reliable. The key requirement of this exercise has been to obtain as reliable an estimate as possible both of the scale of company car ownership and use, and of the ways in which company cars differ in size, power, fuel consumption, etc, from the car fleet as a whole.

No recent research reports with comparative data have yet been identified. The modelling inputs have therefore been compiled based on a combination of the authors' knowledge; relevant material from the questionnaires; and input from members of the FIFRAM group, in particular the subgroup.

Default Values

In spite of the above, obtaining comprehensive and comparable data on company cars and company car taxation across all Member States remains problematic. The state of knowledge on the main data, which we need in order to take properly account of the company car purchases, is good for some countries, but still very incomplete for others. Clearly, however, the modelling requires certain basic data in order to reflect company car purchase decisions realistically. At the very least, basic parameters for the modelling must include:

- Basic details of tax rates levied;
- The proportion of new cars which are purchased as company cars;
- The average engine size of total new cars purchased, and of company cars purchased.

Where these parameters are not available, therefore, default assumptions have been applied. These are based on an average from the data for countries where reliable information has been gathered, coupled with general knowledge of the position elsewhere. The main default assumptions, which are used in these cases are as follows:

Table 2.7 Default values to be applied to company car data where needed

Parameter	Default Assumption
Tax scale charge	22% of purchase price annually
Proportion of company cars in new purchases	25% of new purchases
Car engine size differential	8% above new car average in relevant MS

The selected default charge rate of 22% is above the average basic rate observed in those Member States for which details of the tax regime are available (see below). This however reflects the fact that several of these regimes impose additional charges such as free fuel charges or mileage charges which cannot be modelled separately in the default case, and so the basic charge is modelled at a higher rate to reflect this.

Conversely, the default 25% share of new purchases falls below the observed average figure. This however reflects the fact that our most detailed data come from several countries, which are known for their distinctive company car regimes (notably Germany, Netherlands, Sweden and UK). These are thought unlikely to be typical of the EU as a whole, so a lower market share, equivalent to that of Denmark, has been taken as the default.

In the following section, the extent to which national data are available, and the points at which default values have been applied, are indicated in the data tables.

3.5.3 Taxation Structures for Company Cars

Most countries now apply a scale charge as a basis for the taxation of private benefit from company cars. Typically this represents a proportion of the price or value of the car, although this proportion may vary significantly. In some cases it is related to the size or power of the car, or indirectly to the level of private mileage undertaken. In Germany, for example, daily commuting distance is taken as a proxy for the level of private use.

An additional charge or a higher charge is sometimes levied where companies provide their employees with free fuel for their private use. Typically this is a fixed charge or relates to the characteristics of the car: it rarely reflects the actual level of fuel used. These main elements are illustrated in the box below, which illustrates the requirements, which arise in Danish legislation.

Box 2.1 Example of company car taxation from Danish legislation

Taxation of the private use of a company car in Denmark
Use of a company car for private transportation comprises access to the car outside office hours as well as, for example, transportation between home and work.

To reflect this the notional value of the company car's use for private transportation is added to the employee's taxable income. In 2000 this was 25% of the price of the car (for cars up to 3 years old) (23% in 1999). The price of the car can be minimum 160.000 DKK and maximum 450.000 DKK. This price is defined as the purchase price (of a standard equipped car) plus VAT plus delivery plus registration taxes.

The employer can pay expenses related to the ordinary use of the car without this having any further tax-related consequences for the employee. This concerns, for example, insurance, gasoline, motoring taxes, and repair and maintenance.

Corporate Taxation of Company Cars
Corporate taxation and deductability related to acquisition and ownership of company cars in Denmark is as follows. An employer, who supplies his employee with a company car, can write-off the purchase value using a rate between 0 and 30% annually, and accordingly make annual deductions in the taxable income.
The purchase value is the value of the car plus VAT (as this is otherwise not deductible) plus registration tax.

The above represents a typical pattern, but there are also important differences from state to state. Table 2.8 below illustrates the main structural features of company car taxation across the EU, for countries where the appropriate data are available. Gaps in the data, and default values used in the modelling, are indicated where appropriate.

Table 2.8 Taxes on company cars.

	Fixed Charging System	% of Car Value Charged pa	Charges Modified on Use Level	Charges on Free Fuel Supplied
Belgium	No	0	*	
Germany	*	12%	*	
Denmark	*	25%		
Spain	*	15%		
Greece	?	22%**		
France	?	22%**		
Italy	*	22%**		
Ireland	*	25.5%		*
Luxembourg	?	22%**		
Netherlands	*	0% - 25%		
Austria	*	18%	*	?
Portugal	*	25%		
Finland	*	16.8%		
Sweden	*	10,980 SEK + 9%	*	
United Kingdom	*	35% (max)	*	*

Key * Yes
** Default values
? Not known

The available information is sufficient to suggest that the basic tax structure is quite similar in most countries (i.e. with the tax based on a percentage of the car purchase price), but with some additional ‘special features’ which have been identified in certain cases. Therefore, from a modelling perspective, a basic model for each country, with additional modules to reflect the known special cases, has been applied.

This however requires extra information in cases where ‘special features’ of the tax system have been identified and appear to be significant in their effect. These include, for example, special reductions, and additional taxes on free fuel for private use. In these cases it is also necessary to determine the percentage of company cars that is affected by each special feature. The information gathered on the main features of certain national taxation systems is summarised in the below table.

Table 2.9 Details of tax structures on company cars.

	Charge Modifications on Use Level	Charges on Free Fuel for Private Use	Other Features
Belgium	Charge per private km driven, based on fiscal HP – 5.83BEF at 4fHP; 15.97 at >18fHP		
Germany	0.5 DDM for each km of commuting distance		
Ireland		Additional 4.5% of purchase value charged pa if all fuel is supplied	Charge reductions available if driver pays other running costs eg tax and insurance
Netherlands	Additional 4% of car price payable pa if driver commutes >30km at least 3 days per week. No charge payable if private use is <1000km pa		Charges modified to banding system based on level of private use for 2001
Austria	Charge based solely on distance travelled for low levels of use		
Finland	A charge per kilometre is levied if detailed log of distances is provided – default charge is 0.925pcm	A higher distance charge is levied if free fuel is provided. Default charge rises to 2.27pcm	
United Kingdom	Basic charge is reduced to 25% if *business* travel >4018km, or 15% if business travel >30060km	Additional annual charge based on engine capacity – £1210 for petrol cars <1400cc; rising to 2270 for all cars >2000cc	New system comes into operation from April 2002, based mainly on g/km of CO_2

Corporate taxation related to acquisition of company cars

Little information has been obtained on systems applied for corporate taxation that relate to the acquisition of company cars. Still, it does appear that broadly similar arrangements exist in those countries for which information is available. For modelling purposes, it is therefore assumed that the cost of a company car can be deducted so that the company's taxable profit or income is reduced. It is assumed that the company is allowed to write off the value of the car using an annual rate of 25%.

Future Developments

The UK is about to switch to a system in which the level of value charge payable for company cars not only reflects the value of the car, but is also steeply graduated according to the officially-measured CO_2 emissions level. Others are also now considering a similar approach. This could in future provide a significant driver towards more efficient cars, although its actual effectiveness in doing so is as yet unknown.

3.5.4 Data on Numbers and Sizes of Company Cars

As noted above, company cars vary significantly as a share of the total new car fleet. They are also likely to have significant characteristics distinguishing them from the average of new cars. The table below illustrates this point with respect to the situation in Denmark.

Table 2.10 Data for Denmark on newly registered passenger cars in 1997

	Share	CCM	HP	Diesel share	Litres per 100 km (or gCO2/km)	Top speed km/h
Private passenger cars	75%	1575	92	1,8%	7,6	178
Company passenger cars	25%	1748	108	0,9%	8,1	189

Where comparable data are available for other Member States, these reflect a significant variation from state to state in the proportion of new cars, which are purchased as company cars. The data also confirm that company cars are typically larger, more expensive and more powerful than the fleet average. The table below summarises the available data on the main parameters of the company car fleet in each Member State, and indicates default values, which have been used in the absence of country-specific data.

Table 2.11 Numbers and sizes of new company cars.

	% of New Cars into Company Car Fleets	Engine Size Differential	% paying Free Fuel Charge	Marginal tax rate applied
Belgium	25%**	+8.0%**		66%
Germany	42%	+8.0%**		55%
Denmark	27%	+8.0%		63%
Spain	25%**	+8.0%**		
Greece	25%**	+8.0%**		
France	25%**	+8.0%**		
Italy	10%	+8.0%**		51%
Ireland	7.5%*	+8.0%**		44%
Luxembourg	25%**	+8.0%**		
Netherlands	45%	+8.0%**	25%	60%
Austria	25%**	+8.0%**		
Portugal	25%**	+8.0%**		47%
Finland	36%	+8.0%**		63%
Sweden	50%	+8.0%**		61%
United Kingdom	35%	+7.8%	45%*	40%

Key: * Provisional data
** Default values

3 Vehicle data

Marketing Systems GmbH has supplied the Consultant with monthly records of all new registrations (from January 1999 to the latest available data for 2000) for each of the 15 EU countries. The set of data refers to passenger cars and thus includes company vehicles as well.

Table 3.1 Car data status

Code	Country	Latest data	Included
A	Austria	November	Yes
B	Belgium	December	Yes
D	Germany	October	Yes
DK	Denmark	September	Yes
E	Spain	August	Yes
F	France	September	Yes
HE	Greece	December	Yes
I	Italy	August	Yes
IRL	Ireland	October	Yes
L	Luxembourg	November	Yes
NL	Netherlands	September	Yes
P	Portugal	October	Yes
S	Sweden	September	Yes
SF	Finland	September	Yes
UK	United Kingdom	November	Yes

All new registration entries (for example, Audi TT 1,8 Roadster) are linked to various technical variables and vehicle characteristics, as shown in Table 3.2 overleaf.

Table 3.2 Descriptive vehicle variables

Variable	Definition
Number of doors	2, 3, 4 or 5
Transmission	manual / automatic
Air-conditioning	
Body type	
Price (incl. All taxes)	
Driven wheel	front / rear / all
Space index	
Length	millimetres
Width	millimetres
Wheel base	millimetres
Turning diameter	metres
Luggage capacity	
Fuel type	super unleaded 95 RON / diesel
Acceleration (0 to 100 km/h)	seconds
Fuel consumption	ECE litres per 100 km
CO_2 emission per km	
Driver airbag	standard / optional
Passenger airbag	standard / optional
Side airbags	standard / optional
Engine size	cubic centimetres
HP	
Top speed	miles per hour
Weight	kerb weight and GVW (gross vehicle weight)
Engine type	in-line / V-type
Number of cylinders	
Number of valves per cylinder	2, 3, 4 or 5
Price inclusive of tax and VAT	

NOTE: the above variables are inventoried for each vehicle type (for example, Audi TT 1,8 T Roadster), which is given a unique identification code (in this example, aud-tt0010).

3.1 Vehicle basic data

The following paragraphs give tabular summaries of selected vehicle characteristics for 14 Member States. They highlight the broad spectrum of national realities across the EU and are given for illustrative purposes only (that is, to present general indicators of trends).

All the below tables only include registrations of new cars, and it should be noted that the contents of the tables must be considered as preliminary as the model calculations provide a means of final quality assurance.

Table 3.3 below presents data on number of vehicles per Member State and vehicle type. The highest values are found in Germany (the Member State with the largest car fleet), although Italy accounts for a significant share of “mini” and “small” cars. Two large Member States, France and the United Kingdom, show levels similar to those of Germany for car-derived vans and off-road vehicles, respectively. Table 6.3 shows data for the period July 1999 to June 2000 for all EU Member States.

Table 3.3 Vehicle registrations (1999/2000)

Category	A	B	D	DK	E	IRL	F	HEL	I	Lux	NL	P	S	SF	UK	All
Mini	3%	4%	7%	6%	3%	4%	5%	10%	16%	4%	10%	3%	2%	1%	5%	7%
Small	19%	25%	17%	27%	29%	32%	35%	31%	37%	21%	23%	42%	13%	17%	25%	27%
Lower medium	41%	35%	34%	33%	43%	40%	31%	37%	25%	32%	37%	32%	26%	43%	32%	33%
Medium	20%	21%	22%	29%	19%	17%	19%	13%	11%	20%	20%	11%	29%	29%	22%	19%
Upper medium	5%	6%	7%	4%	3%	3%	3%	1%	3%	8%	4%	2%	25%	7%	4%	5%
Luxury	0%	1%	1%	0%	0%	0%	0%	0%	0%	1%	0%	0%	0%	0%	1%	1%
Sport	2%	1%	4%	1%	2%	1%	1%	2%	2%	4%	1%	1%	1%	0%	4%	2%
Off-road	5%	3%	3%	0%	0%	2%	3%	6%	4%	4%	2%	9%	2%	2%	5%	3%
MPV	5%	5%	3%	1%	2%	1%	3%	0%	2%	5%	3%	0%	2%	1%	2%	2%
Share of EU	2%	4%	24%	1%	10%	2%	15%	2%	17%	0.3%	4%	2%	2%	1%	14%	100%

The following figures serve to illustrate key features of the collected data that are used in the model. They include 12 countries, among which are the 9 countries that have been subject of detailed analyses (the selection of the 9 countries is further described in chapter 4.4 and 5.1).

Table 3.4 below gives a breakdown of average vehicle prices including VAT per Member State and vehicle type. Prices in Denmark are consistently higher for all vehicle types, compared to the other Member States shown in the table. A national pattern seems to emerge for the lower end of the scale (that is, from “mini” to “lower medium”). Here, Finland and the United Kingdom have the second highest average prices. The high prices in UK are likely to be attributable to some extent to the high currency rate. It is claimed that average new car prices in UK have declined since mid 2000 as a result of government pressure[15]. High registration taxes in Portugal are responsible for the country’s dominance, always behind Denmark though, of the “medium” and “upper medium” segments.

[15] According to UK representative of Sub Group

Table 3.4 Average price January – June 2000 (prices in EUR (inclusive of registration tax), January 2000)

	A	B	D	DK	E	F	I	NL	P	S	SF	UK
Mini	10224	10414	9878	15537	8191	9433	8565	10687	11103	9267	12716	11831
Small	13064	12218	13735	20918	11344	11817	11630	13630	13676	12275	15634	14868
Lower medium	18959	16617	17605	28195	15609	17535	16494	18672	19321	16896	21065	20610
Medium	26279	22854	23885	36271	21549	22343	23649	25157	27490	22759	27910	28582
Upper medium	41384	35597	35250	67892	38557	35244	38984	43661	52112	30753	45453	43651
Luxury	78589	62658	66965	200071	68601	70758	73783	95136	100728	75040	136384	70392
Sport	39276	31902	35493	55689	22849	29117	30950	37716	35514	34354	49277	38926
Off-road	31139	28471	29436	55775	13770	26827	24507	41375	22463	29950	43302	32967
MPV	30461	25448	25595	53219	23792	28795	24043	32719	30805	28502	42254	31285

Table 3.5 below presents data on average engine size per Member State and vehicle type. While no clear national pattern can be observed through vehicle categories, registration tax levels are most likely responsible for the generally low average sizes in Portugal and the Netherlands.

Table 3.5 Average engine size (ccm)

	A	B	D	DK	E	F	I	NL	P	S	SF	UK
Mini	1070	1262	1051	1124	1067	1116	1092	1156	1045	1109	1227	1219
Small	1477	1519	1377	1389	1539	1455	1384	1431	1272	1414	1330	1342
Lower medium	1770	1704	1667	1672	1764	1780	1627	1663	1507	1661	1610	1641
Medium	1982	1905	1928	1877	1924	1927	1874	1861	1719	1938	1835	1934
Upper medium	2559	2422	2543	2454	2594	2460	2492	2457	2408	2399	2416	2534
Luxury	3773	3422	3913	4053	3640	3545	3761	3736	3725	3905	4055	3525
Sport	2141	2026	2252	2040	1881	1983	1958	2034	1822	2177	2105	2154
Off-road	2445	2253	2604	2238	1296	2375	2096	2307	1834	2651	2130	2393
MPV	2199	2044	2152	2218	2277	2107	2134	2215	2086	2591	2589	2250

Table 3.6 below shows weighted average circulation tax levels per Member State and vehicle type. Tax levels in the Netherlands are consistently higher for all vehicle types, compared to the remaining Member States represented in the table, whereas Portugal has the lowest levels. The United Kingdom has the second highest levels for both the "mini" and "small" segments, whereas Italy ranks behind the Netherlands for all three "medium" vehicle types, and France does so for "luxury" and "sport" vehicles.

Table 3.6 Average circulation tax (Prices in EUR Jan 2000)

	A	B	D	DK	E	F	I	NL	P	S	SF	UK
Mini	82	167	81	81	43	56	99	312	16	96	118	154
Small	128	218	109	136	70	70	131	405	25	118	144	154
Lower medium	207	259	128	215	82	105	187	556	38	160	147	156
Medium	281	309	144	275	96	132	239	698	51	188	151	168
Upper medium	432	535	188	384	121	268	354	892	110	227	156	204
Luxury	518	1142	272	633	126	859	484	1075	198	286	162	229
Sport	426	300	117	284	78	466	308	522	83	147	118	181
Off-road	313	553	191	410	48	219	230	857	55	250	163	210
MPV	283	357	156	525	103	154	248	908	112	270	158	208

A comparison between tables 5.3 (average vehicle prices) and 5.5 (average circulation tax level) highlights the uniqueness of the various national fiscal regimes. For example, registration taxes in Portugal are well above the Community average, which has resulted in high average vehicle prices (and partly accounts for the low circulation tax levels found in the country). Conversely, the tax burden in the Netherlands is much more evenly split between registration and circulation taxes.

3.2 Technological progress

A basic assumption of the study is that technological improvements through the period 1995-2008[16] will allow for the following CO_2 efficiency gains in new passenger cars:

- 28 % for petrol cars,
- 27 % for diesel cars.

Table 3.7 below shows the current CO_2 efficiency gains achieved thus far for both petrol and diesel cars. In turn, Table 3.8 summarises progress at the Community level in achieving the assumed efficiency gains noted earlier for both petrol and diesel. It should be noted that this section assumes that technological progress will deliver a reduction of 25% compared to 1995, and that the introduction of 10 ppm sulphur fuels will deliver an additional 2%-3%

[16] Implementation of the voluntary agreement concluded between the European Union and the car industry is expected to contribute to further reductions of the tune of 25 % for both petrol cars and diesel cars. Furthermore, the introduction of low sulphur fuels is forecasted to contribute an additional 3 % for petrol cars and 2% for diesel cars.

Table 3.7 Average Community CO_2 emissions from new passenger cars by year and fuel type (g/km)

Year	Petrol	Diesel
1995	188.5	179.0
1999/2000 (July 1999 to June 2000)	179	161

SOURCE: Monitoring Report and basic data calculations

Table 3.8 Average Community CO2 efficiency performance by year and fuel type (percent reductions)

	Petrol	Diesel
Efficiency gains already achieved (1995-2000)	3.7	7.2
Efficiency gains to be achieved (2000-2008)	24.3	19.8
Assumed efficiency gain for the period 1995-2008	*28.0*	*27.0*

The technological improvement is assumed to be smaller for the small cars, which are already technologically well advanced, and to be bigger for larger cars.

In order to allocate the technological improvement on the different cars, a lower limit is defined for the CO2 emissions for the most energy efficient cars in 2008. This hypothetical limit is set at:

- 75 g CO_2 per km for diesel cars
- 95 g CO_2 per km for petrol cars

Having set the lower limit it can be calculated how much technological improvement the larger cars should contribute in order to reach the 27% and 28%[17] respectively. The following figures illustrate the technological improvement from 1999/2000 to 2008 for different categories of cars.

[17] In the calculations we reduce the 28% to 24.3% for diesel cars and 27% to 19.8% for diesel cars to account for the efficiency gain achieved from 1995 to 1999/2000.

Figure 3.1 Technological improvement for petrol cars

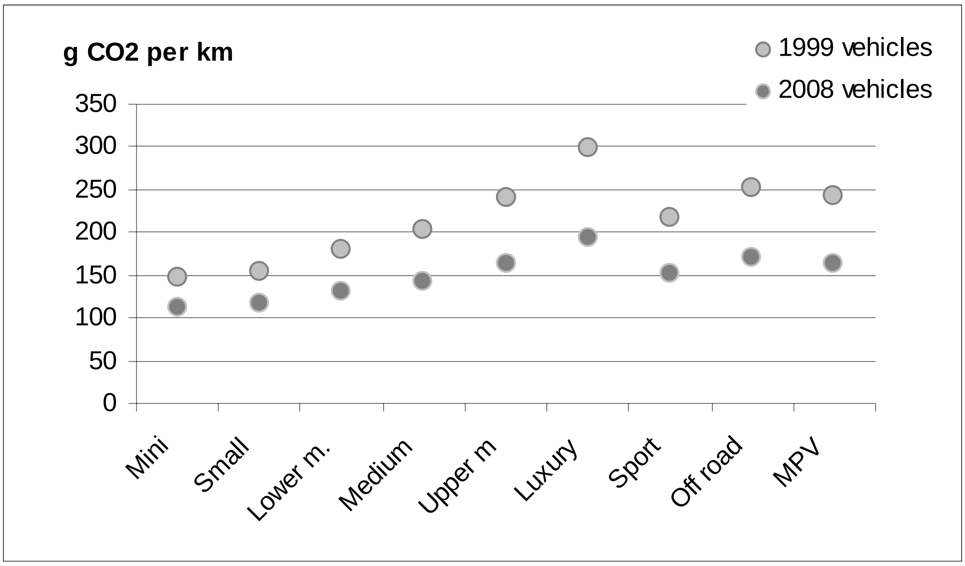
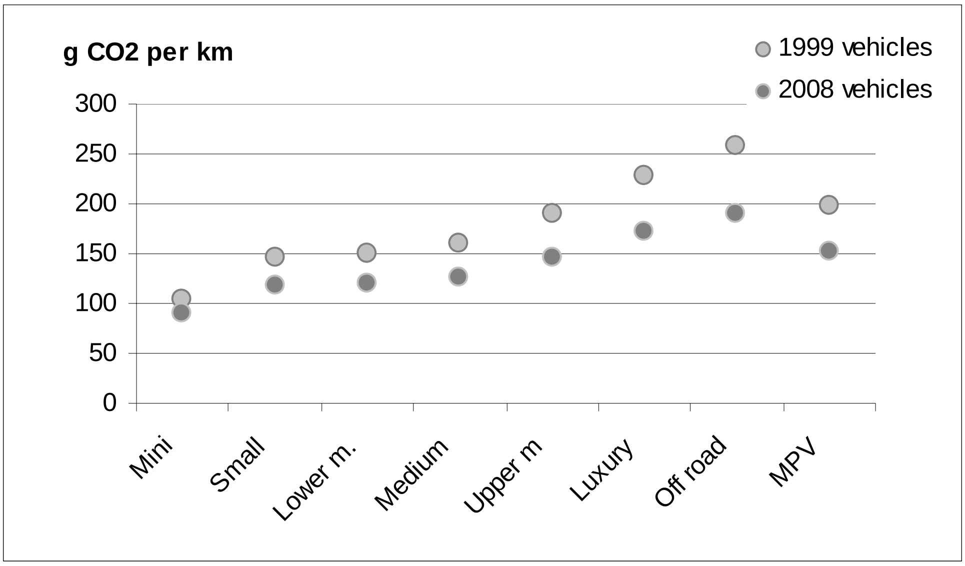


Figure 3.2 Technological improvement for diesel cars



The average reduction percentages for the different categories are shown below.

Table 3.9 Average reduction percentages for the different categories

Car category	Petrol	Diesel
Mini	23%	13%
Small	25%	20%
Lower m.	28%	20%
Medium	30%	21%
Upper m	32%	23%
Luxury	35%	25%
Sport	31%	
Off road	33%	26%
MPV	32%	24%

The base data in the model refers to 1999/2000. To set up a set of data for 2008, two assumptions are made:

- It is assumed that the average CO_2 emission levels are reduced as a result of technological improvements,
- It is assumed that the dealer's prices increase as a result of the costs of introducing the above new technologies.

As mentioned previously, it is generally assumed that the cost of the required technological changes amount to some EUR 1000-2000 depending on the size of the car. The technological changes covered by this amount are assumed to provide a CO_2 efficiency gain in the order of 25 % compared to 1995. Since 1995 some technological progress (and price increases) has already taken place. To take account of this, the study assumes that the cost increases are proportional to the CO_2 reductions achieved. For example, if half of the CO_2 reductions had already been achieved, the cost of achieving the rest would be assumed to be EUR 500-1000.

Changes in the characteristics of a vehicle (reduction in energy consumption and increase in price) will affect the consumer's preferences for the vehicles. Thus, if the fuel economy of the cars is improved, this implies that consumers would tend to prefer bigger cars, because the running costs of the bigger cars have been reduced. As a result of this, the energy efficiency of the cars must be increased by more than the original 25% in order to outweigh such "rebound-effects" from consumers and thereby provide the requested reduction in CO_2 emissions.

The "rebound-effect" for petrol cars is estimated at 2.9 %. This effect has been calculated based on models for Belgium, Denmark, Germany, Italy, Netherlands, Finland, Sweden, Portugal and UK. Table 3.8 shows that the required CO_2 improvement to be provided in 2008 compared to 2000 through technological improvements is 24.3%. This percentage does not however take the rebound effect into account. Taking that into account, the required technological improvements should actually result in 27.2% instead (24.3%+2.9%). Similarly, the efficiency gains for diesel cars must amount be 21.5% in order to allow for the rebound effect and therefore to ultimately provide the required 19.8% reduction.

3.3 CO_2 emissions in 2008

This section describes the past and actually observed CO_2 emission levels, and it assigns CO_2 reduction targets for petrol and diesel cars to each Member State for 2008.

The point of departure is the 1995 emissions level, which constitutes the basis for the agreement with the car industry. Table 3.10 shows the CO_2 emissions from new registered cars in 1995.

Table 3.10 CO_2 emissions from newly registered cars (g/km, 1995)

	Petrol	Diesel	Total
EU-15	188.6	178.8	186.4
Austria	192.3	178.5	186.4
Belgium	189.4	172.8	181.2
Denmark	189.0	197.2	189.2
France	178.0	176.0	177.1
Finland	187.4	177.7	186.6
Germany	195.4	187.9	194.3
Greece	187.2	176.2	187.2
Ireland	179.4	183.5	180.0
Italy	179.6	183.9	180.0
Luxembourg	202.6	181.5	196.5
Netherlands	190.1	176.2	188.1
Portugal	171.9	170.0	171.7
Spain	181.9	165.6	176.6
Sweden	221.7	199.0	221.1
UK	193.1	184.2	191.3

1) *SOURCE: Monitoring Report (Commission of the European Communities) (the monitoring reports of ACEA and KAMA do not include figures for Greece. Therefore JAMAs figures are used) For Finland there is only available data from ACEA and JAMA.*

Table 3.11 provides the indicative emission targets that are necessary to meet the 2008 Assumed efficiency gain (120 g/km). The targets have been calculated under the assumption that the required reduction rate is the same in each of the 15 Member States, i.e. similar percentages are applied for all Member States.

Table 3.11 Calculated Member State CO_2 emissions targets for newly registered cars in 2008 (g/km)

Country	g CO per km
EU-15	120.0
Austria	120.0
Belgium	116.7
Denmark	121.9
France	114.0
Finland	120.2
Germany	125.2
Greece	120.5
Ireland	115.9
Italy	115.9
Luxembourg	126.6
Netherlands	121.2
Portugal	110.5
Spain	113.7
Sweden	142.4
UK	123.2

1)the monitoring reports do not include figures for Greece

Table 3.12 shows the expected situation in 2008 (model calculation of base scenario) without any changes or amendments to the existing fiscal measures.

Table 3.12 2008 scenario reference scenario[18]

	Petrol Average CO_2 emissions	Diesel Average CO_2 emissions	Diesel cars Share of total registrations of new cars	Diesel and petrol Average CO_2 emissions
EU-15	135.8	130.5	29.5%	134.2
Austria	138.5	130.3	57.5%	133.8
Belgium	136.4	126.1	54.5%	130.8
Denmark	136.1	144.0	10.6%	136.9
France	128.2	128.5	44.4%	128.3
Finland	134.9	129.7	7.4%	134.5
Germany	140.7	137.2	21.2%	139.9
Greece	134.8	128.6	0.8%	134.7
Ireland	129.2	134.0	12.3%	129.8
Italy	129.3	134.2	29.3%	130.8
Luxembourg	145.9	132.5	42.0%	140.3
Netherlands	136.9	128.6	22.9%	135.0
Portugal	123.8	124.1	22.6%	123.8
Spain	131.0	120.9	51.5%	125.8
Sweden	159.6	145.3	7.1%	158.6
UK	139.0	134.5	13.9%	138.4

[18] Fiscal measures planned to be in effect in 2008 are included

Table 3.13 compares the base scenario 2008 CO_2 emissions and emissions reductions (the above table) to the calculated country-specific target that must be met to meet the overall 120 g/km objective (table 5.10).

Table 3.13 Required additional reductions to reach the calculated country target

	Base scenario resulting average emissions	Target Required average emissions	Further reductions needed to meet the target
EU-15	134.2	120.0	-10.6%
Austria	133.8	120.0	-10.3%
Belgium	130.8	116.7	-10.8%
Denmark	136.9	121.9	-9.9%
France	128.3	114.0	-11.1%
Finland	134.5	120.2	-10.7%
Germany	139.9	125.2	-10.5%
Greece	134.7	120.5	-10.6%
Ireland	129.8	115.9	-10.7%
Italy	130.8	115.9	-11.4%
Luxembourg	140.3	126.6	-9.7%
Netherlands	135.0	121.2	-10.2%
Portugal	123.8	110.5	-10.8%
Spain	125.8	113.7	-9.6%
Sweden	158.6	142.4	-10.2%
UK	138.4	123.2	-10.3%

Technological improvements will be able to bring the average CO_2 emissions in Germany down to a level of 139.9 g/km. Further reductions in the order of 10.5% are thus needed in order to provide the targeted level of 125.2%. In Denmark, the necessary further reduction is smaller than in Germany. This is mainly because diesel powered vehicles increased their market share significantly in Denmark in the period from 1995 and up to 1999/2000.

4 Socio-economic data

Several socio-economic parameters influence the choice of a vehicle, including household structures, income levels and age. Experience from the Danish model shows that income level is the single most important socio-economic parameter that affects the choice of a new car. Other socio-economic parameters with some influence include family structure and age. To take account of these factors, the model relies on a distribution of vehicle purchases across household structures and income groups. The model was originally developed for Denmark. Consequently, the model contains very detailed and accurate information about these features of Danish car buyers.

It proved however to be infeasible[19] to obtain similar data with the same level of detail and accuracy for the other countries. However, good information was available for some of the major indicators such as income distribution among household groups (see chapter 4.4 and 5.1). Still, the terminology, concepts and definitions that are applied do vary from country to country.

This chapter explains the derivation of the socio-economic database and provides a summary of the data that have ultimately been used for the calculations. The annex reports to this main report contain a more detailed description of the derivation of the nine national socio-economic databases that have been constructed.

In constructing the socio-economic database, the national focal points have provided valuable assistance in terms of data provision as well as the review and commenting upon draft versions. The ultimate contents of the database is however the sole responsibility of the Consultant.

3.6 Definitions and the Danish database

The below table illustrates the generic definitions of the model's database. National definitions as well as categorisations applied in national statistics tend to vary from those - and not in a uniform manner. Consequently, estimations and approximations have been necessary before the national socio-economic information was ready for entry into the model's database.

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[19] within the financial framework of the study, and more importantly: in several cases because the information does not exist.

One should note that throughout this chapter, the term "car buyer" is used for the purchaser of *new* cars solely.

Table 4.1 Socio-economic definitions of car buyers

Definitions of households	Income definition: Yearly net income (after tax payment) inclusive wage, social security benefits, welfare payments etc. received. Excluding income taxes. 2000 prices. Income groups		
	Low income	Medium income	High income
One-person households. Includes: Female car-buyer living with parents Male car buyer living with parents Female car buyer living single Male car buyer living single	All incomes lower than EUR 17.250	All incomes between EUR 17,250 and EUR 51,500	All incomes above EUR 51,500
Two-person households. Includes: Couple with children. Female buyer Couple with children. Male buyer Couple without children. Female buyer Couple with children. Male buyer	All incomes lower than EUR 34,500	All incomes between EUR 34,500 and EUR 68,500	All incomes above EUR 68,500

Table 4.2 shows the distribution of the Danish population across household structures and income groups (data correspond to 1997).[20] *Table 4.3* shows the number of households within each category that purchased a vehicle in the same year.

Investigations indicate that population distributions such as the one given in *Table 4.2* are available in a number of countries albeit not in precisely the same format. This is not the case, however, for the associated breakdown of vehicle purchases as presented in *Table 4.3*. Similarly, a more unspecific distribution of car owners (that is, one that inventories all car owners, regardless of whether they bought the vehicle within the project's reference period or not) was only available in three Member States.

[20] The parameter estimates rely on 1997 data because such information is readily available and the added value of up-dating it would be negligible. Model input data on vehicle fleets, on the contrary, will refer to the latest available period (that is, late 1999 and early 2000).

Table 4.2 Households in Denmark, by household structure and income group (1997)

	Low income	Medium income	High income	Total
Single female	386,629	324,846	1,426	712,900
Single male	318,805	235,584	1,111	555,500
Female living with parents	73,368	10,264	168	83,800
Male living with parents	113,836	39,456	307	153,600
Couple without children (female buyer)	209,168	170,106	7,976	387,250
Couple without children (male buyer)	209,168	170,106	7,976	387,250
Couple with children (female buyer)	56,501	197,525	7,624	261,650
Couple with children (male buyer)	56,501	197,525	7,624	261,650
Total	1,423,977	1,345,411	34,212	2,803,600

SOURCE: Statistics Denmark. Amount of people in one-person high income group are assumed to be 0.2%.

Table 4.3 Households that purchased a vehicle in Denmark, by household structure and income group (1997)

	Low income	Medium income	High income	Total
Single female	2173	6055	109	8,337
Single male	3044	7148	180	10,372
Female living with parents	747	632	21	1,400
Male living with parents	3705	2204	69	5,978
Couple without children (female buyer)	3618	7901	707	12,226
Couple without children (male buyer)	11233	22277	1513	35,023
Couple with children (female buyer)	1159	8622	705	10,486
Couple with children (male buyer)	3149	22071	1419	26,639
Total	28828	76910	4723	110461

SOURCE: Statistics Denmark

Given the scarce data available at the national level on the socio-economic features of buyers of new cars, it is necessary to rely on the available data, and to modify this in order to provide reasonable country specific estimates of tables similar to *Table 4.3* for all countries to be analysed. The methods used for modification are further explained below.

It should be noted that the above table only considers private cars. Thus, for example, it does not take account of the fact that quite a few people use company cars rather than private cars. In Denmark 27% of private cars purchases are company cars. Company car schemes are mostly uses in the high and medium income groups. Therefore, in countries with fewer company cars one would expect to find relatively more private car purchases in the medium and high income groups. This needs to be taken into account in the modifications to be done.

Table 4.4 Share of total households that purchase a vehicle, by households structure and income group

	Low income	Medium income	High income	Total
Single female	0.6%	1.9%	7.6%	1.2%
Single male	1.0%	3.0%	16.2%	1.9%
Female living with parents	1.0%	6.2%	12.5%	1.7%
Male living with parents	3.3%	5.6%	22.5%	3.9%
Couple without children (female buyer)	1.7%	4.6%	8.9%	3.2%
Couple without children (male buyer)	5.4%	13.1%	19.0%	9.0%
Couple with children (female buyer)	2.1%	4.4%	9.2%	4.0%
Couple with children (male buyer)	5.6%	11.2%	18.6%	10.2%
Total (weighted average)	2.0%	5.7%	13.8%	3.9%

NOTE: calculated from data for Denmark, 1997 (see tables 6.1 and 6.2)

3.7 The contents of the socio-economic data database

The following tables illustrate the socio-economic database that enters the model. There is one table for each country apart from Denmark. The Danish table is shown in the above section. The following section provides an overview of the major assumptions and methodological aspects that were used to derive these tables.

Table 4.5 Socio-economics for Belgium buyers of new cars (1999)

	Low	Medium	High	Total
Single Female	7,627	10,507	2,197	20,331
Single male	8,272	10,918	2,972	22,162
Female living with parents (aux)	1,773	4,454	462	6,689
Male living with parents (aux)	10,388	7,406	1,518	19,312
Couple without children female buyer	10,645	19,417	6,565	36,627
Couple without children male buyer	33,052	54,746	14,049	101,846
Couple with children female buyer	13,356	22,783	8,551	44,689
Couple with children male buyer	36,288	58,320	17,211	111,819
Total car purchase	121,402	188,550	53,524	363,476

Table 4.6 Socio-economics for Finnish buyers of new cars (2000)

	Low	Medium	High	Total
Single Female	1,907	5,445	2,196	9,548
Single male	3,621	11,009	7,878	22,508
Female living with parents (aux)	243	1,531	306	2,080
Male living with parents (aux)	693	1,735	935	3,363
Couple without children female buyer	2,874	4,794	996	8,664
Couple without children male buyer	8,924	13,516	2,131	24,570
Couple with children female buyer	2,327	10,358	1,910	14,595
Couple with children male buyer	6,321	26,515	3,845	36,681
Total car purchase	26,909	74,902	20,199	122,010

Table 4.7 Socio-economics for German buyers of new cars (1999)

	Low	Medium	High	Total
Single Female	40,190	58,363	8,568	107,121
Single male	80,107	111,467	21,304	212,879
Female living with parents (aux)	12,410	32,864	2,394	47,667
Male living with parents (aux)	72,714	54,646	7,865	135,225
Couple without children female buyer	82,419	55,798	41,090	179,307
Couple without children male buyer	255,890	157,324	87,933	501,147
Couple with children female buyer	88,123	98,108	89,232	275,463
Couple with children male buyer	239,431	251,142	179,602	670,175
Total car purchase	871,283	819,713	437,988	2,128,983

Table 4.8 Socio-economics for Italian buyers of new cars (2000)

	Low	Medium	High	Total
Single female (more than 18 years old)	92	3,281	8,171	11,544
Single male (more than 18 years old)	682	12,664	12,578	25,923
Female living with parents	448	577	1,748	2,772
Male living with parents	236	2,853	5,294	8,382
Couple without children female car buyer	2,621	11,532	17,634	31,787
Couple with children, female car buyer	5,948	29,080	29,150	64,178
Couple without children, male car buyer	7,982	30,509	35,177	73,668
Couple with children, male car buyer	16,033	70,175	53,890	140,098
Total	34,042	160,671	163,641	358,353

Table 4.9 Socio-economics for Netherlands buyers of new cars (1999)

	Low	Medium	High	Total
Single Female	9,635	6,648	715	16,998
Single male	12,754	8,261	1,155	22,170
Female living with parents (aux)	2,688	2,982	158	5,828
Male living with parents (aux)	15,749	4,678	487	20,913
Couple without children female buyer	23,293	13,062	6,457	42,812
Couple without children male buyer	72,318	36,830	13,817	122,965
Couple with children female buyer	6,002	,323	4,557	28,882
Couple with children male buyer	3,477	1,305	9,172	73,955
Total car purchase	195,915	102,089	36,518	334,522

Table 4.10 Socio-economics for Portuguese buyes of new cars (1999)

	Low	Medium	High	Total
Single Female	6,425	7,849	2,953	17,227
Single male	8,111	13,076	8,771	29,957
Female living with parents (aux)	1,101	2,838	481	4,421
Male living with parents (aux)	3,146	3,753	1,499	8,399
Couple without children female buyer	5,024	11,803	2,548	19,375
Couple without children male buyer	15,600	33,279	5,452	54,330
Couple with children female buyer	4,695	15,366	3,110	23,171
Couple with children male buyer	12,757	39,335	6,260	58,351
Total car purchase	56,860	127,298	31,074	215,232

Table 4.11 Socio-economics for Swedish buyers of new car (1999)

	Low	Medium	High	Total
Single Female	6,425	6,272	2,530	15,227
Single male	8,111	10,604	7,589	26,303
Female living with parents (aux)	1,101	1,961	392	3,455
Male living with parents (aux)	3,146	2,222	1,197	6,565
Couple without children female buyer	5,024	4,059	843	9,927
Couple without children male buyer	15,600	11,446	1,805	28,850
Couple with children female buyer	4,695	9,469	1,746	15,910
Couple with children male buyer	12,757	24,239	3,515	40,511
Total car purchase	56,860	70,271	19,618	146,749

Table 4.12 Socio-economics for UK buyers of new cars (1999-2000)

	Low	Medium	High	Total
Single Female	26,312	57,010	23,389	106,712
Single male	10,831	31,408	23,827	66,066
Aux Female	4,419	9,574	3,928	17,920
Aux Male	6,242	18,103	13,733	38,078
Couple without children F	11,928	62,289	42,410	116,627
Couple without children M	34,169	178,437	121,489	334,094
Couple with children F	55,456	97,891	55,938	209,284
Couple with children M	140,881	248,686	142,106	531,674
Total car purchase GB	290,237	703,398	426,819	1,420,454

3.8 Sources and corrections

Sources

As mentioned, it proved infeasible to obtain the necessary data to immediately establish the socio-economic database that the model requests. This section therefore provides an overview of the corrections that have been made and briefly outlines some of the more generic aspects of the approaches taken.

The requested information could be obtained solely in the case of Denmark - the country for which the model was originally constructed. For the remaining countries covered by the in-depth calculations, the database had, to a varying extent, to be estimated

The table below provides an overview of the types of information that was obtained for the various countries. These data, together with the above Danish data and the available information on company car sales, thus provided the core inputs into the construction of the database.

Key issues in correction

The table also lists the key issues that needed to be addressed for each country in order to provide appropriate estimates to enter the final socio-economic table for the country in question. These issues are further explained below.

Table 4.13 *Overview of types of information available to construct the socio-economic database and of the key issues to be addressed in order to construct these tables*

Country	Type and source of information	Key issues in estimation
Belgium	Family structure Overall income statistics Source: Statistics Belgium	Socio-economics of population: Family structure modification (DK data) Income distribution (NL data corrected for higher income levels in B) Socio-economics of car buyers: Expected distribution on the basis of DK distribution but corrected for 1. more car purchases in absolute terms by private families in Belgium, and 2. relatively higher fraction of private cars in the sales in Belgium.
Finland	Family structure Overall income statistics Source: Statistics Belgium	Socio-economics of population: Family structure modification (DK data) Income distribution (Swedish data) Socio-economics of car buyers: Expected distribution on the basis of DK distribution but corrected for 1. more car purchases in absolute terms by private families in Finland, and 2. relatively higher fraction of private cars in the sales in Finland.
Germany	Socio-economic tables (income/family structure) on the whole population Source: Sta-	Socio-economics of population: Family structure modification (DK data) Calculation of model income groups and adjustment from 1998 to 1999 Socio-economics of car buyers:

Country	Type and source of information	Key issues in estimation
	tistisches Bundesamt, Statistisches Jahrbuch	Expected distribution on the basis of DK distribution but corrected for 1. more car purchases in absolute terms by private families in Finland, and 2. relatively higher fraction of private cars in the sales in Finland
Italy	Socio-economic tables (income/family structure) on buyers of new cars Source: Data provided by Italy during the study	Socio-economics of car buyers: Modifications of family structure and re-calculation of income distribution (estimation of income distributions in categories and calculation of new fractiles)
Netherlands	Socio-economic tables (income/family structure) on the whole population Source: Statistics Netherlands - Household survey	Socio-economics of population: Family structure modification (DK data) Revision of model income groups and adjustment from 1998 to 1999 Socio-economics of car buyers: Expected distribution on the basis of DK distribution but corrected for 1. more car purchases in absolute terms by private families in Netherlands, and 2. relatively higher fraction of company cars in the sales in Netherlands.
Portugal	n.a.	Socio-economics of car buyers (the database had to be estimated): Expected distribution on the basis of Italy distribution but corrected for 1. lower incomes in Portugal, 2. fewer car purchases in absolute terms by private families in Portugal
Sweden	Socio-economic tables (income/family structure) on the whole population Source: Statistics Sweden	Socio-economics of population: Family structure modification (DK data) Revision of model income groups Socio-economics of car buyers: Expected distribution on the basis of DK distribution but corrected for 1. more car purchases in absolute terms by private families in Sweden, and 2. relatively higher fraction of company cars in the sales in Sweden
UK	Socio-economic sample data on car buyers	Up-scaling to cover the whole population based on data about total sales of new vehicles and share of company cars. Distribution according to sex of car buyers and inclusion of auxillary families based on Danish data

Two steps in correction

Basically, this was a two-step procedure involving first:

- An estimation of the socio-economics of the population (where this was not available) and implementation of the necessary corrections to provide for the requested categories (in the cases where the table existed, but did not fully match the requirements as regards income groups and/or family types).
- An estimation of the car purchases within each of the socio-economic groups.

These two steps are further explained below.

3.8.1 Socio-economics of the population

Corrections of available tables on socio-economics of population

Basically, the approach has been first to construct tables similar to *Table 4.2* for all countries. In cases where such a table was available in some form, this was mainly an issue of ensuring 100% consistency with respect to the applied dimensions and categories. This was the case for Germany, the Netherlands and Sweden. In the case of Italy, a table similar to *Table 4.3* was actually provided, but it was necessary to undertake some corrections to ensure full consistency with regard to the categories (incomes and family types). Basically, these corrections were made on the basis of similar or relevant information from another country which was assessed to be the one most similar to the one in question.

In each of the above cases, as well as in the below three cases, the modifications and corrections that needed to be made were highly individual and thus unique to each country. Therefore, this chapter does not aim to provide an in-depth description of the steps undertaken. The reader is referred to the individual country annex reports for this information. Here it should be noted though that in some cases, e.g. the above cases, the necessary modifications were quite limited and very specific.

Construction of tables

As mentioned, for the remaining countries (Belgium, Portugal and Finland[21]), tables similar to *Table 4.2* had to be estimated. For Finland, information existed that allowed for a break-down into family types. As regards income distribution, it was assumed that Sweden was the country most similar to Finland. For Belgium, existing data on family structures were corrected based on the Danish distribution in order to provide the same categories. As regards income distribution, it was assumed that the Netherlands was the most adequate country to base the correction on taking into account also that the income level in Belgium is 8% higher than in the Netherlands. In the case of Portugal, the estimation was based on the Italian corrected table on the socio-economics of car-buyers. This table was further corrected to take into account the fact that income levels are lower in Portugal than in Italy.

3.8.2 Socio-economics of car buyers

Generally, it was necessary to carry out the following steps in order to derive the requested table (similar to *Table 4.3*) on the socio-economics of car buyers. These steps have been undertaken for virtually all countries apart from Italy, the UK and Denmark in which cases the original data that was supplied was concerned exactly with the socio-economic features of car buyers.

Difference in the relative amount of car sales

First, the share of the total population that purchased a new (private) car was estimated. This would first involve an estimate based on the Danish distribution. However, such an estimate would not take account of the fact that in some (most of them actually) countries, the average number of cars per family is higher than in Denmark. One would expect this to be reflected also in a higher number of new cars sold.

[21] For the UK, sample based data were provided that was applicable to the format of table 6.3

To illustrate how this is taken into account, one may use the example of Germany. In Germany, there are 506 cars/1000 inhabitants compared to 355 in Denmark. Furthermore, the German population amounted to 82,057,000 in 1999. Considering that the average lifetime of a vehicle is 11.5 years, the additional number of cars sold in Germany amounts to 1,077,444 per year. The underlying calculation is as follows:

$$\frac{82{,}057{,}000*(506-355)}{1000*11.5}$$

Difference in the share of company cars

Secondly, the socio-economics only relate to the features of purchasers of private cars as opposed to company cars. Consequently, the number of car purchases needs to be corrected for possible differences between the relative Danish company car sales and the sales of company cars in the country in question.

Taking again the German corrections as an example, company cars account for 42% of the total sales of new cars in Germany. The corresponding Danish share is only 27%. Consequently, the total number of car purchases covered by the socio-economic table for Germany needs to be reduced to properly reflect the actual sales of private cars.

In this case, as well as in the above case where the correction related to the number of cars sold, the correction is made proportionate to the number of households in the relevant income groups. In regard to the latter it should also be mentioned that it is assumed that these corrections are only relevant for the medium and for the high income groups.

4 Scenarios for the CO_2 effectiveness of national fiscal policies

This chapter describes the approach used to illustrate the CO_2 effectiveness of the existing as well as possible new national fiscal policies. The approach taken and the framing of the scenarios has been an integral part of the conduct of the Study.

The scenario approach consists of the following elements (types of scenarios):

1. Effectiveness of the existing tax system
2. Adding CO_2 differentiation
3. Purely CO_2 differentiated taxes
4. Country specific calculations if relevant (only on the specific request from the country representatives)

Technical potential

However, prior to the framing of the scenarios, calculations were undertaken to assess the technical potential of achieving the target of 120 g/km. These assessments were done for Denmark, Germany, Portugal, UK and Italy. Basically, these calculations assessed the (highly theoretical and hypothetical) situation where all cars within each of the eight segments are assumed to become as energy effective as the most energy efficient one. This calculation showed that, in theory, the target would be feasible[22] if one defines feasibility as being reflected in the current technological availability.

Diesel replacement

Furthermore, the initial calculations also assessed what would happen to CO_2 emissions if one allowed the proportion of diesel cars to increase up to a level where the target was reached if this is at all possible. These calculations were done for the same five countries as above. The calculations show that this would in most cases not be possible. In other words, if all petrol cars were replaced by diesel cars, there would still be a considerable gap compared to the target. In some countries though, current proportions of diesel cars are so low

[22] It is included in the calculation that the requirements for reduction of sulphur content in lighter fuels is expected to induce a reduction of CO_2 emissions from petrol cars of approximately 3%, due to lower carbon content and new technology. This means that each petrol car is assumed to reach the emission level of 1995 minus 28%. Likewise, a reduction of 2% is expected to be the effect for diesel cars, and therefore each diesel car is assumed to reach the emission level of 1995 minus 27%.

that relatively high CO_2 reductions could be achieved in this hypothetical and theoretical situation.

Simple tax increases

Lastly, the preparatory calculations involving five countries have also shown that merely increasing the levels of current taxes implies only small reductions in CO_2 emissions. This is due to the fact that there is only a very weak relation to CO_2 emissions in the current tax systems. Thus, one would need at least to allow for a more distinct differentiation in order to obtain CO_2 reduction effects.

Table 4.1: Fiscal measures scenarios

Scenario types	Specific assumptions	RT	CT	CO_2 - incentive	Comments
CO_2 effectiveness of the existing national taxation systems	Differentiated registration tax based on national parameters	variable	constant	constant	Existing national tax system will be held constant. Relevant for countries with registration tax.
	Differentiated circulation tax based on national parameters	constant	variable	constant	Existing national tax system will be held constant
Adding CO_2 differentiation	Existing national tax system plus differentiated CO_2 element into registration tax	variable	constant	constant	Existing national tax system will be held constant. Relevant for countries with registration tax.
	Existing national tax system plus differentiated CO2 element into circulation tax	constant	variable	constant	Existing national tax system will be held constant
CO_2 based tax structure	CO_2 differentiated registration tax	variable	constant	constant	Relevant for countries with registration tax.
	CO_2 differentiated circulation tax	constant	variable	constant	
	Mixed CO_2 differentiated scenario	variable	variable	(variable)	

To the (limited) extent that countries have requested analyses of specific scenarios in addition to those outlined above, this has been done. The results are presented in the relevant annex country reports.

4.1 Scenario assumptions

The below provides a description of each of the scenario types (cf. *Table 4.1*).

4.1.1 Effectiveness of existing taxation systems

These scenarios analyse the CO_2 effectiveness of the existing national taxation system. The tax base and the basic structure of the existing national taxation systems remain unaltered, but allowance is made for an enhanced differentiation. The effectiveness of the existing systems is thus assessed by means of calculating the CO_2 reductions that would result from merely enhancing the use of differentiation based on existing parameters.

For example, in the case of a national weight tax, the scenario could involve a more steep differentiation according to weight.

4.1.2 Adding CO_2 differentiation

In the second group of scenarios, it is assumed that the existing national taxation systems are supplemented by a differentiated CO_2 element. The analyses are carried out for two hypothetical cases. One, where the CO_2 element is added to the registration tax and one where it is added to the circulation tax. Noting that there are countries that do not have registration taxes, this calculation is of course omitted for these countries.

Using the above example of the weight tax, the starting point of this scenario will be the existing national weight tax. A CO_2 differentiation would then be allowed for - on top of this existing circulation tax. The resulting circulation tax would then be a combination of a weight tax and a CO_2 based tax.

4.1.3 Purely CO_2 differentiated taxes

The third group of scenarios assumes that the existing national taxation systems are completely replaced by a system with applies the CO_2 performance of the cars as the tax base. Different scenarios are analysed. One scenario type assumes that the CO_2 differentiated tax replaces the registration tax, and another one assumes that the circulation tax is replaced.

These scenarios will, if relevant, also include a CO_2 incentive. The incentive will provide a subsidy for the most energy efficient cars, and be balanced against a CO_2 based tax for the less CO_2 efficient cars.

A calculation, which assumes replacement of both taxes with CO_2 based taxes constitutes part of the analysis of these scenarios.

4.2 The boundary conditions and sensitivity analyses

All of the above scenario analyses assesses the extent to which the target of 120 g/km can be reached given the assumptions of the specific scenario. It is however a general and essential requirement that the CO_2 reductions are achieved with the least possible impact on the tax revenue, the proportion of diesel cars, and the business conditions for the car manufacturing industry and consumers. To this end, the following boundary conditions are established:

- Budget neutrality
- Proportion of diesel cars
- Downsizing

7
The scenarios are all analysed in respect of the boundary conditions. Thus, they assess the maximum CO_2 reduction that can be achieved without violating any of the above conditions.

Budget neutrality

The implications of the budget neutrality condition are analysed through the related sensitivity analyses (cf. below).

Proportion of diesel cars

The possible further CO_2 reduction that can be achieved from an increase in diesel share is estimated in chapter 5. In some countries, the proportion of diesel cars has already increased substantially. Therefore, calculation are done to illustrate the implications if the proportion of diesel cars of new car registrations was to double (increase 100%), up to a 50% share in each country. For countries, that already exceed this share, this calculation does not allow further increases. This calculation is done for purely CO_2 differentiated taxes.

Downsizing

As regards downsizing, the analyses do not consider the CO_2 reduction potential of violating this constraint. The motivation being that while sufficient downsizing would probably allow one to achieve the target of 120 g/km on average for new cars, this will have numerous other implications. The balancing of these implications against the advantages of attaining the target would be a difficult, complex and highly political issue that lies beyond the scope of this study.

The boundary condition on down sizing is concerned with the distribution of new car sales on categories. In setting up the calculations, an operational method was developed to obtain a quantitative measure of the effect on car sizes. The categories used are based on Marketing Systems segmentation of passenger cars and explained in the annex.

Definition and discussion of budget neutrality definition

The boundary condition on budget neutrality contains the following elements: RT, (CT * lifetime vehicle), CO_2-incentive and fuel tax. Noting that the actual lifetime of a vehicle may differ from one country to the other, the lifetime of vehicles is however assumed to be the same for all, namely 11.6 years. Mileage is the actual average mileage for each country and separate for diesel and petrol cars. This boundary condition is only defined and used for the new cars covered by the analyses.

The sensitivity analyses look at the implications of applying other formulations of the budget boundary condition. Thus, it is assumed that this condition is formulated solely in terms of the tax under consideration itself. Alternatively, the implications are analysed of an alternative formulation, which leaves out the fuel tax revenue.

The below table provides an overview of the sensitivity analyses that are carried out.

Table 4.2 Overview of sensitivity analyses to be carried out

Issue	Specific assumptions	RT	CT	CO_2 - incentive	Comments
Fuel tax sensitivity analyses	Increase of fuel tax by 25%	constant	constant	constant	To be analysed for four countries.
	Increase of fuel tax by 25%	variable	constant	constant	Compensate with differentiated registration tax based on national parameters. To be analysed for four countries.
	Increase of fuel tax by 25%	constant	variable	constant	Compensate with differentiated circulation tax based on national parameters. To be analysed for four countries.
Budget neutrality sensitivity analyses	Existing national taxation system plus differentiated CO_2 element into registration tax	variable	constant	constant	Revenue from registration tax and circulation tax constitutes the budget boundary condition. To be analysed for four countries.
	Existing national taxation system plus differentiated CO_2 element into registration tax	variable	constant	constant	Revenue from registration tax constitutes the budget boundary condition. To be analysed for four countries.
	Existing national taxation system plus differentiated CO_2 element into circulation tax	constant	variable	constant	Revenue from registration tax and circulation tax constitutes the budget boundary condition. To be analysed for four countries.
	Existing national taxation system plus differentiated CO_2 element into circulation tax	constant	variable	(constant	Revenue from circulation tax constitutes the budget boundary condition. To be analysed for four countries.

Fuel taxes

Fuel tax revenue is taken into account in the sense that the revenue from fuel taxes declines as a direct result of the improvement of fuel economy, which is again induced by changes in the car taxes. In this study, it is a precondition that fuel taxes should not be regarded as a variable. This issue is the subject of other separate work and studies. This precondition in some ways does represent a limitation to the analyses. For example, it implies a disregard of the option where car taxes are combined with other fiscal instruments, such as fuel taxes. In such a case, a fee-bate solution introducing a CO_2-incentive for cars with good energy performance could be combined with an increase in fuel taxes. Such increases could further have a CO_2 reducing effect on fuel consumption as a whole. It is essential that such schemes are taken into account in the framing of more specific policies and measures.

VAT

VAT is not included in the calculation of the revenue. VAT is a general tax on consumption. Reductions in the VAT revenue from car sales could therefore most likely be compensated for by increases in the VAT revenue from sales of other items, as it is unlikely that there will be an effect on savings. However, some countries apply a lower VAT to some other categories of goods (e.g. food), and there could be an effect on the VAT revenue for these countries. However, the effect is most likely quite small. For this reason, and because it is very difficult to estimate the type of consumption that would substitute car purchase, it has been decided to exclude VAT from the definition of budget neutrality.

Circulation tax

The condition on budget neutrality only applies to new cars. The circulation tax revenue thus also applies only to new cars. In practical policy making, Member States may of course decide to apply a differentiated circulation tax for the whole fleet rather than just for the new cars.

4.3 Functional approaches to defining tax scenarios

This section describes the functional forms that have been used when setting up the assumed new or modified car taxes.

Different functional forms have been used for the different scenarios:

5. Effectiveness of the existing tax system
6. Adding CO_2 differentiation
7. Purely CO_2 differentiated taxes

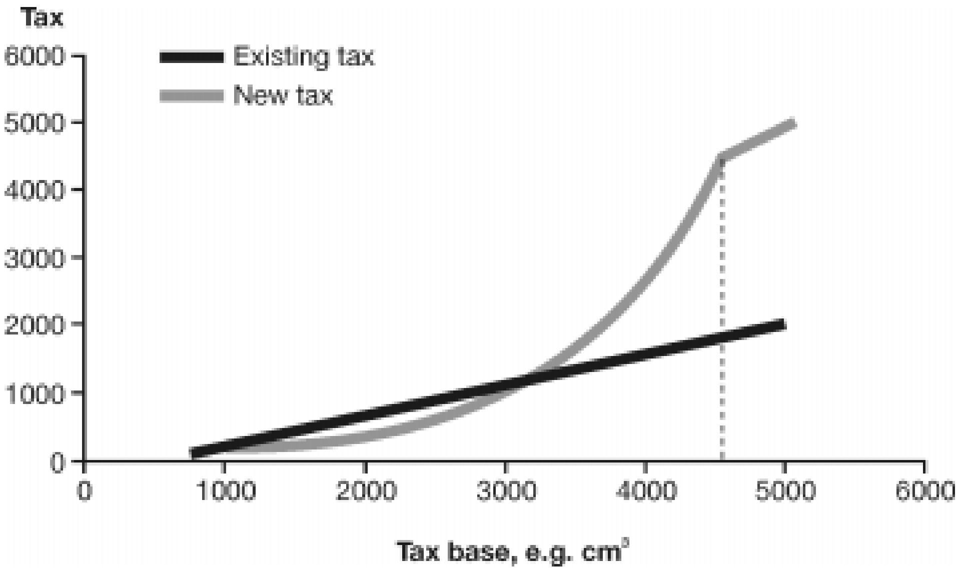
In the following the functional form of each tax scenario will be outlined and discussed briefly.

4.3.1 Increasing the progression

The "Effectiveness of the existing tax system" scenarios analyse what happens if the progression of the existing tax system is changed. The most efficient way to change the progression turned out to be to increase the progression, Therefore, the functional form used for this scenario is an exponential function. The exponential function is very flexible since, dependent on the parameters, it can provide almost any progression required.

This function is illustrated below together with a typical existing stepwise and linear tax.

Figure 4.1 Functional form for the "increased progression scenarios"



Note: The functional form for the modified tax is: $a * e^{(b*cm3)}$. For $a * e^{(b*cm3)}$ > limit (dashed line) a linear function is applied.

Beyond some point the exponential function increases very dramatically. This means that the taxes beyond this point would be extremely and unrealistically high. To avoid this, the exponential function is only applied to a certain limit point (marked in the figure by the dashed line). Beyond this limit, a linearly increasing function is applied. Alternatively, one could fix the amount, i.e. making the curve horizontal above the limit. However, this would prohibitively hamper the economic incentives beyond the limit point.

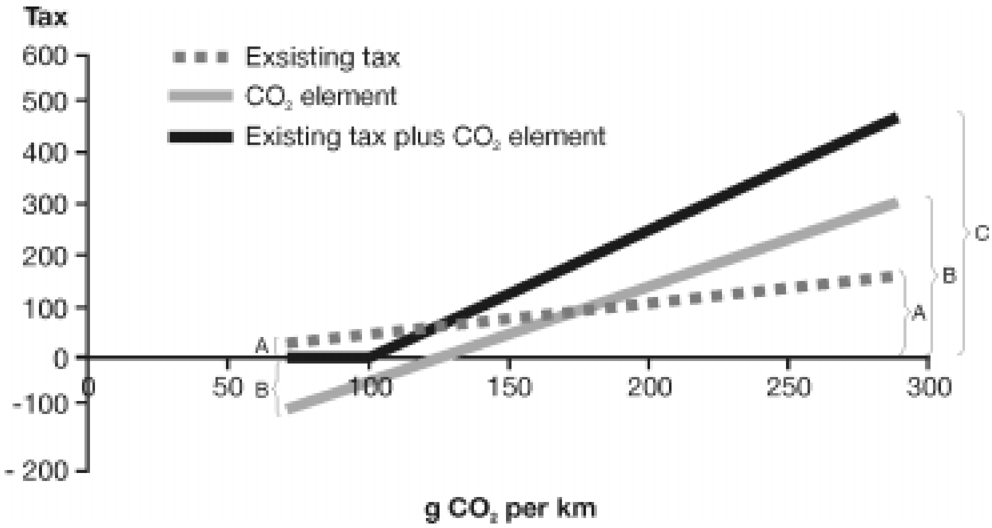
4.3.2 Adding a CO_2 element

In this scenario, a CO_2 differentiated element is added to the existing tax. The functional form for the CO_2 tax addition is linear and could for instance be a tax of 2 EUR per g CO_2 per year. In order to keep the budget constant a fixed tax release is also included. All in all this gives the following tax function

New tax = Old tax + $a * g\ CO_2 - b$

This tax function is illustrated below.

Figure 4.2 Adding CO_2 element to the existing tax



Note: The functional form of the total tax is obtained by adding the new CO_2 based linear tax to the existing tax. Graphically this means that ‖A‖ + ‖B‖ = ‖C‖, with the exception that the total tax is not allowed to become negative. In cases where this would happen the tax is fixed at zero.

The actual parameters (the price per g CO_2 and the fixed amount) are determined in an iterative process seeking to maximise the resulting CO_2 reductions subject to the boundary conditions.

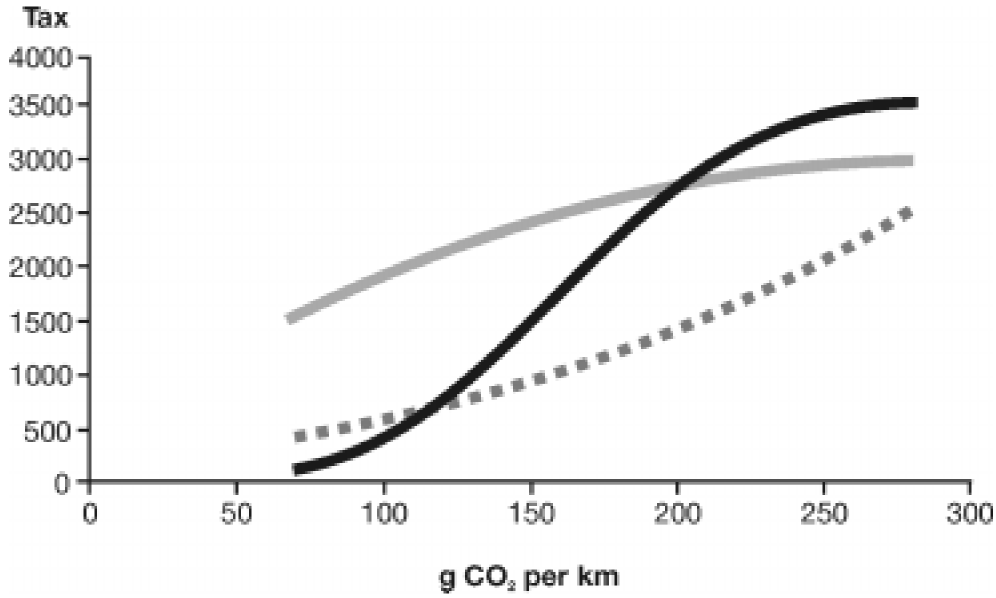
One should note that the CO_2 element plus the existing tax is restricted to be positive. If this constraint was not applied, it would give no meaning to have a budget constraint because then it would always be possible to outweigh too high budget revenue by subsidies (negative taxes).

When a large amount of the taxes are restricted to zero this gives the function a marked progressive character.

4.3.3 Purely CO_2 based taxes

The pure CO_2 tax scenario analysis is based on the cumulative normal distribution. This functional form is very flexible since it allows for both convex and concave forms in the relevant interval. Furthermore, the cumulative normal distribution has the appealing feature that it enables a rapid increase in the taxes in some interval and a “flattening out” for higher values of the tax base (e.g. cm^3), cf. Figure 4.3. Hence, there is no need for an upper limit. Three different examples of this functional form are illustrated in Figure 4.3. The only difference in the three functions is the parameters.

Figure 4.3 Three examples of the functional form for the pure CO_2 tax



Note: The functional form for the purely CO_2 differentiated tax is the cumulative normal distribution: $F(\mu, \sigma)*c$, where μ, σ and c are parameters that shape the curve of the function. μ denotes the mean, σ the standard deviation while c is a scale parameter.

The parameters and thereby also the shape of the function are determined in an iterative process seeking to maximise CO_2 reductions subject to the boundary conditions.

4.4 Coverage of the analyses

The tables overleaf provide an indication of the types of analyses that are carried out. Unless otherwise specified, the specific analyses are conducted for all countries covered by the analyses. As mentioned, the sensitivity analyses will be conducted for a smaller number of countries, namely four. Furthermore, analyses that involve registration tax modifications are of course only relevant to those countries that do apply a registration tax today.

The countries covered by the scenario calculations are:

- Belgium
- Denmark
- Finland
- Germany
- Italy
- Netherlands
- Portugal
- Sweden
- UK

These countries represent a broad range of Member States with regard to selected key issues of relevance to this study. Furthermore, the first phases of the study showed that the quality of data and the availability of data were insufficient (to a varying extent) to allow for sufficiently robust calculations in the cases of Luxembourg, Spain, France, Ireland and Greece. Additionally, the analyses of Spain and France would be further complicated to carry out due to a relatively high degree of regional autonomy in these countries.

In any case, the detailed analyses of these nine countries are considered to be sufficiently representative to ensure that the study does provide results and conclusions that can be considered to apply generically to EU and its Member States as such.

5 Results and conclusions from model calculations

The detailed results from the model-based calculations are presented in nine separate annex reports - one for each country. The purpose of this chapter is therefore to provide an overview of the results from these calculations, and to motivate and explain the conclusions that are drawn from these calculations. For more country specific analyses and results, reference is made to the annex reports. Furthermore, the technical annexes included in this report provide summary tables of the results from the scenario calculations and the sensitivity analyses.

Thus, this chapter presents the results from using the model-based approach described in chapter 3 and the data that was described in chapters 2, 3 and 4. The scenarios that are analysed are explained in chapter 4, where also the underlying assumptions regarding the functional relations are explained in detail.

As mentioned in the previous chapter, the model-based calculations were conducted for nine countries. This chapter therefore commences with an overview of EU-15 in order to illustrate key features of the whole of the European Community and to illustrate that the nine selected countries can be considered as representative of EU-15. After this overview, a brief description of the preparatory steps undertaken prior to the actual scenario calculations is provided.

Following that, the results from the scenario calculations are summarised in the next three sections. Analyses were conducted of the implications of allowing for higher diesel proportions and higher fuel taxes and of applying alternative formulations of the budget constraint. The results from these analyses are shown in the following sections. Lastly, the chapter highlights and motivates the major conclusions that can be drawn from the study and discusses the inherent policy implications.

5.1 Coverage of calcuations

Taxes and tax systems in EU-15

The table below illustrates the extent to which the various relevant types of taxes are in force in EU Member States. Whereas company cars and fuels are taxed in all Member States and circulation taxes apply in all countries except France, only ten countries apply registration taxes. Registration taxes are not in force in France, Luxembourg, Germany, Sweden and the UK. The detailed model-based calculations are done for the latter three of this group.

Table 5.1: Prevalence of tax types

	A	B	D	DK	E	F	HE	I	IRL	L	NL	P	S	SF	UK	#
RT	●	●		●	●		●	●	●		●	●		●		10
CT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15
Fuel tax	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15
CC tax	●	●	●	●	●	○	○	●	●	○	●	●	●	●	●	15
CO_2 incentive	●		●	●						●						4
Reg. charge	●	●	●	●	●	●		●		●	●	●			●	11
Insurance tax	●	●	●	●		●		●		●			●			8
VAT	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	15

Note: RT = registration tax, CT = circulation tax, CC= company car taxation, VAT = VAT imposed on purchase of new car; ● = Tax in use; ○ = Default value.

The calculations cover nine countries

The model based scenario analyses were conducted for the following nine Member States: Belgium, Denmark, Finland, Germany, Italy, Netherlands, Portugal, Sweden and the UK.

These countries were assessed to be sufficiently representative with regard to relevant background features (GDP, population density, family structures and urbanisation) as well as with regard to taxation systems, income groups/levels, and the extent to which cars are imported. Furthermore, they provide a broad geographical representation of the EU ranging from the Northern to the Southern countries. Lastly, data and/or relevant qualitative information could be obtained to a sufficiently high degree from these countries.

Key background features of EU-15

The below table summarises selected key features of the nine countries as well as of the remaining six Member States.

Table 5.2 Overview of key features of EU Member States

	CO_2 emis-sions per car, g/km 1995	Base year features 1999					General features		
		Circula-tion tax EUR per car/year	Regis-tration tax yes/no	Fuel tax EUR per litre		Propor-tion of diesel vehicles (new cars) 1999	Average number of cars cars/1000 inhabitants 1998	Average GDP 1000 EUR per capita 1999[a]	Population density People per km^2 1999
				Petrol 95 RON	Diesel				
Austria	186.4	228	Yes	0,406	0283	29.5	481	29	96[1]
Belgium	181.2	177	Yes	0,507	0,29	57.5	435	27	335[1]
Denmark	189.2	404	Yes	0,52	0,345	54.5	355	37	123
Finland	186.6	118	Yes	0,559	0,304	7.4	390[2,b]	28	15
France	177.1	109	No	0,59	0,392	44.4	442[2]	27	108
Germany	194.3	88	No	0,562	0,378	21.2	506[2]	29	230
Greece	187.2	118	Yes	0,3	0,254	0.8	223[2]	13	80[2]
Ireland	180.0	274	Yes	0,374	0,325	12.3	279[3]	28	53
Italy	180.0	151	(Yes)	0,527	0,388	29.3	539[2]	23	190
Luxembourg	196.5	78	Yes	0,372	0,253	42.0	576	50	166
Netherlands	188.1	433	Yes	0,6	0,353	22.9	379	28	387
Portugal	171.7	35	Yes	0,289	0,246	22.6	309[2]	13	108[1]
Spain	176.6	182	Yes	0,372	0,27	51.5	385[2]	17	78
Sweden	221.1	150	No	0,52	0,34	7.1	428	30	20
UK	191.3	231	No	0,764	0,764	13.9	392	27	242[1]
EU-15	186.4			0,484	0,362	29.5	441[a]	25	116[a]

[1]1998, [2]1997, [3]1996, [a]calculated, [b]corrected from 39 to 390. Sources: this study and OECD (background data on GDP, population, land area and vehicle fleet)

5.2 Methodology and preparatory calculations

In establishing the results, the methodology has been as follows.

Validity assessment

First, the validity of the model was analysed for each of the nine countries, and the necessary, if any, calibration has been undertaken. These steps and their results are further described in section 1.1.

Reduction targets

Second, the hypothetical reduction targets for each country were estimated. They are hypothetical in the sense that the target for EU-15 was defined at the outset of this study to be the 120 g/km. However, no considerations were mentioned as to the country specific targets to be achieved. Therefore, these country specific targets have been defined as similar relative reductions in all Member States. The results are shown *Table 5.3*. The derivation of the reduction targets is further explained in section 3.3. As mentioned, the defined targets assume that each country is to provide similar relative reductions compared to the emission level in 1995. The table compares 1999 to 2008. In the period 1995 to 1999, the proportion of diesel cars has increased, albeit at different rates. Diesel cars emit about 10% less of CO_2 than petrol cars. Consequently, the percentages given in the table vary a bit from country to country reflecting different developments in the diesel proportion from 1995 to 1999. Furthermore, the levels of the targets differ somewhat from country to country. This is due to the assumption that the required *relative* reduction would be the same for all countries. For example, average CO_2 emissions from new passenger cars in Sweden are the highest in 2008 reflecting a very high level also in 1995. This is due to the combined effect from a) the share of diesel cars is very low in Sweden, and 2) the average size of cars in Sweden is relatively large. On the other side of the scale, Belgium and Italy have fairly low *absolute* target values mostly because of the high diesel share in these countries, but also because of (on average) smaller cars. These aspects are illustrated in *Table 5.5*.

It is important to underline that the definition of the country specific target values is purely hypothetical. It can be argued that the imposition of similar relative reduction requirements onto each country actually renders the target very difficult to reach in countries that originally (i.e. in 1995) had very low average CO_2 emissions compared to the EU average. Such countries could for example have a composition of their car sales which is more dominated by smaller cars and/or more energy effective cars than countries with high initial average emissions have.

Table 5.3 2008 CO_2 emission targets and required reductions to achieve this target - compared to 1999.

CO_2	Belgium	Denmark	Finland	Germany	Italy	Netherlands	Portugal	Sweden	UK
Reduction %	10.8	9.9	10.7	10.5	11.4	10.2	10.8	10.2	10.3
2008 target g/km	116.7	121.9	120.2	125.2	115.9	121.2	110.5	142.4	123.2

Calculation of boundary condition values

Third, the boundary conditions and the initial tax values have been established. Given the current tax systems, described in chapter 2, tables similar to the below example for the Netherlands were produced for each country. They are found in the nine separate annex reports. In constructing this table, the model has made use also of the socio-economic database, the data on the distribution of car sales between company cars and private cars and the vehicle database. Furthermore, the 2008 base is calculated under the assumption that the target of 140 g/km is met. This is further explained in section 3.2. The values of the boundary conditions are shown in bold in the below table.

Table 5.4 Average values in base year 1999/2000 and base scenario 2008, the Netherlands.

	Petrol cars		Diesel cars	
	1999/2000	2008 base	1999/2000	2008 base
Boundary conditions				
Average lifetime tax revenue (EUR per car)	**16,661**	16,370	**23,248**	23,875
Average size[1]	**2.82**	3.05	**3.43**	3.50
Other values				
Average registration tax (EUR per car)	3,726	4,893	6,032	7,555
Average circulation tax (EUR per car per year)	433	471	986	1,005
Average dealer's price, EUR excl. VAT[2]	11,293	13,798	14,180	15,500
Average (lifetime) tax revenue consists of				
Registration tax	3,726	4,893	6,032	7,555
Circulation tax	5,022	5,464	11,443	11,661
Fuel tax	7,914	6,013	5,774	4,659

[1] See Annex in main report for definition of size.

[2] Average dealers price is calculated as consumers price minus registration tax and VAT.

Rebound effect

One should note that the average size in the 2008 base is larger than the average size in 1999/2000. This is a generic feature for all countries that have been analysed, and it occurs due to the rebound effect. The rebound effect is further explained in section 3.2. Roughly speaking, it occurs because cars, as a result of the technological progress become more energy efficient. This enhanced energy efficiency has an effect on demand resulting in more demand for larger cars.

The table below summarises the values of the boundary conditions for all the nine countries. The calculation of the lifetime tax revenue is explained in section 4.2.

Table 5.5 Values of boundary conditions for all nine countries. 1999-2000.

CO_2	Belgium	Germany	Denmark	Italy	Nether-lands	Portugal	Sweden	Finland	UK
Diesel share %	54.5	21.2	10.6	29.3	22.9	22.6	7.1	7.4	13.9
Average size of petrol cars	2.78	3.18	2.98	2.28	2.82	2.54	3.69	3.26	3.10
Average size of diesel cars	3.42	3.62	3.29	3.32	3.43	3.67	3.60	3.45	3.60
Average size - all cars	3.13	3.27	3.01	2.58	2.96	2.80	3.68	3.27	3.17
Average life tax revenue from petrol cars, EUR/car	7,845	6,950	29,286	5,696	16,661	5,348	7,814	13,539	11,824
Average life time tax revenue from diesel cars. EUR/car	9,916	7,845	34,753	6,545	23,208	9,200	12,248	19,920	12,248
Average life time tax revenue. EUR/car	8,973	7,140	29,868	5,945	18,170	6,217	8,129	14,009	11,883

Having thus set the scene, the scenarios shown in *Table 4.1* are analysed for each country together with selected sensitivity analyses.

In conducting the scenario analyses, the resulting tax schemes are calculated as an iterative process that involves numerous calculations in order to identify the tax structure, which brings the highest CO_2 reductions without violation of the boundary conditions. The functional relations that are applied for each of the three scenario types are explained in chapter 4.3.

5.3 CO_2 efficiency of existing taxation systems

5.3.1 Initial calculations

Simple tax increases

At first, the study looked into the extent to which significant CO_2 reductions could be achieved solely be means of increasing current taxation rates, i.e. without neither adding further differentiation nor changing the tax base. The results from these analyses, that were conducted for five countries, showed that the CO_2 performance of existing tax systems (with regard to new vehicles) were quite insensitive to such increases. It was shown that it would take unrealistically high levels of taxation in order to provide for any significant effect.

Technological potential

Another preparatory calculation looked into the "technological potentials". It was thus assessed to what extent significant CO_2 reductions could be provided if all vehicles within a given category became as energy effective as the most effective one is today. These calculations showed that in this highly hypothetical situation the target of 120 g/km was achievable.

As the current systems would thus not provide any significant CO_2 effect from merely increasing the level of taxation, the efficiency of the current systems was assessed in terms of considering to what extent the introduction of more distinct differentiation into existing schemes would provide for significant CO_2 reductions. The results are shown in the below section.

5.3.2 Enhanced differentiation of existing systems

Relevance

These scenarios are only relevant in the cases where the current systems already allow for some kind of differentiation. This proved to be the case in most instances with the exception of cases where registration taxes are not applied and cases where taxes are set as a fixed amount. These cases are marked in the below table with an "-".

Results

The table below summarises the results from the calculations. The total reductions are calculated as the weighed average of the reductions for petrol cars and for diesel cars. They are weighted with the relative shares of petrol and diesel cars.

Table 5.6 *Calculated CO_2 reduction from increasing the progression of existing taxes.*

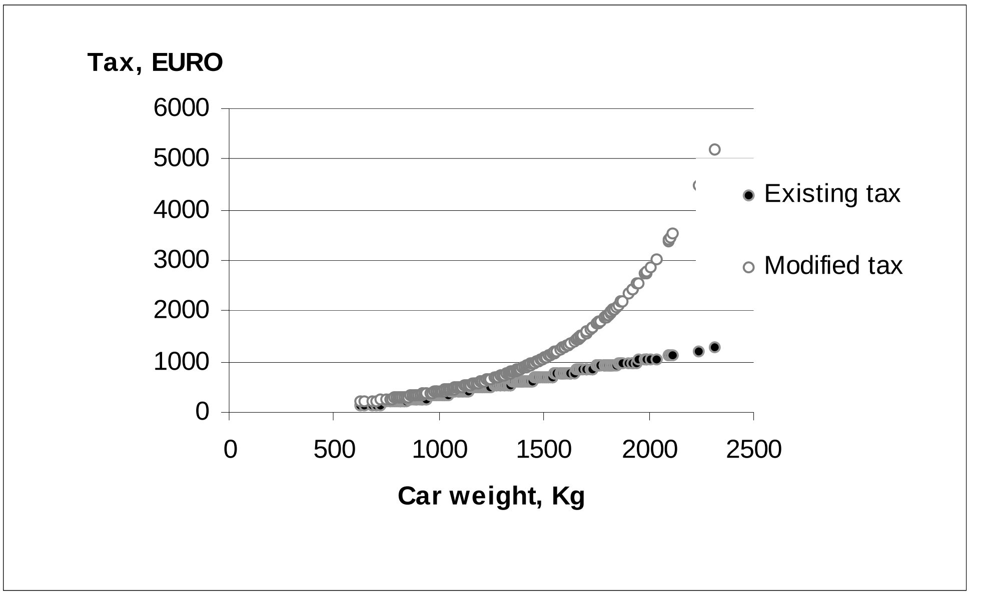
Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Increased differentiation of registration tax									
- petrol	*3.7*	*-*	*3.6*	*-*	*4.4*	*1.5*	*-*	*2.6*	*-*
- diesel	*1.5*	*-*	*1.0*	*-*	*1.2*	*3.0*	*-*	*1.3*	*-*
Total reduction	2.5	-	3.3	-	3.6	1.8	-	2.5	-
Difference from target	8.3	-	7.7	-	6.6	9.0	-	8.2	-
Increased differentiation of circulation tax									
- petrol	*3.7*	*5.1*	*5.8*	*3.3*	*4.3*	*1.7*	*2.2*	*-*	*4.9*
- diesel	*1.3*	*1.8*	*2.3*	*1.2*	*1.4*	*2.6*	*4.5*	*1.7*	*4.5*
Total reduction	2.4	4.4	5.4	2.7	3.6	1.9	2.4	0.1	4.8
Difference from target	8.4	5.5	5.6	8.7	6.6	8.9	7.8	10.6	5.1

Underlying calculations

To illustrate the calculations underlying the table, the below figure shows the resulting structure of the Dutch circulation tax for petrol cars. It should be noted that each analysis (in terms of country and fuel type) is specific, and hence the figure merely serves to provide an example.

For Netherlands the existing circulation tax is a stepwise linear relation adding approx. 0.7 EUR for each kg car weight. In this scenario the linear relation between car weight and circulation tax is changed to a progressive relation.

Figure 5.1 Changing the progression of the Dutch circulation tax, petrol cars



Note: The functional form for the modified tax is: $a * e^{(b*weight)}$. For $a * e^{(b*weight)} > (3 * weight)$ the linear function (3 * weight) is applied.

The results from applying the above differentiation of the circulation tax in the Netherlands, are shown in Table 5.7. As can be seen, the boundary conditions are complied with. The average dealer's price increases a little, and there is a re-distribution of the tax burden and revenue towards more circulation tax and less fuel tax. Tables similar to this one have been constructed for all nine countries - and for diesel as well as petrol cars. The results are shown in the annex tables.

Table 5.7 Effects from changing the progression of the Dutch circulation tax, petrol cars

	Scenario result	1999/2000 base
CO_2 effect	**-4.3%**	
Boundary conditions		
Average lifetime tax revenue (EUR per car)	16,661	**16,661**
Average size	2.82	**2.82**
Other effects		
Average registration tax (EUR per car)	4,135	3,726
Average Circulation tax (EUR per car per year)	584	433
Average dealers price, EUR excl. VAT	12,170	11,293
Average (lifetime) tax consists of		
Registration tax	4,135	3,726
Circulation tax	6,772	5,022
Fuel tax	5,754	7,914

Table 5.6 shows that there are actually substantial CO_2 reductions to be harvested simply from enhancing current differentiation systems. Nevertheless, the reductions are, in most cases, insufficient compared to the target reductions that are necessary to provide compliance with the EU target. Therefore, it is relevant to investigate the possible reductions that result from the inclusion of a more direct relation to CO_2 emissions into the tax system. This is analysed in the next section.

UK Scenario results

In the case of the UK, one should note that this is a special case in the sense that the current circulation tax is already solely determined by CO_2 emissions. For the UK therefore, the calculations merely serve to illustrate the extent to which the CO_2 effectiveness can be increased if the existing progression rates are enhanced. Furthermore, the three different scenarios only serve to illustrate the CO_2 effectiveness of the three different functional relations that are applied. Therefore, care should be taken in interpreting the various scenario results for the UK.

5.4 Adding CO_2 differentiation to existing systems

The scenario analyses that are summarised in this section consider the situation where existing systems are maintained *and* supplemented with an additional element, which is purely CO_2 related. The results from these analyses are summarised below. The outline of this table is similar to the outline of *Table 5.6* above.

Table 5.8 *Calculated CO_2 reduction from adding a CO_2 element to existing taxes*

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Adding CO_2 element to registration tax									
- petrol	*4.3*	*-*	*4.9*	*3.0*	*3.9*	*2.0*	*-*	*2.9*	*-*
- diesel	*2.5*	*-*	*1.6*	*3.0*	*1.7*	*2.4*	*-*	*2.1*	*-*
Total reduction	3.3	-	4.6	3.0	3.4	2.1	-	2.8	-
Difference from target	7.5	-	5.3	8.4	6.8	8.7	-	7.9	-
Adding CO_2 element to circulation tax									
- petrol	*4.0*	*5.0*	*5.4*	*3.6*	*4.7*	*1.9*	*317*	*3.2*	*-*
- diesel	*2.0*	*2.4*	*1.9*	*2.7*	*1.9*	*2.7*	*4.3*	*2.5*	*-*
Total reduction	2.9	4.4	5.0	3.3	4.0	2.1	3.2	3.1	-
Difference from target	7.9	6.1	4.9	8.1	6.2	8.7	7.0	7.6	-

Underlying calculations

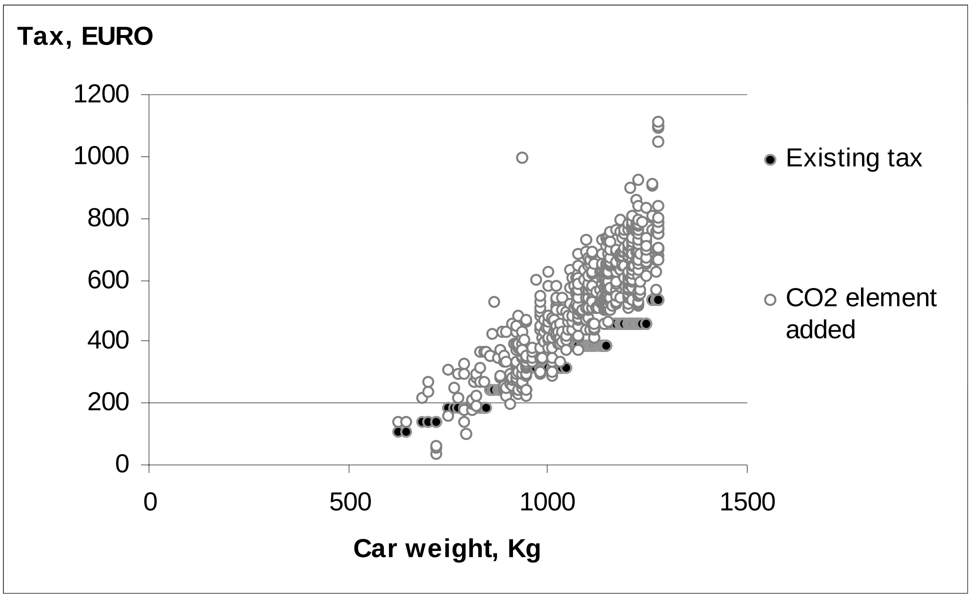
To illustrate the underlying calculations, the Netherlands can serve as an example. In the Netherlands the CO_2 element is calculated as:

CO_2 tax = 6 * g CO_2 – 626.

For a car emitting 150 g CO_2 the additional annual circulation tax would amount to 6*150 – 626 = 274 EUR . For a car emitting 120 g CO_2 per km the additional tax would amount to 94 EUR . For cars below 105 g CO_2 the additional CO_2 would result in a reduction in the existing annual tax.

The following figure and table show the modified circulation tax and the results from the calculations in the Netherlands.

Figure 5.2 Adding a CO_2 element to the existing annual circulation tax for petrol cars



Note: The functional form for the supplementary tax is: a * g CO_2 - b . When the sum of the exisisting tax and the supplementary tax becomes negative the total tax applied is restricted to zero.

The following table shows the calculation results from adding a CO_2 element to the existing annual circulation tax for petrol cars for the Netherlands.

Table 5.9 Effects from adding a CO_2 element to the annual circulation tax for petrol cars - The Netherlands

	Scenario result	1999/2000 base
CO2 effect	**-4.7%**	
Boundary conditions		
Average lifetime tax revenue (EUR per car)	16,661	**16,661**
Average size	2.82	**2.82**
Other effects		
Average registration tax (EUR per car)	4,189	3,726
Average circulation tax (EUR per car per year)	581	433
Average producers price, EUR excl. VAT	12,287	11,293
Average (lifetime) tax consists of		
Registration tax	4,189	3,726
Circulation tax	6,742	5,022
Fuel tax	5,730	7,914

Adding a CO_2 component to the annual circulation tax according to the above figure could thus reduce the CO_2 emissions from new petrol cars by 4.7% relative to the 2008 base scenario.

5.5 Purely CO_2 differentiated taxes

The last group of scenarios represents the most radical move away from today's situation. In these scenarios, it is assumed that the existing circulation tax or registration tax is fully replaced by a new and purely CO_2 related tax. Furthermore, the implications are analysed of introducing a whole new system, which replaces both the circulation taxes and the registration taxes.

Boundary conditions

It is vital to emphasise that these calculations as well as the above always respect the boundary conditions. In other words, the calculations assess how much CO_2 reduction can be achieved without violation of any of the boundary conditions, i.e. without affecting the total revenue from the taxes, without changing the proportion of diesel cars and without downsizing. The boundary conditions are, as explained above, defined for 1999/2000.

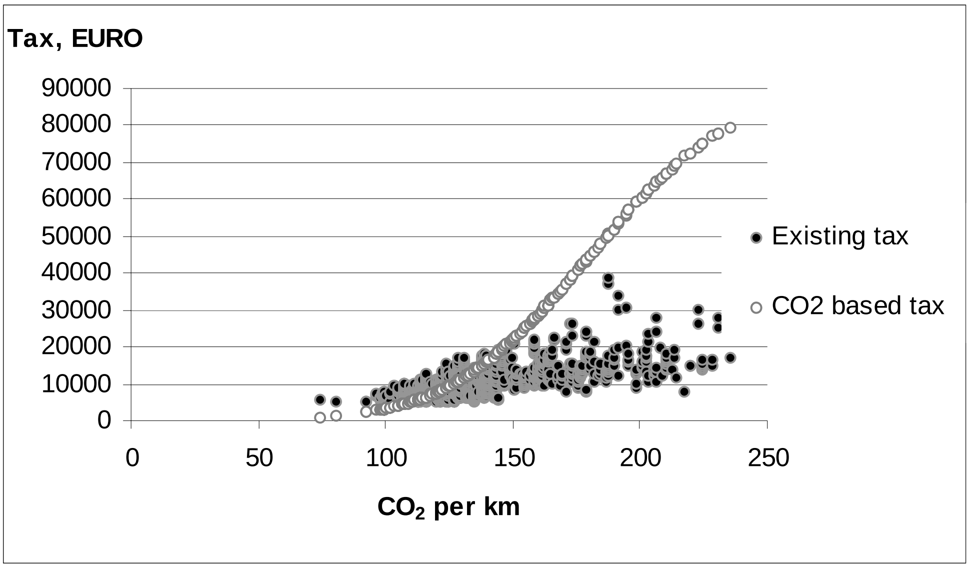
Table 5.10 *Calculated CO_2 reduction from purely CO_2 differentiated taxes*

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)	10.8	10.5	9.9	11.4	10.2	10.8	10.2	10.7	10.3
Replacing the registration tax									
- petrol	*4.6*	*-*	*8.5*	*1.3*	*5.9*	*2.8*	*-*	*4.1*	*-*
- diesel	*2.7*	*-*	*7.6*	*2.9*	*4.2*	*4.5*	*-*	*6.1*	*-*
Total reduction	3.5	-	8.4	1.8	5.5	3.2	-	4.3	-
Difference from target	7.3	-	1.5	9.6	4.7	7.6	-	6.4	-
Replacing the circulation tax									
- petrol	*5.2*	*5.5*	*5.9*	*4.3*	*6.5*	*2.1*	*3.9*	*3.4*	*4.7*
- diesel	*3.4*	*3.4*	*1.8*	*3.7*	*4.3*	*3.2*	*4.4*	*4.3*	*4.4*
Total reduction	4.2	5.0	5.5	4.1	6.0	2.3	3.9	3.5	4.7
Difference from target	6.6	5.5	4.4	7.3	4.2	8.5	6.3	7.2	5.6
Replacing both the circulation tax and the registration tax									
- petrol	5.4	5.5	8.6	4.2	7.4	2.9	-	4.1	4.6
- diesel	4.8		7.7	3.5	5.8	4.6	4.2	7.0	4.2
Total reduction	5.1	4.9	8.5	4.0	7.0	3.3	0.3	4.3	4.5
Difference from target	5.7	5.6	1.4	7.4	3.2	7.5	9.9	6.4	5.8

Underlying calculations

Again, the Netherlands may serve as an illustrative example of the underlying calculations. The purely CO_2 differentiated registration tax has been designed in an iterative process involving a large number of calculations. The design of the tax, which brings the highest CO_2 reductions given the boundary conditions, is shown below. In the figure the new tax is compared to the existing registration tax.

Figure 5.3 Purely CO_2 differentiated registration tax for diesel cars



Note: The functional form for the purely CO_2 differentiated tax is the cumulative normal distribution: $F(\mu, \sigma)*\kappa$, where μ, σ and κ are parameters that shape the curve of the function. μ denotes the mean, σ the standard deviation while c is a scale parameter. The estimated CO_2 function has the parameters $\mu = 180.45$, $\sigma = 43.68$, $\kappa = 88390$

The results from applying this modified registration tax are shown in the following table.

Table 5.11 Effect from purely CO_2 differentiated registration tax for diesel cars. The Netherlands

	Scenario result	1999/2000 base
CO_2 effect	**-4.2%**	
Boundary conditions		
Average lifetime tax revenue (EUR per car)	23,248	**23,248**
Average size	3.43	**3.43**
Other effects		
Average registration tax (EUR per car)	7,379	6,032
Average circulation tax (EUR per car per year)	984	986
Average producers price, EUR excl. VAT	15,239	14,180
Average (lifetime) tax consists of		
Registration tax	7,379	6,032
Circulation tax	11,412	11,443
Fuel tax	4,458	5,774

It appears that the new modified tax would reduce the CO_2 reductions from new cars by 4.2%.

5.6 CO_2 tax differentiation levels

Calculations have been done to illustrate the implicit levels of differentiation that apply under the two CO_2 differentiation scenarios, viz. the scenario that adds a CO_2 tax to the existing tax and the scenario that replaces the existing tax with a completely CO_2 based tax.

For the scenario that adds the CO_2 dependent tax to the existing tax, the calculations draw directly on the functional forms that have been established for each individual country. The specific functional forms are described in the individual and country specific annex reports. For the scenario that assumes a replacement of the existing tax with a purely CO_2 dependent tax, the calculation of the required level of EUR per gram of CO_2 necessitated simplifications in order to provide an indicator of this. The need for simplifications arises due to the more complex functional forms that are applied in these scenarios (the S-curve approach explained in section 4.3.3). More specifically, the EUR per gram of CO_2 that were calculated for this scenario are based on a calculation of the average taking an emission of 90 g/km as the lower end (and 75 g/km for diesel cars), and defining the upper end to be the 90% quartile. The results for the scenario that assumes a replacement of the existing taxes with purely CO_2 differentiated taxes should thus be interpreted with care as they disregards the very most CO_2 emitting cars.

The tables include both the calculated level of differentiation as well as the resulting average level of the tax in question. As mentioned in the tables, the underlying functional forms all include a negative constant value, implying that the resulting tax level *cannot* be calculated or indicated by multiplying the level of differentiation with the emission level of specific cars. Therefore, the resulting average tax level is shown in this table only in order to provide an indication of the resulting level on the tax in question. All calculations, and hence also the implicit levels of differentiation, are subject to the boundary condition on budget neutrality. The tables also show the baseline average values of the tax in question in order to facilitate comparison.

8 While the table could indicate that the level of differentiation required to achieve a reduction in the order of 1% is always larger in the scenario, which assumes a complete replacement of the existing tax by a fully CO_2 dependent tax, there are a number of reservations to this conclusion. First, the underlying functional relations are completely different, and therefore such comparisons should be done with the utmost care. Secondly, it is important to note that this scenario (with a replacement of existing taxes by a fully CO_2 dependent tax) always provide more total CO_2 reduction than the other scenario, which simply adds the CO_2 dependent tax to the existing tax. Thus, while the differentiation per 1% reduction is larger, this order-of-magnitude can however provide for a larger total reduction, which still complies with the boundary conditions. In other words, the shown levels of differentiation only apply up to the limits (the achievable CO_2 reduction) given in *Table 5.8* and *Table 5.10*.

9 Taking Denmark as an example (and referring also to the above tables), a differentiation of 41 EUR/g for petrol cars may be multiplied by a maximum of 4.9 and thereby provide a total reduction of 4.9%. And in this case, the average registration tax would amount to 20,816 EUR/car, while the budget neutrality will be maintained through corresponding changes in the revenue of the other taxes. If larger reductions are desired, the boundary conditions will be violated in the scenario of adding a CO_2 element to existing taxes.

10 By comparison, for the scenario of replacing the existing registration tax by a purely CO_2 differentiated one, the differentiation level of 75 may be multiplied by 5.4 to provide a total reduction of 5.4%. This would result in an average registration tax of 21,334 and corresponding decline in revenue from the other vehicle related taxes to ensure that budget neutrality is complied with.

Thus, the shown average levels of taxation apply to the case, which has provided the maximum possible CO_2 reduction for the given scenario, i.e. the reductions shown in *Table 5.8* and *Table 5.10*. To allow for comparisons however the shown differentiation levels have been normalised to apply to a reduction of 1 percentage point.

Level of differentiation of the registration tax

The below tables illustrate the implicit level of differentiation that is inherent in the cases where the registration tax is subject to the analysis.

Table 5.12 *The level of CO_2 differentiation implicit in the scenario calculation on the registration tax: Petrol cars.*

Scenario	Scenario calculations 2008				Base scenario values	
	Adding a CO_2 element to existing taxes		Replacing existing taxes with purely CO_2 dependent taxes		Average registration tax	
Country	EUR per g CO_2 per 1% emissions reduction 1)	Average registration tax EUR	EUR per g CO_2 per 1% emissions reduction 1)	Average registration tax EUR	Average registration tax EUR 1999	Average registration tax EUR 2008
Belgium	163	1,786	11	1,860	208	277
Germany	Not relevant					
Denmark	41	20,816	75	21,334	16,025	20,713
Italy	93	1,135	38	1,007	151	151
Netherlands	34	5,823	36	5,983	3,726	4,893
Portugal	44	2,955	51	2,971	2,236	2,534
Sweden	Not relevant				0	0
Finland	48	9,046	60	9,081	7,863	7,535
UK	Not relevant				0	0

1) these figures only indicate the *level of differentiation*. All functional forms also include a constant with a negative value.

As can be seen the level of differentiation for petrol cars lies in the range of between 35 and 48 EUR per gram of CO_2 to achieve 1 percentage point reduction. These figures ignore the cases of Belgium and Italy, where the existing registration tax is quite small. In these countries the registration tax will increase significantly (and the revenues from the other taxes decline correspondingly thus maintaining budget neutrality) in order to provide for a significant effect from the differentiation.

The figures apply to the scenario that adds the CO_2 element to the existing taxation. In the case of replacement of existing taxes, the average level of differentiation becomes higher for each country as mentioned above. As mentioned in the footnotes to the tables, all functional relations include a negative constant. Therefore, the resulting level of the registration tax needs to take this constant into account. As shown in the table, the resulting tax levels represent increases compared to today's level in particular, but also compared to the levels that apply in the 2008 base scenario. In this regard, it is must be underlined that all calculations are still subject to the boundary conditions, and thus they remain budget neutral. The higher average registration tax is thus counterbalanced by lower fuel taxes and by lower average circulation taxes.

Table 5.13 *The level of CO_2 differentiation implicit in the scenario calculation on the registration tax: Diesel cars.*

Scenario	Scenario calculations 2008				Base scenario values	
	Adding a CO_2 element to existing taxes		Replacing existing taxes with purely CO_2 dependent taxes		Average registration tax	
Country	EUR per g CO_2 per 1% emissions reduction 1)	Average registration tax EUR	EUR per g CO_2 per 1% emissions reduction 1)	Average registration tax EUR	Average registration tax EUR 1999	Average registration tax EUR 2008
Belgium	54	1,418	17	1,458	291	313
Germany	not relevant					
Denmark	67	25,784	116	26,835	22,530	25,610
Italy	41	1,036	12	1,035	151	151
Netherlands	55	7,207	55	7,279	6,032	7,555
Portugal	13	7,077	19	7,111	6,583	7,136
Sweden	not relevant				0	0
Finland	44	10,991	58	11,116	10,410	11,326
UK	not relevant				0	0

1) these figures only indicate the *level of differentiation*. All functional forms also include a constant with a negative value.

In the case of diesel cars, the situation is a little different. The difference is due mainly to the underlying functional forms, and to differences in the existing tax schemes applying to petrol cars and diesel cars respectively.

Circulation taxes

The below tables provide similar results in the case of circulation taxes.

Table 5.14 The level of CO_2 differentiation implicit in the scenario calculation on the circulation tax: Petrol cars.

Scenario	Scenario calculations 2008				Base scenario values	
	Adding a CO_2 element to existing taxes		Replacing existing taxes with purely CO_2 dependent taxes		Average circulation tax	
Country	EUR per g CO_2 per 1% emissions reduction 1)	Average circulation tax	EUR per g CO_2 per 1% emissions reduction 1)	Average circulation tax EUR	Average circulation tax EUR 1999	Average circulation tax EUR 2008
Belgium	1.0	310	4.1	307	177	200
Germany	0.7	230	1.4	232	88	97
Denmark	2.6	411	4.9	440	404	227
Italy	1.1	239	3.9	241	151	163
Netherlands	1.3	581	4.1	606	433	471
Portugal	1.8	89	6.5	91	35	37
Sweden	1.5	297	2.1	300	150	155
Finland	1.3	292	1.8	295	118	118
UK	1.2	449	1.6	450	231	167

1) these figures only indicate the *level of differentiation*. All functional forms also include a constant with a negative value.

Table 5.15 The level of CO_2 differentiation implicit in the scenario calculation on the circulation tax: Diesel cars.

Scenario	Scenario calculations 2008				Base scenario values	
	Adding a CO_2 element to existing taxes		Replacing existing taxes with purely CO_2 dependent taxes		Average circulation tax	
Country	EUR per g CO_2 per 1% emissions reduction 1)	Average circulation tax EUR	EUR per g CO_2 per 1% emissions reduction 1)	Average circulation tax EUR	Average circulation tax EUR 1999	Average circulation tax EUR 2008
Belgium	2.6	480	8.8	483	384	395
Germany	1.1	366	2.0	369	282	321
Denmark	5.9	513	17.3	525	574	403
Italy	1.5	266	2.0	269	190	193
Netherlands	3.6	979	10.3	997	986	1,005
Portugal	0.5	46	1.2	48	31	32
Sweden	1.1	746	2.2	753	659	678
Finland	1.4	573	2.8	578	572	579
UK	0.9	414	1.2	415	236	182

1) these figures only indicate the *level of differentiation*. All functional forms also include a constant with a negative value.

Observations similar to the above apply also in this case. The level of differentiation is higher for the case where the existing tax is replaced by the CO_2 tax compared to the case of simply adding a CO_2 element to the existing tax. This observation applies in this case both to petrol cars and to diesel cars with no exceptions. Again, it should be noted that differences are due to different underlying functional forms, and that the former scenario provides more CO_2 reductions than the latter.

In the scenario, which adds a CO_2 element, the differentiation levels are in the order of between 0.7 and 2.6 EUR per gram of CO_2 to achieve 1 percentage point of reduction - and allowing for a total reduction level as indicated by *Table 5.8*. If reductions are to be achieved in excess of those indicated in the table, the boundary conditions will no longer be met in this scenario. By comparison, the replacement of the existing taxes with purely CO_2 dependent taxes implies differentiation levels in the order of between 1.4 and 6.5 EUR. This level of differentiation will provide 1percentage point of reduction, and the total room of manoeuvre is indicated in *Table 5.10*, from which table it can also be seen that this scenario allows for more CO_2 reductions than the other one while still respecting the boundary conditions. The tax levels do also increase in this case compared to the base scenario values, but it should again be noted that all calculations do respect the boundary conditions including the one on budget neutrality.

For diesel cars, the level of differentiation lies in the range of between 0.9 and 5.9 EUR per gram CO_2 to achieve 1 percentage point reduction in the case of adding a CO_2 element to the existing tax. When replacing the existing tax by a fully CO_2 dependent tax, the level of differentiation is in the order of between 1.2 and 17.3 EUR.

5.7 Implications of increased proportion of diesel cars

Current trend of increased proportions of diesel cars

All calculations have been done under the assumption that the proportion of diesel cars in the total sales of new cars remains unaltered. However, as mentioned earlier, the current trend in almost all countries is one of increased proportions of diesel cars. Diesel cars emit about 10% less CO_2/km than petrol cars do. Therefore, there may be a CO_2 reducing effect from simply replacing petrol cars by diesel cars.

Therefore, calculations have been undertaken that investigate to which extent increased diesel proportions have an impact upon the reduction potentials from applying fiscal measures. The calculations are rough in the sense that they assume that any replacement will be in the form of a completely similar car, the only difference being the type of fuel.

Starting point for calculation

The calculations all take as the starting point the scenario results that provided the maximum CO_2 reduction. In most cases, this corresponds to the scenario where the registration tax and the circulation tax are both replaced by purely CO_2 dependent taxes.

Alternative calculations

Two alternative calculations have been carried out:

- One, which assumes that the proportion of diesel cars is doubled. However, it is not allowed to exceed 50%. In the case of Belgium, where the original proportion was 54%, this proportion is simply maintained.

- One, which assumes that the proportion of diesel cars in the sales of new cars increase to 50% in all countries. Again, in the case of Belgium, the proportion is kept constant at the original 54%.

Results

The table below shows the resulting CO_2 reductions. The table shows how much of the achieved reduction can be attributed to the shift in fuel and how much can be attributed to a shift in the fiscal regime. Once it is assumed that a diesel car replaces a petrol car the purchase decision comes to be made under the conditions governing diesel cars instead. It is important to bear in mind, that the proportions of diesel cars mentioned in the table only apply to new cars. Thus, the proportion of diesel cars in the *car fleet* is lower.

Decomposition of results

The table also shows that in a number of cases, there are substantial additional CO_2 reductions to be harvested. The gain may be more than an additional 6 g/km. This is the case for Sweden and Finland. However, the major reason for this is the current very low proportion of diesel vehicles. Hence, increasing the proportion up to 50% may represent an important policy shift, which may be considered undesirable among other things because of the other environmental impacts attributable to the use of diesel such as emissions of particulate matter.

The table further decomposes the additional gain into a part, which is due to a shift to a fuel that is less CO_2 emitting and a part, which is due to the shift in fiscal regime. Both of these factors do influence the final result. Comparing for example Portugal and the Netherlands where original diesel proportions are of about the same size, one can see that the effect from increasing the diesel proportion varies significantly. Throughout the table, the reduction due to the shift in fuel is of about the same size, which is what could be expected given the similar original proportions of diesel cars. However, in the Netherlands, the increased diesel proportion implies that the CO_2 reduction provided by the fiscal measures declines from 7.8 g/km and down to 6.8 g/km. In Portugal, the opposite occurs: here the original reduction was 4.1 g/km and this increases to 4.5 g/km. The reason for this can be found in the first part of the table, which illustrates that the changed fiscal regime provides largest reductions from diesel cars in Portugal, but largest reductions for petrol cars in the Netherlands.

As a consequence, the difference between the reduction levels between these two countries is reduced from 3.7 g/km and to 2.4 g/km. There is however still a difference, and this is due to the original difference in the composition of the sales of cars. In Portugal, smaller cars constitute a relatively much higher fraction of the total sales than the larger cars. The variation in CO_2 emissions tends to increase the larger the size category of the cars.

Table 5.16 Implications of increases in the proportion of diesel cars. Reduction in average CO_2 emission

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)									
Original result									
Diesel proportion, %	54	21	11	29	23	23	7	7	14
- petrol, g/km reduction	6.8	7.5	12.4	5.8	8.3	3.6	5.6	5.3	6.6
- diesel, g/km reduction	6.3	4.7	10.5	4.8	5.8	5.7	7.0	9.4	6.2
Total, g/km reduction	6.5	6.9	12.2	5.5	7.8	4.1	5.7	5.6	6.5
Total, percentage reduction	**5.1**	**5.0**	**8.5**	**4.1**	**6.0**	**3.3**	**3.9**	**4.3**	**4.8**
Doubling of proportion of diesel cars									
Diesel proportion, %	54	42	21	50	46	45	14	15	28
- petrol, g/km reduction		7.5	12.4	5.8	8.3	3.6	5.6	5.3	6.6
- diesel, g/km reduction		4.4	10.2	4.7	5.4	5.4	6.4	8.8	5.8
Total, g/km reduction due to shift in fiscal regime		6.2	11.9	5.2	7.0	4.4	5.7	5.8	6.4
Reduction due to shift in fuel, g/km		2.9	1.5	2.8	2.9	2.8	1.1	1.0	1.9
Total g/km reduction		9.1	13.5	8.0	9.9	7.2	6.8	6.8	8.2
Total percentage reduction		**6.6**	**9.4**	**6.0**	**7.6**	**5.8**	**5.2**	**5.2**	**6.1**
Diesel proportion = 50%									
Diesel proportion, %	54	50	50	50	50	50	50	50	50
- petrol, g/km reduction		7.5	12.4		8.3	3.6	5.6	5.3	6.6
- diesel, g/km reduction		4.4	10.0		5.3	5.3	5.9	8.4	5.6
Total, g/km reduction due to shift in fiscal regime		6.0	11.2		6.8	4.5	5.8	6.9	6.1
Reduction due to shift in fuel, g/km		3.9	5.7		3.5	3.4	6.2	5.5	4.9
Total g/km reduction		9.9	16.9		10.3	7.9	12.0	12.4	10.9
Total percentage reduction		**7.2**	**11.8**		**7.9**	**6.4**	**8.2**	**9.5**	**8.1**

5.8 Alternative formulations of the budget constraint

The original formulation of the budget boundary condition required that the total revenue in terms of the sum of fuel taxes, circulation taxes and registration taxes (collected from the new cars in question) was to be maintained at the 1999/2000 level.

The calculations have however looked into the extent to which the results are influenced by alternative formulations of this boundary condition. Two alternatives are investigated:

- First, the formulation of the budget constraint disregards fuel taxes

- Second, the formulation of the budget constraint is limited to only consider the tax in question.

The alternative calculations are carried out for the scenario, which investigates the CO_2 reduction potential of adding a CO_2 element to existing taxes.

The tables contained in the technical annexes to this report provide a more detailed overview of the results from these alternative calculations. The below table provides a summary of the results in terms of CO_2 reductions.

Table 5.17 Implications of alternative formulations of budget boundary condition. CO_2 reduction relative to 2008 base. %

Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)	10.8	10.5	11.0	11.4	10.2	10.8	10.2	10.7	11.0
Adding a CO_2 element to the registration tax									
Original results									
- petrol	4.3	-	4.9		3.9	2.0	-	2.9	-
- diesel	2.5	-	1.6		1.7	2.4	-	2.1	-
Disregard fuel tax revenue in formulation of budget boundary condition									
- petrol	-	-	4.5		4.0	1.8	-	2.8	-
- diesel	0.3	-	1.4		1.4	2.2	-	1.9	-
Budget boundary condition only considers registration tax revenue									
- petrol	0.3	-	4.1		4.0	1.8	-	2.8	-
- diesel	0.5	-	0.9		1.4	2.2	-	1.7	-
Adding a CO_2 element to the circulation tax									
Original results									
- petrol	4.0	5.0	5.4		4.7	1.9	3.1	3.2	4.6
- diesel	2.0	2.4	1.9		1.9	2.7	3.7	2.5	4.3
Disregard fuel tax revenue in formulation of budget boundary condition									
- petrol	4.0	4.9	6.1		4.7	2.0	3.2	3.2	4.6
- diesel	1.9	2.3	1.9		1.9	-	3.6	2.4	4.3
Budget boundary condition only considers circulation tax revenue									
- petrol	4.0	4.9	5.4		4.7	2.0	3.2	3.2	4.6
- diesel	1.9	2.3	1.9		1.9	3.0	3.6	2.5	4.3

The overall picture that emerges from the above table is that the alternative formulations of the budget boundary conditions have very little implications for the potential CO_2 reduction. In the case where a CO_2 element is added to the circulation tax this has virtually no implications. The calculated CO_2 reduction remains unaltered or changed by only 0.1 percentage points. The sole exception from this observation is the case of Denmark, where the CO_2 reduction increases from 5.4% to 6.1% when the fuel tax revenue is omitted from the budget formulation. The reason for this is that this calculation implies that the point where the circulation tax becomes positive and increasing is increased in terms of the car's CO_2 reduction.

In the case of registration taxes it should first be noted that Belgium is a special case, since the Belgian registration tax is very little. Therefore, reducing the scope of the budget formulation significantly reduces the scope of action for changes to the registration tax. Otherwise, the alternative budget formulations have little impact on the results in the case of the registration tax, although results are more affected than in the case of the circulation tax. In Denmark, changes to the budget formulation have significant implications for the calculated CO_2 reduction.

Generally, however, it can be concluded that the definition of the budget boundary condition has only little implications for the results of the scenario. This observation is particularly robust in the case of circulation taxes, whereas there are cases where the effects from adding a CO_2 element to registration taxes, is affected by the way the budget constraint is defined. Nevertheless, in most of these cases the sensitivity is also quite small and close to being negligible.

5.9 Implications of increased fuel taxes

The original formulation of the budget boundary condition assumed that fuel taxes (EUR/litre) remain constant at today's level. The study has investigated to what extent the results of the calculations would be affected if the fuel tax per litre of fuel increased by 25%.

The CO_2 reduction potential of an increase in the fuel taxes of 25% has been calculated assuming no other changes to the tax regimes, and allowing for the consequent change in lifetime tax revenue (the budget boundary condition).

Furthermore, the effects from a change in fuel taxes have been calculated under the assumption that the original budget was to be complied with. In other words, under the assumption that the average lifetime tax revenue should remain at the original 1999/2000 level, i.e. the level before the assumed fuel tax increases.

The alternative calculations have been undertaken in the context of the scenario, which assumes that the progression of the existing tax is increased.

The tables contained in the technical annexes to this report provide a more detailed overview of the results from these alternative calculations. The below table provides a summary of the results in terms of CO_2 reductions.

Table 5.18 Implications of an increase in fuel tax (EUR/litre) of 25%. Reduction relative to 2008 base. %

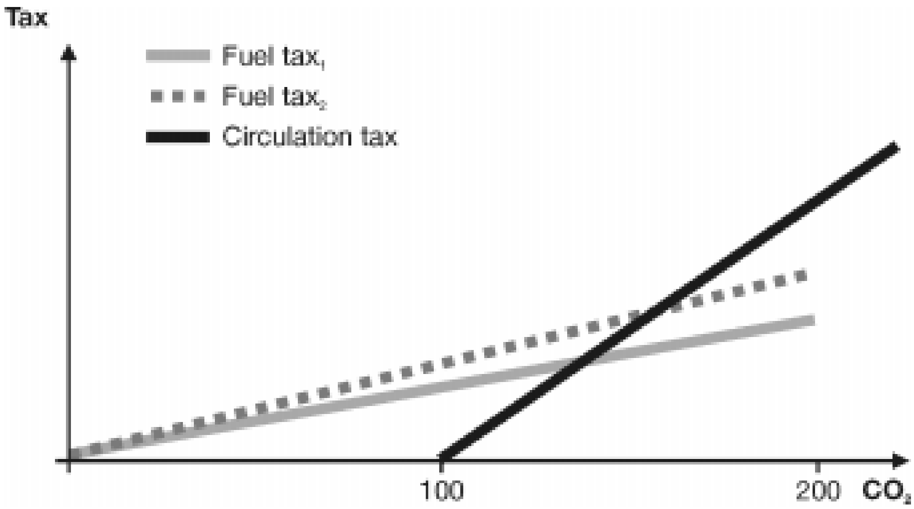
Output/Country	B	D	DK	I	NL	P	S	SF	UK
Target (2008 baseline)	10.8	10.5	11.0	11.4	10.2	10.8	10.2	10.7	11.0
Effect from increase in fuel tax of 25%									
- petrol	0.9	1.4	0.8		1.3	0.3	0.8	0.7	1.6
- diesel	0.3	0.7	0.2		0.3	0.8	0.9	0.5	1.9
Increase in fuel tax and changing the progression of the registration tax									
Original result									
- petrol	3.7	-	3.6		4.4	1.5	-	2.6	-
- diesel	1.5	-	1.0		1.2	3.0	-	1.3	-
Fuel tax increase of 25% and adjusting the registration tax a to maintain the original value of the budget boundary condition									
- petrol	2.2	-	3.9		4.6	1.6	-	2.8	-
- diesel	1.4	-	1.1		1.4	3.0	-	1.8	-
Increase in fuel tax and changing the progression of the circulation tax									
Original result									
- petrol	3.7	5.1	5.8		4.3	1.7	2.2		4.9
- diesel	1.3	1.8	2.3		1.4	2.6	3.3	1.7	4.5
Fuel tax increase of 25% and adjusting the circulation tax to maintain the original value of the budget boundary condition									
- petrol	3.8	5.2	5.9		4.5	1.8	2.5		4.8
- diesel	1.5	2.0	2.3		1.6	2.8	3.5	2.2	4.4

The overall picture that emerges from the above table is that simply increasing the fuel tax by 25% has a very little CO_2 reduction effect. In most cases, the reduction is below 1%. In the UK, the tax increase will provide a little bit more CO_2 reduction namely 1.6% (petrol cars) and 1.9% (diesel cars). The major explanation for this being that the effect from the increased fuel tax will be fully supported by the existing circulation tax, which is also explicitly CO_2 related.

If the fuel tax increase of 25% is combined with a requirement that the original budget boundary condition is to be maintained, this will bring about only very small further CO_2 reductions in the calculations where it is the progression of the circulation tax that is changed. In the case, where it is the progression of the registration tax that is changed, the effect is a little higher, but still very modest.

The major reason for this poor CO_2 reduction potential is to be found in the lack of progression of such a tax in regard to the issue at hand here, namely the average CO_2 emission from new cars measured as g/km.

The figure below serves to illustrate this:



The less energy efficient a particular vehicle is, the more fuel will it use per km., and the more CO_2 will it emit. An increase in the fuel tax of 25% will thus of course impact upon the running cost of a vehicle, and it will affect the less energy effective vehicles the most. However, it will apply equally (in terms of costs/litre) to all cars and the only penalty that the more CO_2 emitting cars will be invoked is the costs of the additional fuel that they use, and there is no way of enhancing the differentiation further. The fuel tax is namely imposed on all vehicle owners without any consideration to the type of car that they buy. Comparing this to for example a progressive circulation tax, such a tax can be directly designed to penalise more those cars that have high average CO_2 emissions to the benefit of those that have low emissions. This is illustrated in the figure where the circulation tax curve is shown to be much steeper than the fuel tax curve when comparing the tax and the average CO_2 emission.

5.10 Interpretation of results

There are a number of major and critical issues to be aware of when interpreting the results of the study.

First, it is important to bear in mind that the major purpose of the calculations described here, has been to investigate the CO_2 reduction potential of fiscal measures. In other words to assess whether fiscal measures would be capable to bring significant CO_2 reductions, and to assess whether they would constitute a relevant instrument by which to support the realisation of the target of an average of maximum 120 g/km for new cars in 2008. In this regard it should be underlined that the study is by no means intended as the basis for detailed policy planning neither at the national level nor at the EU level. This will require a more integrated study of all possible instruments including awareness building (e.g. labelling and information campaigns) and the possible synergies and interactions involved. By the same token the what-if approach that has been taken should be mentioned. The implications are further described in sections 2.2 and 3.1. It should also be mentioned that the study only considers petrol and diesel vehicles. Incentives may be put in place or strengthened that encourage the purchase of cars fuelled with alternative fuels.

The calculations have clearly confirmed that fiscal measures do have a potential in regard to supporting the reduction of the average CO_2 emissions of new cars. In particular it is worth noting that the study illustrates that even without downsizing significant CO_2 reductions can be provided merely be implementing modifications or changes to the existing fiscal systems. In this regard, it should be noted though, that while the study has paid attention to avoid downsizing, this does not necessarily imply that structural changes on the car market does not occur. The downsizing requirement has been complied with by means of controlling the average size of cars, as described in annex D.

The calculations have also shown that there is no type of tax that is superior to another type of tax in regard to the ability to provide CO_2 reductions. Both the registration tax and the circulation tax can do this. On the other side the calculations have shown that the structure of the whole system is of importance.

Increasing the share of diesel vehicles can provide significant further CO_2 reductions, while changes to the definition of the budget boundary condition have smaller implications.

The calculations have also shown that merely enhancing the differentiation of existing systems can provide significant CO_2 reductions, although additional gains are to be achieved from adding a CO_2 element to existing taxes or replacing existing taxes with a purely CO_2 differentiated element. The latter provides in most cases the largest reductions.

The calculations have also shown that fuel taxes are not very effective as an instrument to reduce average CO_2 emissions from new cars. However, fuel taxes are also typically used with a broader perspective, namely to control transportation as such and to encourage energy efficient driving behaviours. For these purposes, fuel taxes are most likely to be a good instrument.

This point to another important aspect of the study, namely that it is concerned only with the average CO_2 emissions from new cars. Thus, while the calculations have shown that fiscal measures can assist to reduce this average significant, this does not at all imply that CO_2 emission due to passenger car transport will decline.

By the same token it should be noted that the calculations do not take into account neither the possible impacts on average mileage nor the driving behaviours. Such changes would have implications for the value of the budget in terms of fuel tax revenue and lifetime of the cars. In this regard, the fact that the average lifetime of cars is assumed to be the same for all countries should be noted.

Lastly, attention should be brought to the fact that while the EU target is an agreed-upon target, the national targets applied in these calculations are purely hypothetical. It has been assumed that the same relative reduction requirements would apply to all countries. This assumption thus maintains current differences in the sense that for example the average size of cars in Italy and Portugal is smaller than the average size in Finland and the Netherlands. Consequently, today's average CO_2 emissions measured as g/km/car are lower in the former types of countries.

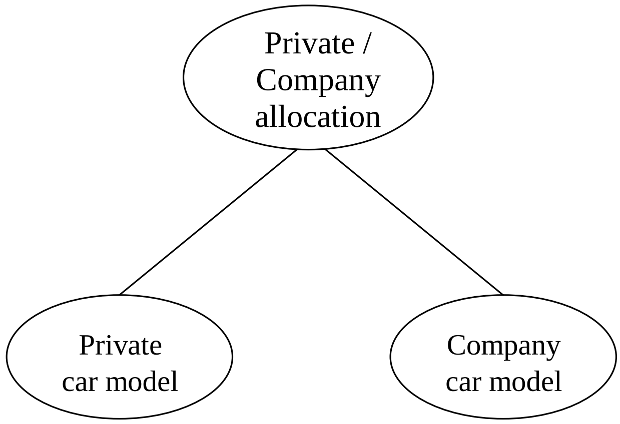
Technical Annexes

A. The passenger car model

The model estimates the effect of fiscal measures on CO_2 emissions from passenger cars. This is done by calculating the demand for passenger cars in each of the 15 EU Member States and comparing a base scenario with alternative scenarios where fiscal measures are used to alter the incentives at play when choosing between different vehicles.

A.1 The car choice model framework

The car choice model consists of three sub models.



The Private/Company model allocates the cars into private and company cars. The driving force in this model is the benefit the consumer gets from choosing a specific car as a company car instead of a private car. This benefit is closely connected to the taxation rules for acquisition and use of company cars which is varying a lot between the EU Member States. The parameters for this model have been estimated based on data from Denmark 1997 and Germany 1999 – 2000 and the appropriate taxation rules in these two countries.

The private car model allocates the demand on the specific cars. The driving force in the private car choice model is the following

- Price of the car (inclusive tax and VAT)
- Running cost (fuel and circulation tax)
- Size of the car (length)
- Luggage capacity
- Acceleration

Furthermore the model include a “home-market” parameter to account for the fact that consumers tends to choose cars produced in their own country.

The parameters (elasticities)[23] in the private car choice model have been estimated based on a full-scale dataset from all new registrations in Denmark in

[23] Parameter estimates and elasticities are not the same, but the size of the parameter estimates determine the size of the elasticities.

1997. The parameter estimates from the Danish model have been compared with parameter estimates from a model based on data for 11 EU Member States for the period 1999 – 2000. This comparison showed that the parameter estimates (elasticities) from the Danish model are very close to the parameter estimates from the EU model. This means that the Danish model will predict the same effect of fiscal measures as a general EU model.

The company car model allocates the demand on the specific company cars. The driving force in the company car choice model is the following

- Cost of acquisition (Personal taxation rules)
- Running cost (Personal taxation rules)
- Size of the car (length)
- Luggage capacity
- Acceleration
- Horse power

Furthermore the model includes a home market parameter to account for the fact that consumers tends to choose cars produced in their own country.

The parameter estimates from the Danish company car model have been compared with similar parameter estimates from a model based on data for 11 EU Member States for the period 1999 – 2000. This comparison showed that the parameter estimates (elasticities) from the Danish model is very close to the same parameter estimates from the EU model.

A.2 Private/company split

The Private/Company split model takes each specific car and calculates the benefit of having this car as a company car, i.e. the cost of having the car as private car minus the cost of having it as company car. Based on this measure and other characteristics, the model calculates the probability that this car is chosen as a company car.

The model is a binary discrete choice model, with the following formulation:

$$P(Companycar) = \frac{e^V}{e^V + 1}$$

Where *V* is the utility of having the car as a company car which is a function of the benefit (B) and the physical characteristics of the car (C).

$V = \beta * B + \alpha * C$

A. 3 Private car choice model

The private car model has 45 “agents”. These agents differ with respect to family type, household income and age.

Separate sub models has been estimated for 24 types of car buyers:

Table A.1 Car buyer family type and income in basic data

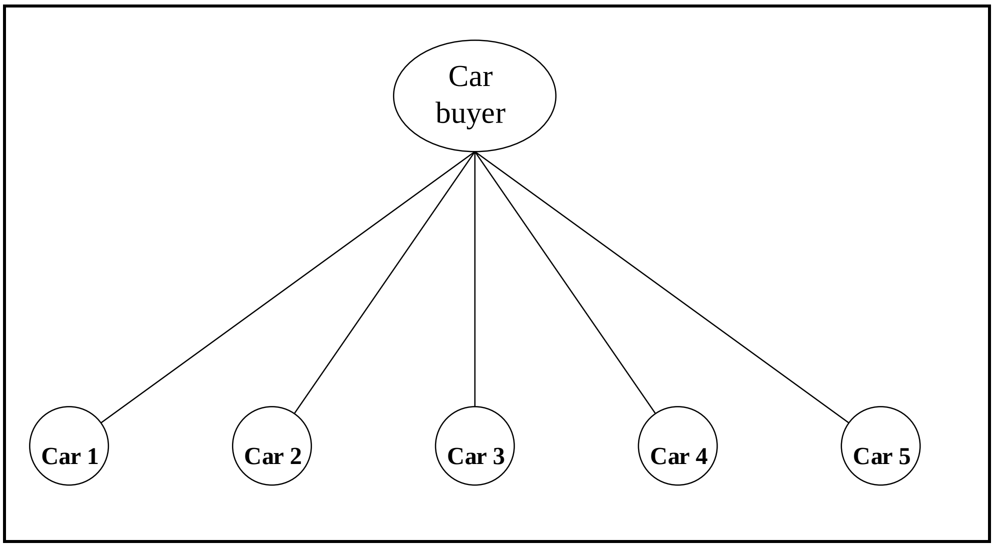
	Low Income	Medium income	High income	Total
Single female	2173	6055	109	8337
Single male	3044	7148	180	10372
Female living with parents	747	632	21	1400
Male living with parents	3705	2204	69	5978
Couple without children (female buyer)	3618	7901	707	12226
Couple without children (male buyer)	11233	22277	1513	35023
Couple with children (female buyer)	3618	7901	707	12226
Couple with children (male buyer)	3149	22071	1419	26639
Total	31287	76189	4725	112201

Furthermore car buyers aged 18 to 29 have special preferences for acceleration. Therefore these individuals have their own parameter for acceleration.

The approach is a discrete choice model implemented as a logit model.

In the logit model the consumer faces a number of possible choices as illustrated in Figure A.1 for a situation with five alternative choices.

Figure A.1 Logit model choice structure



With each alternative there is associated a utility function.

$V_i = \beta_1 * C_{1i} + \beta_2 * C_{2i} + ...$ (Utility function)

Where V_i is the utility of alternative i and β is the parameters and C is the characteristics of the car.

The deterministic part contains explanatory variables pertaining to the consumer and to the choice. The stochastic part of the utility function can be interpreted as representing the unobserved factors that influences the consumer's utility of each alternative.

The consumer is assumed to make the choice associated with the highest utility. Since the utility function for each choice contains an unknown stochastic component, the logit model states the probability that a given choice is made. The probability for choosing car *i* is based on the observed explanatory variables.

$$P(i) = \frac{e^{V_i}}{\sum_{i \in I} e^{V_i}} \qquad \text{(Simple logit)}$$

$$P(i, j) = P(j) * P(i \mid j) \qquad \text{(Nested logit)}$$

$$= \frac{e^{\theta \log \sum_{i \in J} e^{V_i}}}{\sum_{j \in J} e^{\theta \log \sum_{i \in J} e^{V_i}}} * \frac{e^{V_i}}{\sum_{i \in J} e^{V_i}}$$

The parameters of the utility functions (the β‘s have been estimated using standard maximum likelihood technique.

To estimate the parameters in the model each agent has been given a random set of alternative cars to choose from (63 cars for each choice). The estimation procedure then estimates the set of parameters to the utility functions that gives the highest utility to the car that was actually chosen.

After the parameters are estimated it is straightforward to calculate the total demand for each car by first calculating the probabilities for this car for each agent and then sum up all individuals probabilities for the specific car, c.

A. 4 Company car model

The company car model has 6 “agents” (companies). The model distinguish between three aggregate sectors:

- Agriculture, fishery and manufacturing industries (NACE[24] 1 – 2)
- Energy and construction (NACE 3 – 4)
- Service (NACE 5 – 9)

[24] Nomenclature generale des Activitiés économique dans les Communautes Européennes, Industrial Classification Code prepared by EU in 1970 and adopted by all Member States.

Each of these sectors is further divided into two, to take account of the fact that company car choice generally are determined in two ways:

- Companies where the company managers decide which cars to offer to the employee based on consideration regarding price and running cost.
- Companies where the employee decides which car to have based on considerations regarding his/her cost (benefit tax payments).

The company car model uses the same model approach as the private car choice model.

B. Sub-Group Members and other national contacts

Name	Country/institution[25]
Sub Group Members:	
Thor Karup (chairman) Lise Gottlieb	Denmark
Heikki Kuitunen	Finland
Gordo Jain	Germany
George Kounadis	Greece
Jean Kennedy	Ireland
Antonio Mattucci	Italy
Louis Zuidgeest	Netherlands
Jan Larsson	Sweden
Andrew Short	UK
John Turner	ACEA
Consultants	
Jørgen Jordal-Jørgensen Malene Sand Jespersen Anne Ohm	COWI COWI COWI
European Commission	
Karl-Heinz Zierock Anthony Zom Christos Liolios	DG-ENV DG-TAXUD DG-TAXUD
Other national contacts	
Alberto Cornejo Gerhard Gratt (Mr Pilz) Paula Mota P.E. de Beer Hugues Latteur Alain Bellot	Spain Austria Portugal France Belgium Luxembourg

[25] The table only includes national experts, ACEA members, regular participants from the Consultant and from the European Commission

C. Model validation

Parameter values

Figure 5.4 Length parameter estimates, log(length in cm)

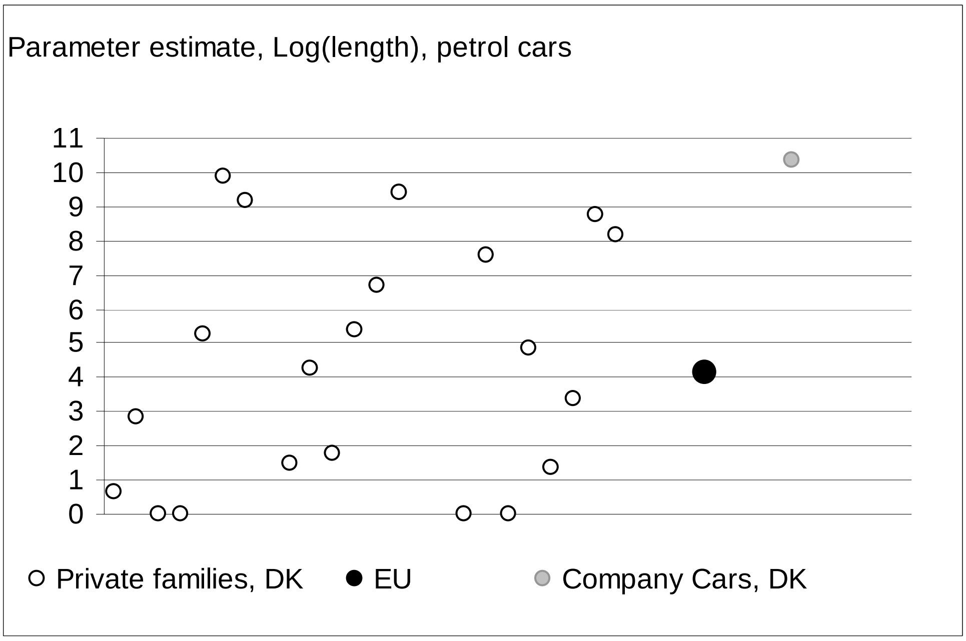


Figure 5.5 Luggage capacity parameter estimates, log(Liter)

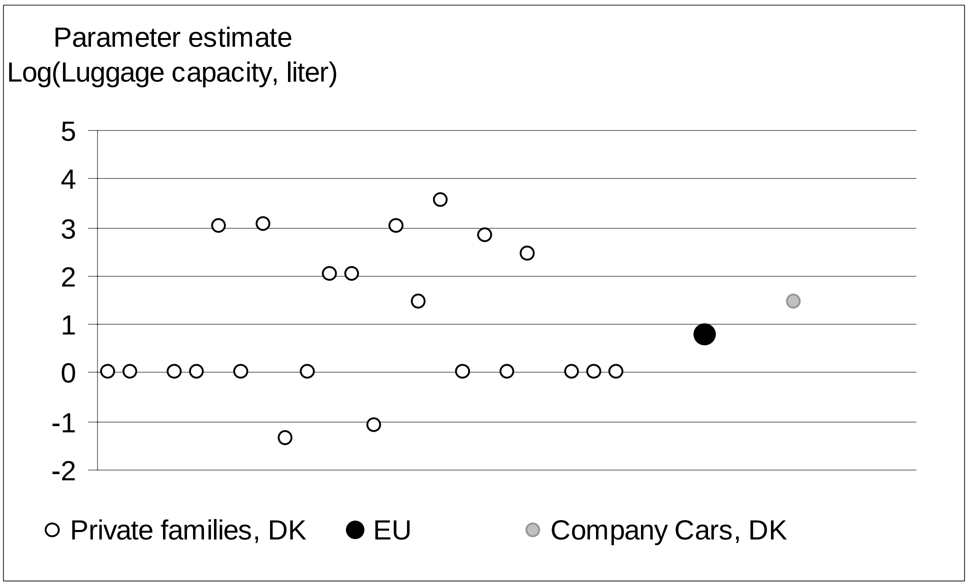
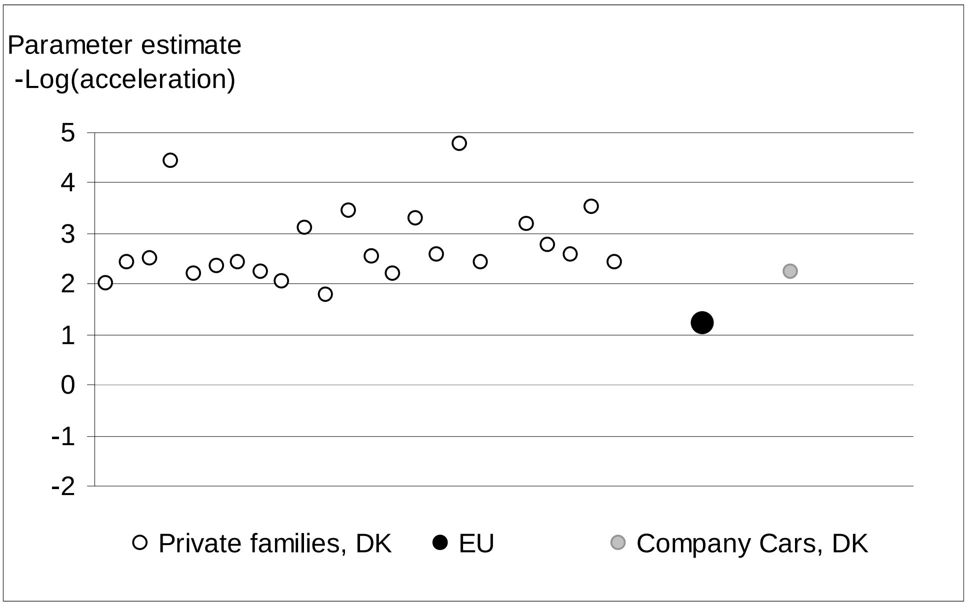


Figure 5.6 Acceleration parameter estimates, -log(sec. 0 - 100)



Model calculations compared with observed data
Petrol cars, Germany

Figure 5.7 Number of registrations as a function of CO_2 emissions for petrol cars in Germany (g per km)

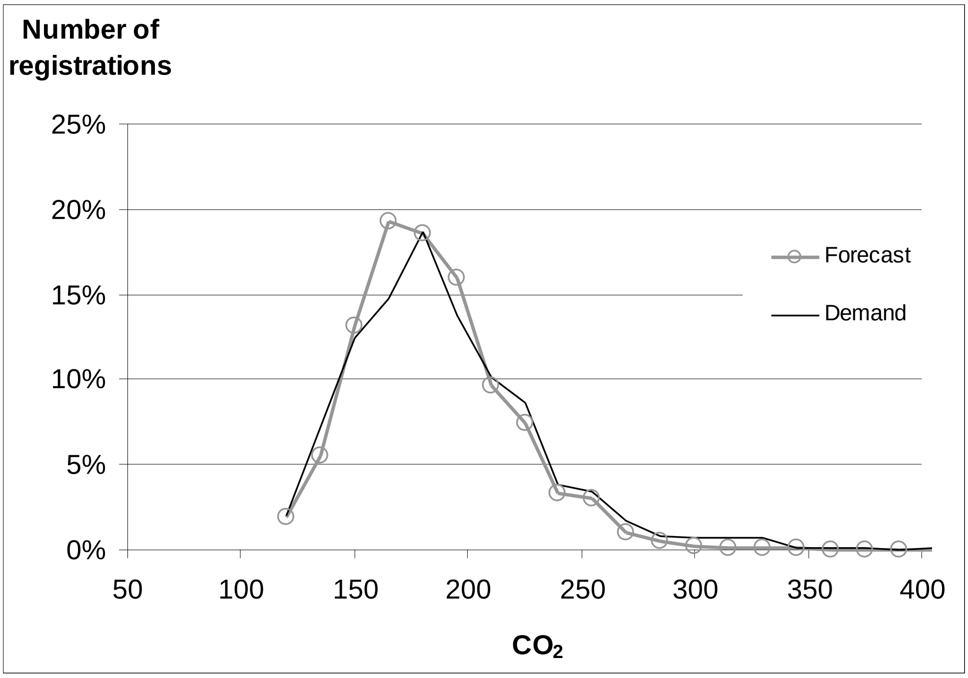


Figure 5.8 Number of registrations as a function of engine size volume (ccm) for petrol cars in Germany

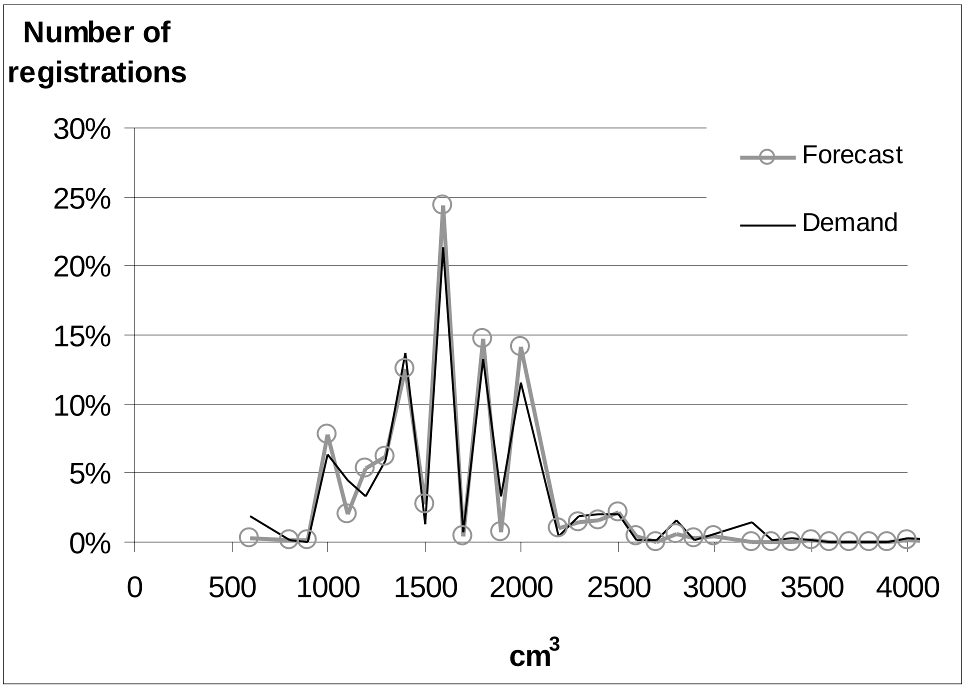
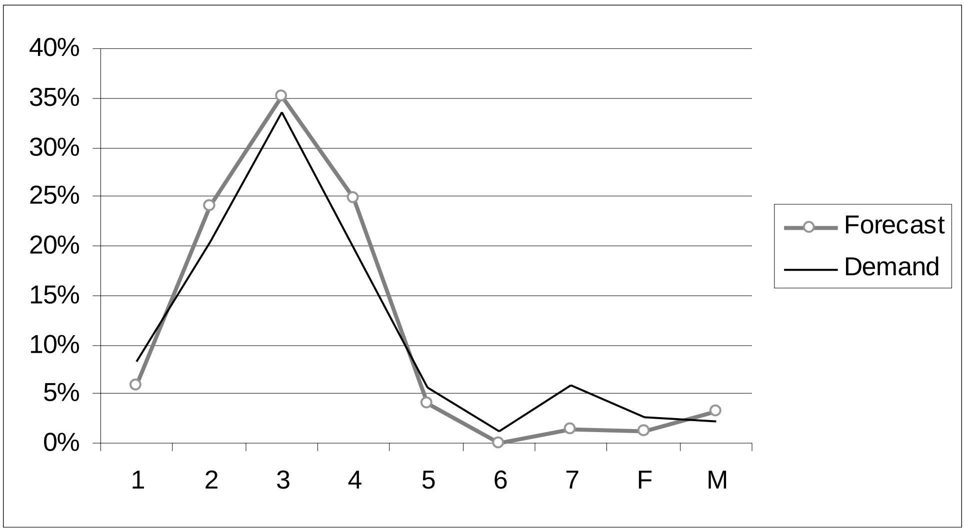


Figure 5.9 Number of registrations as a function of engine size class for petrol cars in Germany



Diesel cars, Germany

Figure 5.10 Number of registrations as a function of CO_2 emissions for diesel cars in Germany (g per km)

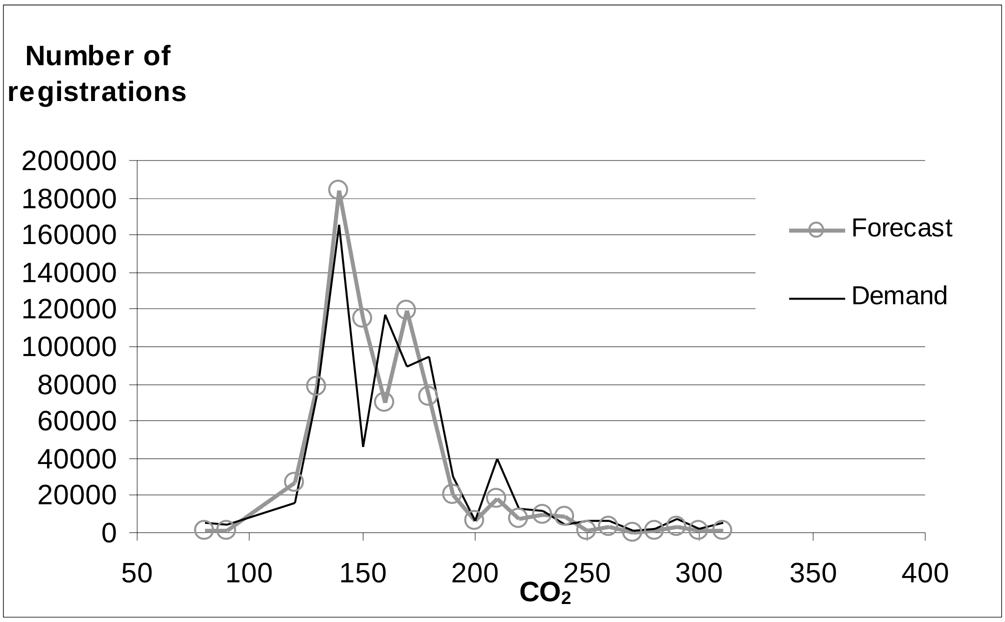


Figure 5.11 Number of registrations as a function of engine size volume (ccm) for petrol cars in Germany

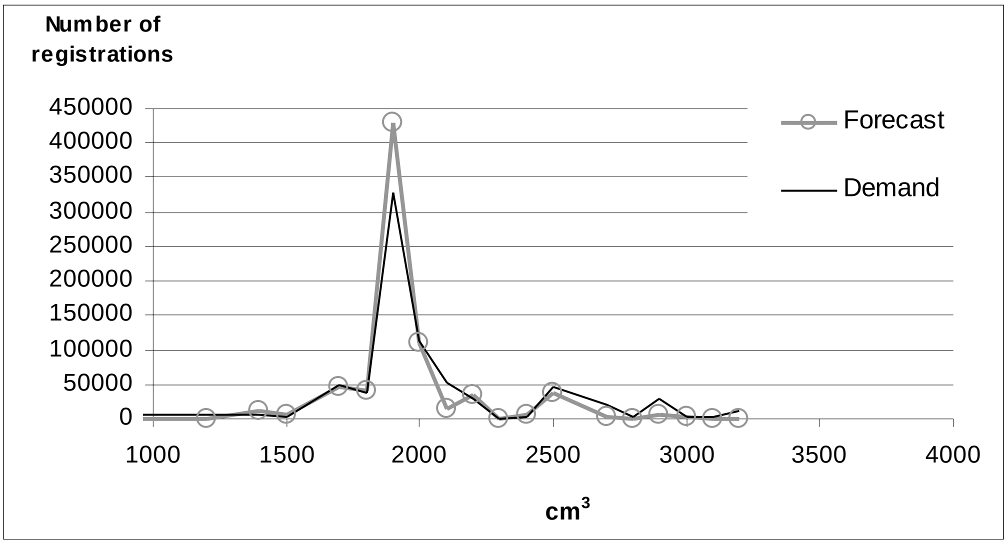
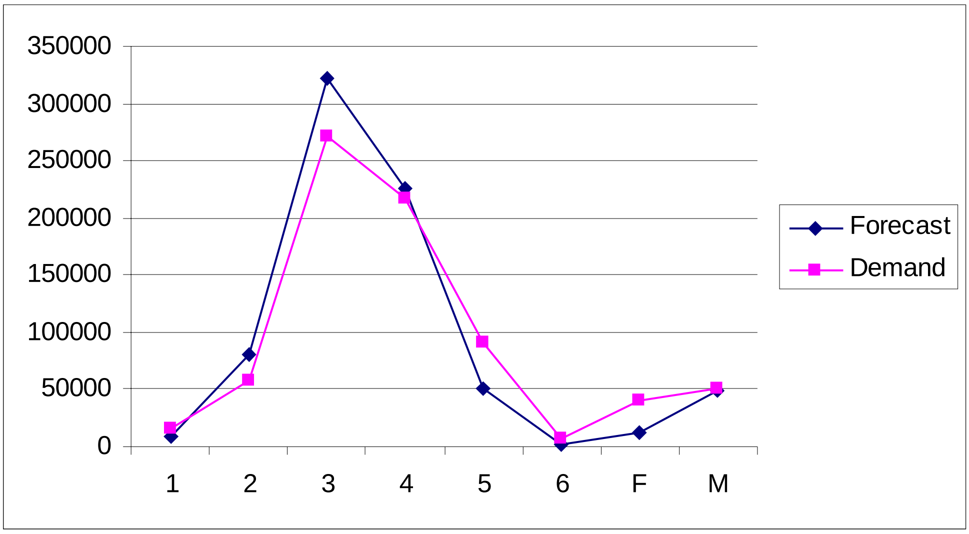


Figure 5.12 Number of registrations as a function of engine size class for diesel cars in Germany



Petrol cars, Denmark

Figure 5.13 Number of registrations as a function of CO_2 emissions for petrol cars in Denmark (g per km)

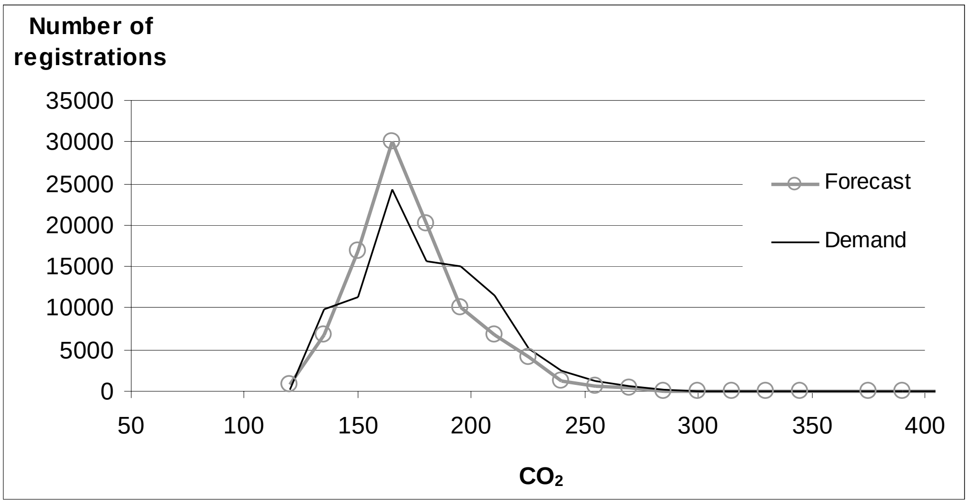


Figure 5.14 Number of registrations as a function of engine size volume (ccm) for petrol cars in Denmark

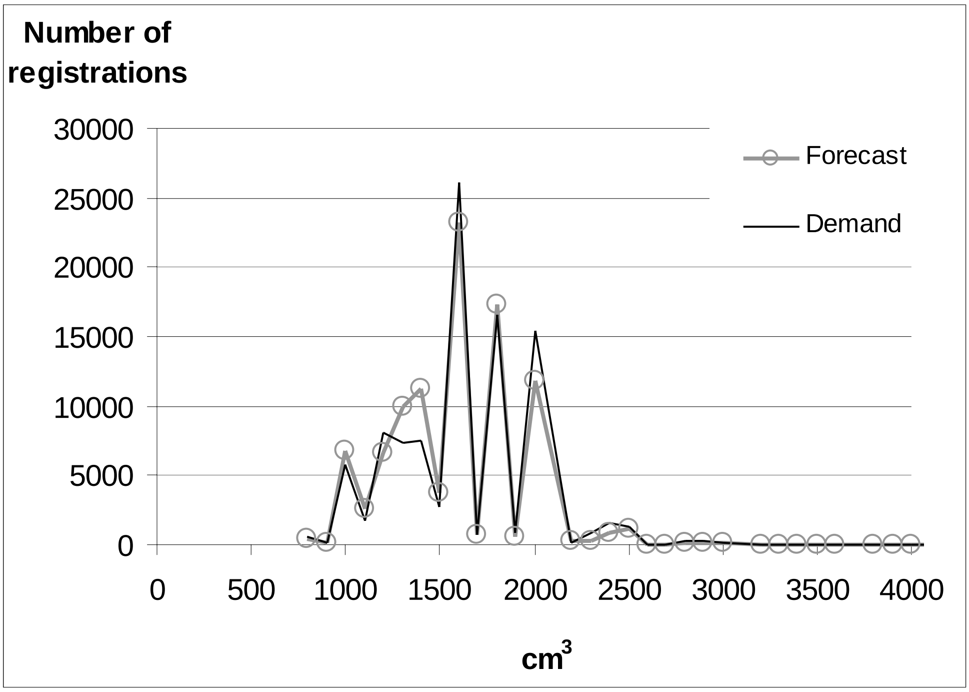
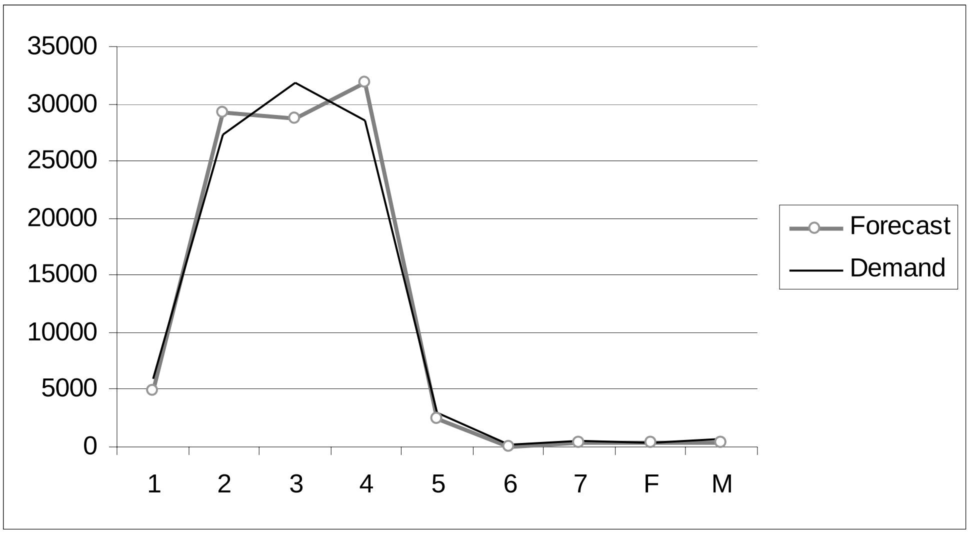


Figure 5.15 Number of registrations as a function of engine size class for petrol cars in Denmark



Diesel cars, Denmark

Figure 5.16 Number of registrations as a function of CO_2 emissions for diesel cars in Denmark (g per km)

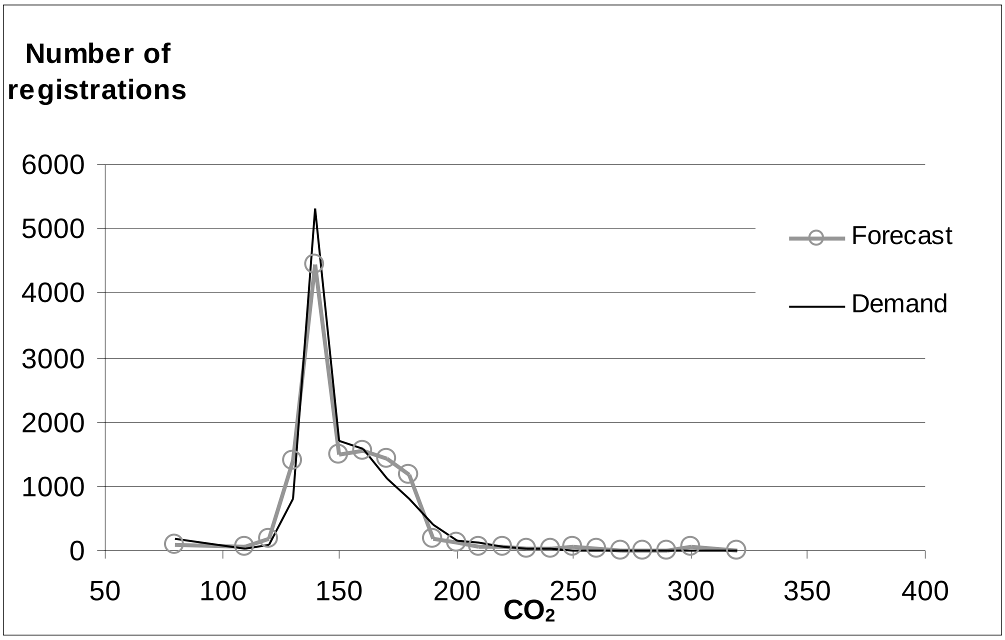


Figure 5.17 Number of registrations as a function of engine size volume (ccm) for diesel cars in Denmark

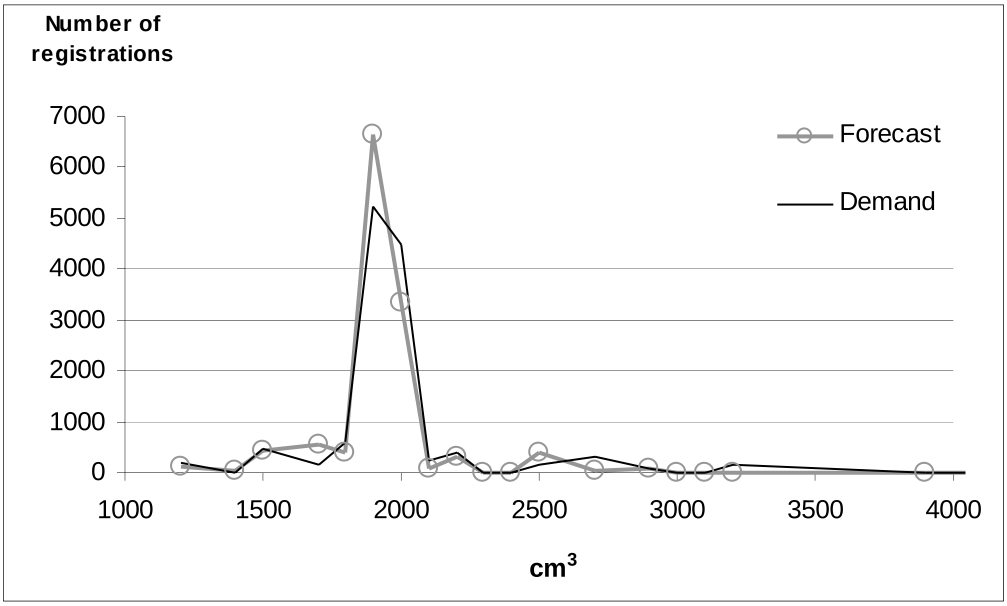


Figure 5.18 Number of registrations as a function of engine size class for diesel cars in Denmark

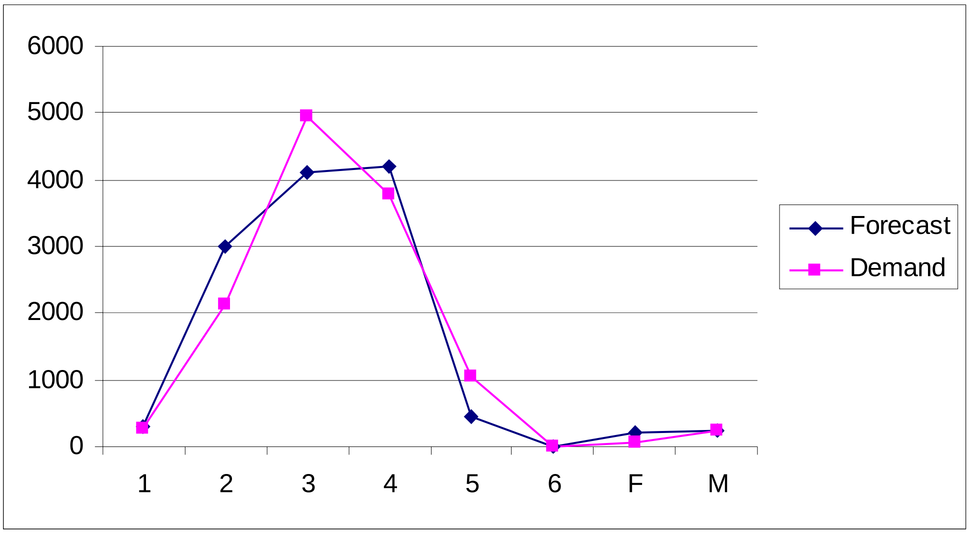


Table 5.19 Parameter values, privat car models

Socio group	Income	Log(price)	EUR /100km	Log(Length)	Lower medium	Upper medium	Log(Luggage capacity)	-LOG(Acceleration)	-LOG(Acceleration) age 10-29	Home market
Single female	Low	-3.681072	-0.5003133	0.6688492	0	0	0	2.017302	2.272791	1.073
Single male	Low	-3.344913	-0.2179292	2.831917	0	-0.1194194	0	2.443413	1.565678	1.073
Female living with parents	Low	-3.123343	-0.5019507	0	0	0	-4.494091	2.509464	0	1.073
Male living with parents	Low	-2.918457	-0.2526308	0	-0.2528312	0	0	4.443167	0	1.073
Couple without children (female buyer)	Low	-4.601463	-0.3132364	5.281321	-0.2036553	-0.2468095	0	2.185326	2.410201	1.073
Couple with children (female buyer)	Low	-4.311502	-0.4112274	9.848043	-0.665926	-0.4277391	3.03019	2.341922	-1.896978	1.073
Couple without children (male buyer)	Low	-4.257321	-0.3938955	9.185479	-0.2874441	-0.2530148	0	2.425613	1.435636	1.073
Couple with children (male buyer)	Low	-3.918205	-0.3456389	11.77293	-0.6555912	-0.2726159	3.065146	2.219755	-1.01218	1.073
Single female	Medium	-4.156333	-0.3974561	1.507084	-0.3194857	-0.3183673	-1.37137	2.032662	3.28691	1.073
Single male	Medium	-3.147771	-0.2861134	4.258919	0	-0.1593341	0	3.091352	2.493744	1.073
Female living with parents	Medium	-3.014497	-0.3812928	1.782464	0	0	2.017379	1.796473	1.542384	1.073
Male living with parents	Medium	-2.854821	-0.3328474	5.407728	0	-0.2289288	2.047119	3.464879	0.8062032	1.073
Couple without children (female buyer)	Medium	-3.200376	-0.4468239	6.681251	-0.1805938	-0.1543565	-1.097528	2.530581	0.7735574	1.073
Couple with children (female buyer)	Medium	-3.887113	-0.3827205	9.397603	-0.3221199	-0.4123921	3.037826	2.186116	-0.9545073	1.073
Couple without children (male buyer)	Medium	-3.249307	-0.4424095	11.69086	-0.1441058	-0.2799526	1.472198	3.304444	0	1.073
Couple with children (male buyer)	Medium	-3.64373	-0.4134923	14.17298	-0.1635534	-0.3845342	3.537927	2.596306	-0.8187477	1.073
Single female	High	-2.250488	0	0	0	0	0	4.785141	0	1.073
Single male	High	-1.046699	-0.293283	7.567457	0	-0.6802249	2.850425	2.437744	0	1.073
Female living with parents	High	-4.796304	-0.2342488	0	0	0	0	6.123727	0	1.073
Male living with parents	High	-2.148932	-0.2769433	4.860999	0	-0.4725064	2.443231	3.170856	0	1.073
Couple without children (female buyer)	High	-1.011549	-0.4430838	1.341725	0	-0.2702588	-5.158028	2.771955	0	1.073
Couple with children (female buyer)	High	-1.809964	-0.287518	3.38312	-0.4568296	-0.7040053	0	2.588287	0	1.073
Couple without children (male buyer)	High	-1.220896	-0.3344522	8.728763	-0.429782	-0.728257	0	3.507137	0	1.073
Couple with children (male buyer)	High	-1.36189	-0.2686632	8.148526	-0.9043017	-0.8315611	0	2.414329	0	1.073

Table 5.20 Parameter values, company car model

Parameter name	Parameter value
Log(price)	-1.406425
EUR per 100 km	-0.457251
Log(Length)	10.33004
Lower medium	-0.334255
Upper medium	-0.5471
Log(Luggage capacity)	1.49342
-LOG(Acceleration)	2.265564
Privatcost/Taxcost	0.307905

D. The boundary conditions

This chapter gives a short description of how the boundary conditions are implemented in the model calculations in practical terms.

Budget neutrality
The indicator of budget neutrality is the average tax per new registered car. The average tax includes revenue effects from circulation tax, registration tax including possible CO_2 tax incentives and fuel tax. The budget neutrality condition relates to the long run and therefore the indicator includes the circulation tax revenue and the fuel tax revenue for the entire lifetime of the vehicles.

VAT will not be included in the budget neutrality assessment, since VAT is a general tax on consumption. VAT will however - as hitherto assumed - be included in the cost assumptions in the model.

Diesel share
The indicator of the diesel share is percentage of new registered cars that are diesel fuelled. The diesel share to be kept constant is the present diesel share (1999/2000).

Table 5.21 Diesel share in the Member States 1999/2000

Country	Diesel share of new registered vehicles 1999/2000
Austria	57.5
Belgium	54.5
Denmark	10.6
France	44.4
Finland	7.4
Germany	21.2
Greece	0.8
Ireland	12.3
Italy	29.3
Luxembourg	42.0
Netherlands	22.9
Portugal	22.6
Spain	51.5
Sweden	7.1
UK	13.9

Estimations will however be undertaken of the implications for the resulting CO_2 reductions from doubling of the diesel share - applying however an upper limit of 50%.

Down sizing

The indicator of downsizing is the average size of the registered cars. The average size is measured by assigning a value to each category according to the Marketing Systems segmentation of passenger cars. These values are shown in the table below.

Table 5.22 Size values of Marketing Systems categories

Car category	Size value
Mini	1
Small	2
Lower medium	3
Medium	4
Upper medium	5
Luxury	6
Sport	5
Off-road	5
MPV<4.70m	4
MPV>4,70m	5

If we had ten small cars and 20 upper medium cars the average size would be

(2*10 + 5*20) / (10+20) = 4.

Now suppose 5 of the upper medium cars where downgraded to be medium cars then the average would be

(2*10+4*5+5*15)/(10+5+15)=3.83 which is smaller than what we had before.

E. Model Results

Petrol cars, Belgium	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-3.7%	-3.7%	-4.3%	-4.0%	-4.6%	-5.2%	-5.4%
Average lifetime tax revenue (EUR per car)	7,845	6,812	7,845	7,845	7,845	7,845	7,845	7,845	7,845
Average size	2.78	2.98	2.80	2.78	2.79	2.78	2.78	2.78	2.78
Average registration tax (EUR per car)	208	277	1,891	153	1,786	197	1,860	275	323
Average Circulation tax (EUR per car per year)	177	200	163	313	174	310	169	307	304
Average dealers price, EUR excl. VAT	12,246	14,646	12,910	12,878	13,260	13,256	13,084	13,436	13,478
Average (lifetime) tax consists of									
Registration tax	208	277	1,891	153	1,786	197	1,860	275	323
Circulation tax (whole life time)	2,054	2,316	1,893	3,629	2,018	3,596	1,959	3,563	3,522
Fuel tax	5,583	4,218	4,061	4,063	4,040	4,052	4,025	4,007	4,000

Diesel cars, Belgium	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-1.5%	-1.3%	-2.5%	-2.0%	-2.7%	-3.4%	-4.8%
Average lifetime tax revenue (EUR per car)	9,916	9,039	9,916	9,916	9,916	9,916	9,916	9,916	9,913
Average size	3.42	3.49	3.42	3.42	3.42	3.42	3.42	3.42	3.42
Average registration tax (EUR per car)	291	313	1,563	275	1,418	287	1,458	309	3,287
Average Circulation tax (EUR per car per year)	384	395	369	479	384	480	382	483	231
Average dealers price, EUR excl. VAT	15,692	16,962	16,437	16,388	16,699	16,554	16,637	16,672	16,901
Average (lifetime) tax consists of									
Registration tax	291	313	1,563	275	1,418	287	1,458	309	3,287
Circulation tax (whole life time)	4,456	4,588	4,280	5,559	4,459	5,570	4,429	5,606	2,678
Fuel tax (whole life time)	5,168	4,138	4,073	4,081	4,039	4,059	4,029	4,001	3,948

Petrol cars, Denmark	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-3,6%	-5,8%	-4,9%	-5,4%	-8,5%	-5,9%	-8,6%
Average lifetime tax revenue (EUR per car)	29.286	29.875	29.286	29.286	29.286	29.286	29.286	29.286	29.286
Average size	2,98	3,22	2,98	2,98	2,98	2,98	2,98	2,98	2,98
Average registration tax (EUR per car)	16.025	20.713	20.702	17.938	20.816	18.330	21.334	18.026	21.113
Average Circulation tax (EUR per car per year)	404	227	197	449	193	411	168	440	188
Average dealers price, EUR excl. VAT	8.898	10.858	9.858	9.701	10.287	9.865	10.583	9.738	10.460
Average (lifetime) tax consists of									
Registration tax	16.025	20.713	20.702	17.938	20.816	18.330	21.334	18.026	21.113
Circulation tax (whole life time)	4.690	2.628	2.290	5.207	2.244	4.773	1.950	5.104	2.177
Fuel tax (whole life time)	8,572	6,534	6,294	6,141	6,225	6,183	6,002	6,156	5,996

Diesel cars, Denmark	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-1,0%	-2,3%	-1,6%	-1,9%	-7,6%	-1,8%	-7,7%
Average lifetime tax revenue (EUR per car)	34.753	34.813	34.753	34.753	34.753	34.753	34.753	34.753	34.752
Average size	3,29	3,37	3,29	3,29	3,29	3,29	3,29	3,29	3,29
Average registration tax (EUR per car)	22.530	25.610	25.662	24.169	25.784	24.346	26.835	24.167	25.324
Average Circulation tax (EUR per car per year)	574	403	396	536	389	513	323	525	451
Average dealers price, EUR excl. VAT	11.615	12.914	11.986	12.317	12.738	12.390	14.543	12.313	14.215
Average (lifetime) tax consists of									
Registration tax	22.530	25.610	25.662	24.169	25.784	24.346	26.835	24.167	25.324
Circulation tax (whole life time)	6.655	4.673	4.592	6.218	4.508	5.949	3.751	6.086	5.231
Fuel tax (whole life time)	5.567	4.530	4.498	4.365	4.461	4.458	4.166	4.500	4.197

Petrol cars, Finland	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-2,6%		-2,9%	-3,2%	-4,1%	-3,4%	-4,1%
Average lifetime tax revenue (EUR per car)	13.539	12.119	13.539		13.539	13.539	13.539	13.539	13.548
Average size	3,26	3,40	3,26		3,26	3,26	3,26	3,26	3,26
Average registration tax (EUR per car)	7.863	7.535	9.040		9.046	7.034	9.081	6.999	9.086
Average Circulation tax (EUR per car per year)	118	118	118		118	292	118	295	118
Average dealers price, EUR excl. VAT	10.857	12.747	11.744		12.215	11.900	12.140	11.840	12.132
Average (lifetime) tax consists of									
Registration tax	7.863	7.535	9.040		9.046	7.034	9.081	6.999	9.086
Circulation tax (whole life time)	1.369	1.369	1.369		1.366	3.389	1.366	3.428	1.371
Fuel tax (whole life time)	4.307	3.216	3.130		3.127	3.116	3.092	3.112	3.091

Diesel cars, Finland	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-1,3%	-1,7%	-2,1%	-2,5%	-6,1%	-4,3%	-7,0%
Average lifetime tax revenue (EUR per car)	19.920	20.376	19.920	19.920	19.920	19.920	19.920	19.920	19.920
Average size	3,45	3,53	3,45	3,45	3,45	3,45	3,45	3,45	3,45
Average registration tax (EUR per car)	10.410	11.326	10.977	10.971	10.991	10.996	11.116	10.979	10.260
Average Circulation tax (EUR per car per year)	572	579	572	573	573	573	570	578	646
Average dealers price, EUR excl. VAT	14.374	15.638	14.958	15.149	15.266	15.183	15.407	15.159	15.365
Average (lifetime) tax consists of									
Registration tax	10.410	11.326	10.977	10.971	10.991	10.996	11.116	10.979	10.260
Circulation tax (whole life time)	6.632	6.715	6.638	6.652	6.643	6.646	6.613	6.708	7.492
Fuel tax (whole life time)	2.878	2.335	2.305	2.297	2.285	2.277	2.191	2.234	2.168

Petrol cars, Germany	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registration	Circulation	Registration	Circulation	Registration	Circulation	Combination
CO2 effect				-5,1%		-5,0%		-5,5%	-5,5%
Average lifetime tax revenue (EUR per car)	6.950	5.625		6.950		6.950		6.950	6.950
Average size	3,18	3,40		3,18		3,18		3,18	3,18
Average registration tax (EUR per car)	-3	-		-		-		-	-
Average Circulation tax (EUR per car per year)	88	97		231		230		232	232
Average dealers price, EUR excl. VAT	16.863	20.130		17.227		17.900		17.649	17.649
Average (lifetime) tax consists of									
Registration tax	-3	-		-		-		-	-
Circulation tax (whole life time)	1.016	1.121		2.678		2.666		2.689	2.689
Fuel tax (whole life time)	5.937	4.503		4.272		4.284		4.261	4.261

Diesel cars, Germany	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-1,8%		-2,4%		-3,4%	-2,8%
Average lifetime tax revenue (EUR per car)	7.845	7.409		7.845		7.845		7.845	7.845
Average size	3,62	3,70		3,62		3,62		3,62	3,62
Average registration tax (EUR per car)	-11	-6		-6		-8		-6	-208
Average Circulation tax (EUR per car per year)	282	321		364		366		369	384
Average dealers price, EUR excl. VAT	19.985	21.419		20.710		20.914		20.973	21.087
Average (lifetime) tax consists of									
Registration tax	-11	-6		-6		-8		-6	-208
Circulation tax (whole life time)	3.273	3.720		4.225		4.245		4.280	4.459
Fuel tax (whole life time)	4.583	3.695		3.627		3.608		3.571	3.594

Petrol cars, Italy	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registration	Circulation	Registration	Circulation	Registration	Circulation	Combination
CO2 effect				-3,3%	-3,0%	-3,6%	-1,3%	-4,3%	-4,4%
Average lifetime tax revenue (EUR per car)	5.696	4.917		5.696	5.696	5.696	5.696	5.696	5.696
Average size	2,28	2,46		2,28	2,29	2,28	2,39	2,28	2,28
Average registration tax (EUR per car)	151	151		151	1.135	151	1.007	151	867
Average Circulation tax (EUR per car per year)	151	163		239	153	239	160	241	180
Average dealers price, EUR excl. VAT	10.421	12.537		10.987	11.726	11.399	12.334	11.281	11.412
Average (lifetime) tax consists of									
Registration tax	151	151		151	1.135	151	1.007	151	867
Circulation tax (whole life time)	1.752	1.896		2.769	1.778	2.778	1.856	2.797	2.084
Fuel tax (whole life time)	3.794	2.870		2.776	2.784	2.767	2.834	2.749	2.745

Diesel cars, Italy	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-1,2%	-3,0%	-2,7%	-2,9%	-3,7%	-3,9%
Average lifetime tax revenue (EUR per car)	6.545	5.788		6.545	6.545	6.545	6.545	6.545	6.545
Average size	3,32	3,41		3,32	3,32	3,32	3,32	3,32	3,32
Average registration tax (EUR per car)	151	151		151	1.036	151	1.035	151	923
Average Circulation tax (EUR per car per year)	190	193		262	191	266	191	269	203
Average dealers price, EUR excl. VAT	16.263	17.655		16.776	17.240	17.137	17.235	17.243	17.336
Average (lifetime) tax consists of									
Registration tax	151	151		151	1.036	151	1.035	151	923
Circulation tax (whole life time)	2.200	2.238		3.036	2.215	3.090	2.213	3.126	2.359
Fuel tax (whole life time)	4.195	3.400		3.358	3.295	3.304	3.298	3.269	3.263

Petrol cars, Netherlands	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-4,4%	-4,3%	-3,9%	-4,7%	-5,9%	-6,5%	-7,4%
Average lifetime tax revenue (EUR per car)	16.661	16.370	16.661	16.661	16.661	16.661	16.661	16.661	16.661
Average size	2,82	3,05	2,82	2,82	2,82	2,82	2,82	2,82	2,82
Average registration tax (EUR per car)	3.726	4.893	5.910	4.135	5.823	4.189	5.983	4.005	4.629
Average Circulation tax (EUR per car per year)	433	471	431	584	436	581	432	606	556
Average dealers price, EUR excl. VAT	11.293	13.798	11.937	12.170	12.955	12.287	12.407	11.892	12.065
Average (lifetime) tax consists of									
Registration tax	3.726	4.893	5.910	4.135	5.823	4.189	5.983	4.005	4.629
Circulation tax (whole life time)	5.022	5.464	5.004	6.772	5.057	6.742	5.015	7.029	6.452
Fuel tax (whole life time)	7.914	6.013	5.747	5.754	5.781	5.730	5.663	5.628	5.581

Diesel cars, Netherlands	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-1,2%	-1,4%	-1,7%	-1,9%	-4,2%	-4,3%	-5,8%
Average lifetime tax revenue (EUR per car)	23.248	23.875	23.248	23.084	23.248	23.248	23.248	23.248	23.248
Average size	3,43	3,50	3,43	3,43	3,43	3,43	3,43	3,43	3,43
Average registration tax (EUR per car)	6.032	7.555	7.212	7.304	7.207	7.327	7.379	7.233	6.554
Average Circulation tax (EUR per car per year)	986	1.005	986	965	988	979	984	997	1.062
Average dealers price, EUR excl. VAT	14.180	15.500	14.819	14.962	15.162	15.010	15.239	14.808	15.097
Average (lifetime) tax consists of									
Registration tax	6.032	7.555	7.212	7.304	7.207	7.327	7.379	7.233	6.554
Circulation tax (whole life time)	11.443	11.661	11.436	11.189	11.466	11.355	11.412	11.567	12.319
Fuel tax (whole life time)	5.774	4.659	4.600	4.591	4.576	4.566	4.458	4.449	4.375

Petrol cars, Portugal	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-1,5%	-1,7%	-2,0%	-1,9%	-2,8%	-2,1%	-2,9%
Average lifetime tax revenue (EUR per car)	5.348	4.987	5.348	5.348	5.348	5.348	5.348	5.348	5.348
Average size	2,54	2,63	2,54	2,54	2,54	2,54	2,54	2,54	2,54
Average registration tax (EUR per car)	2.236	2.534	2.955	2.254	2.955	2.327	2.971	2.305	2.868
Average Circulation tax (EUR per car per year)	35	37	34	95	35	89	35	91	44
Average dealers price, EUR excl. VAT	10.568	12.120	11.675	11.393	11.787	11.582	11.643	11.503	11.640
Average (lifetime) tax consists of									
Registration tax	2.236	2.534	2.955	2.254	2.955	2.327	2.971	2.305	2.868
Circulation tax (whole life time)	401	427	397	1.102	405	1.032	404	1.059	510
Fuel tax (whole life time)	2.712	2.026	1.997	1.992	1.988	1.989	1.973	1.985	1.970

Diesel cars, Portugal	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect			-3,0%	-2,6%	-2,4%	-2,7%	-4,5%	-3,2%	-4,6%
Average lifetime tax revenue (EUR per car)	9.200	9.316	9.200	9.200	9.200	9.200	9.200	9.200	9.200
Average size	3,67	3,76	3,67	3,67	3,67	3,67	3,67	3,67	3,67
Average registration tax (EUR per car)	6.583	7.136	7.102	6.741	7.077	6.909	7.111	6.898	7.095
Average Circulation tax (EUR per car per year)	31	32	30	60	31	46	31	48	33
Average dealers price, EUR excl. VAT	15.950	16.928	16.766	16.554	17.049	17.013	17.870	17.163	17.992
Average (lifetime) tax consists of									
Registration tax	6.583	7.136	7.102	6.741	7.077	6.909	7.111	6.898	7.095
Circulation tax (whole life time)	355	369	345	698	359	533	363	553	381
Fuel tax (whole life time)	2.262	1.811	1.753	1.761	1.764	1.758	1.726	1.749	1.725

Petrol cars, Sweden	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-2,2%		-3,1%		-3,9%	-3,8%
Average lifetime tax revenue (EUR per car)	7.814	6.299		7.814		7.814		7.814	7.814
Average size	3,69	3,83		3,69		3,69		3,69	3,69
Average registration tax (EUR per car)	-	-		-		-		-	-45
Average Circulation tax (EUR per car per year)	150	155		294		297		300	303
Average dealers price, EUR excl. VAT	16.263	18.325		17.416		17.339		17.170	17.204
Average (lifetime) tax consists of									
Registration tax	-	-		-		-		-	-45
Circulation tax (whole life time)	1.735	1.797		3.409		3.443		3.478	3.519
Fuel tax (whole life time)	6.079	4.503		4.405		4.371		4.336	4.341

Diesel cars, Sweden	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-4,5%		-4,3%		-4,4%	-4,2%
Average lifetime tax revenue (EUR per car)	12.248	9.887		12.248		12.248		12.248	12.248
Average size	3,60	3,73		3,60		3,60		3,60	3,60
Average registration tax (EUR per car)	-	-		-		-		-	-102
Average Circulation tax (EUR per car per year)	236	182		415		414		415	422
Average dealers price, EUR excl. VAT	22.357	24.511		23.297		23.360		23.322	23.371
Average (lifetime) tax consists of									
Registration tax	-	-		-		-		-	-102
Circulation tax (whole life time)	2.738	2.117		4.817		4.801		4.811	4.901
Fuel tax (whole life time)	9.510	7.770		7.431		7.448		7.437	7.450

Petrol cars, UK	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-4,9%		-4,6%		-4,7%	-4,6%
Average lifetime tax revenue (EUR per car)	11.824	8.869		11.824		11.824		11.824	11.827
Average size	3,10	3,30		3,10		3,10		3,10	3,10
Average registration tax (EUR per car)	-	-		-		-		-	-93
Average Circulation tax (EUR per car per year)	231	167		451		449		450	458
Average dealers price, EUR excl. VAT	18.607	21.755		19.553		19.695		19.616	19.697
Average (lifetime) tax consists of									
Registration tax	-	-		-		-		-	-93
Circulation tax (whole life time)	2.676	1.942		5.233		5.212		5.224	5.312
Fuel tax (whole life time)	9.148	6.927		6.590		6.612		6.600	6.608

Diesel cars, UK	Base	Base	Increase progression		Add CO2 element		CO2 taxes		
	1999/2008	2008	Registra-tion	Circulation	Registra-tion	Circulation	Registra-tion	Circulation	Combina-tion
CO2 effect				-4,5%		-4,3%		-4,4%	-4,2%
Average lifetime tax revenue (EUR per car)	12.248	9.887		12.248		12.248		12.248	12.248
Average size	3,60	3,73		3,60		3,60		3,60	3,60
Average registration tax (EUR per car)	-	-		-		-		-	-102
Average Circulation tax (EUR per car per year)	236	182		415		414		415	422
Average dealers price, EUR excl. VAT	22.357	24.511		23.297		23.360		23.322	23.371
Average (lifetime) tax consists of									
Registration tax	-	-		-		-		-	-102
Circulation tax (whole life time)	2.738	2.117		4.817		4.801		4.811	4.901
Fuel tax (whole life time)	9.510	7.770		7.431		7.448		7.437	7.450

F. Sensitivity analyses - results

Petrol, Germany	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-1,4%			-5,1%	-5,2%				-5,0%	-4,9%	-4,9%
Average lifetime tax revenue (EUR per car)	6.950	5.625	6.642			6.950	6.950				6.950	5.299	5.302
Average size	3,18	3,40	3,34			3,18	3,18				3,18	3,18	3,18
							0						
Average registration tax (EUR per car)	- 3	-	0			0	0				0	0	0
Average Circulation tax (EUR per car per year)	88	97	94			231	139				230	87	88
Average producers price, EUR excl. VAT	16.863	20.130	19.459			17.227	17.253				17.900	17.917	17.918
Average (lifetime) tax consists of							0						
Registration tax	- 3	-	0			0	0				0	0	0
Circulation tax (whole life time)	1.016	1.121	1.094			2.678	1.615				2.666	1.013	1.016
Fuel tax (whole life time)	5.937	4.503	5.548			4.272	5.335				4.284	4.286	4.286

Diesel, Germany	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO_2 effect			-0,7%			-1,8%	-2,0%				-2,4%	-2,3%	-2,3%
Average lifetime tax revenue (EUR per car)	7.845	7.409	8.281			7.845	7.846				7.845	6.873	6.875
Average size	3,62	3,70	3,68			3,62	3,62				3,62	3,62	3,62
							0						
Average registration tax (EUR per car)	- 11	- 6	-6			-6	-7				-8	-8	-8
Average Circulation tax (EUR per car per year)	282	321	319			364	287				366	282	282
Average producers price, EUR excl. VAT	19.985	21.419	21.286			20.710	20.743				20.914	20.914	20.914
Average (lifetime) tax consists of													
Registration tax	- 11	- 6	-6			-6	-7				-8	-8	-8
Circulation tax (whole life time)	3.273	3.720	3.701			4.225	3.329				4.245	3.270	3.273
Fuel tax (whole life time)	4.583	3.695	4.586			3.627	4.523				3.608	3.610	3.610

Petrol, Belgium	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,9%	-3,7%	-2,2%	-3,7%	-3,8%	-4,3%		-0,3%	-4,0%	-4,0%	-4,0%
Average lifetime tax revenue (EUR per car)	7.845	6.812	7.722	7.845	7.845	7.845	7.845	7.845		6.692	7.845	6.313	6.302
Average size	2,78	2,98	2,94	2,80	2,88	2,78	2,78	2,79		2,98	2,78	2,78	2,78
							0						
Average registration tax (EUR per car)	208	277	256	1.891	668	153	152	1.786		208	197	196	196
Average Circulation tax (EUR per car per year)	177	200	193	163	174	313	226	174		196	310	178	177
Average producers price, EUR excl. VAT	12.246	14.646	14.306	12.910	13.540	12.878	12.870	13.260		14.539	13.256	13.241	13.241
Average (lifetime) tax consists of													
Registration tax	208	277	256	1.891	668	153	152	1.786		208	197	196	196
Circulation tax (whole life time)	2.054	2.316	2.243	1.893	2.022	3.629	2.622	2.018		2.277	3.596	2.066	2.054
Fuel tax (whole life time)	5.583	4.218	5.222	4.061	5.155	4.063	5.071	4.040		4.207	4.052	4.052	4.052

Diesel, Belgium	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO_2 effect			-0,3%	-1,5%	-1,4%	-1,3%	-1,5%	-2,5%	-0,3%	-0,5%	-2,0%	-1,9%	-1,9%
Average lifetime tax revenue (EUR per car)	9.916	9.039	10.023	9.916	9.916	9.916	9.916	9.916	8.873	8.964	9.916	8.807	8.803
Average size	3,42	3,49	3,48	3,42	3,43	3,42	3,42	3,42	3,48	3,47	3,42	3,42	3,42
							0						
Average registration tax (EUR per car)	291	313	309	1.563	495	275	276	1.418	175	291	287	287	287
Average Circulation tax (EUR per car per year)	384	395	393	369	373	479	392	384	394	393	480	385	384
Average producers price, EUR excl. VAT	15.692	16.962	16.894	16.437	16.436	16.388	16.393	16.699	16.897	16.868	16.554	16.554	16.553
Average (lifetime) tax consists of													
Registration tax	291	313	309	1.563	495	275	276	1.418	175	291	287	287	287
Circulation tax (whole life time)	4.456	4.588	4.559	4.280	4.324	5.559	4.546	4.459	4.573	4.555	5.570	4.461	4.456
Fuel tax (whole life time)	5.168	4.138	5.155	4.073	5.097	4.081	5.094	4.039	4.125	4.117	4.059	4.059	4.059

Petrol, Denmark	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,8%	-3,6%	-3,9%	-5,8%	-5,9%	-4,9%	-4,5%	-4,1%	-5,4%	-6,1%	-5,4%
Average lifetime tax revenue (EUR per car)	29.286	29.875	27.310	29.286	29.286	29.286	29.286	29.286	26.960	24.587	29.286	26.854	29.193
Average size	2,98	3,22	3,19	2,98	2,98	2,98	2,98	2,98	2,98	2,98	2,98	2,98	2,98
							0						
Average registration tax (EUR per car)	16.025	20.713	16.659	20.702	19.186	17.938	17.905	20.816	18.449	16.025	18.330	17.976	18.321
Average Circulation tax (EUR per car per year)	404	227	220	197	195	449	320	193	195	198	411	236	404
Average producers price, EUR excl. VAT	8.898	10.858	10.696	9.858	9.798	9.701	9.688	10.287	10.234	10.175	9.865	9.718	9.861
Average (lifetime) tax consists of													
Registration tax	16.025	20.713	16.659	20.702	19.186	17.938	17.905	20.816	18.449	16.025	18.330	17.976	18.321
Circulation tax (whole life time)	4.690	2.628	2.552	2.290	2.259	5.207	3.710	2.244	2.265	2.291	4.773	2.738	4.689
Fuel tax (whole life time)	8.572	6.534	8.099	6.294	7.841	6.141	7.672	6.225	6.246	6.271	6.183	6.140	6.182

Diesel, Denmark	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,2%	-1,0%	-1,1%	-2,3%	-2,3%	-1,6%	-1,4%	-0,9%	-1,9%	-1,9%	-1,9%
Average lifetime tax revenue (EUR per car)	34.753	34.813	35.847	34.753	34.753	34.753	34.753	34.753	33.657	31.608	34.753	33.646	35.488
Average size	3,29	3,37	3,36	3,29	3,29	3,29	3,29	3,29	3,29	3,29	3,29	3,29	3,29
							0						
Average registration tax (EUR per car)	22.530	25.610	25.574	25.662	24.591	24.169	24.151	25.784	24.653	22.530	24.346	24.303	24.376
Average Circulation tax (EUR per car per year)	574	403	399	396	393	536	444	389	391	395	513	421	574
Average producers price, EUR excl. VAT	11.615	12.914	12.900	11.986	11.952	12.317	12.309	12.738	12.676	12.560	12.390	12.371	12.405
Average (lifetime) tax consists of													
Registration tax	22.530	25.610	25.574	25.662	24.591	24.169	24.151	25.784	24.653	22.530	24.346	24.303	24.376
Circulation tax (whole life time)	6.655	4.673	4.632	4.592	4.557	6.218	5.150	4.508	4.532	4.586	5.949	4.883	6.655
Fuel tax (whole life time)	5.567	4.530	5.641	4.498	5.605	4.365	5.452	4.461	4.471	4.492	4.458	4.460	4.456

Petrol, Finland	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,7%	-2,6%	-2,8%			-2,9%	-2,8%	-2,8%	-3,2%	-3,2%	-3,2%
Average lifetime tax revenue (EUR per car)	13.539	12.119	12.766	13.539	13.539			13.539	12.362	12.359	13.539	12.348	11.520
Average size	3,26	3,40	3,37	3,26	3,26			3,26	3,26	3,26	3,26	3,26	3,26
Average registration tax (EUR per car)	7.863	7.535	7.411	9.040	8.264			9.046	7.866	7.863	7.034	7.035	7.034
Average Circulation tax (EUR per car per year)	118	118	118	118	118			118	118	118	292	189	118
Average producers price, EUR excl. VAT	10.857	12.747	12.538	11.744	11.739			12.215	12.186	12.186	11.900	11.901	11.900
Average (lifetime) tax consists of													
Registration tax	7.863	7.535	7.411	9.040	8.264			9.046	7.866	7.863	7.034	7.035	7.034
Circulation tax (whole life time)	1.369	1.369	1.366	1.369	1.369			1.366	1.366	1.366	3.389	2.197	1.369
Fuel tax (whole life time)	4.307	3.216	3.989	3.130	3.906			3.127	3.130	3.130	3.116	3.116	3.117

Diesel, Finland	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO_2 effect			-0,5%	-1,3%	-1,6%	-1,7%	-1,9%	-2,1%	-1,9%	-1,9%	-2,5%	-2,4%	-2,5%
Average lifetime tax revenue (EUR per car)	19.920	20.376	20.872	19.920	19.920	19.920	19.920	19.920	19.333	19.345	19.920	19.321	19.906
Average size	3,45	3,53	3,52	3,45	3,45	3,45	3,45	3,45	3,45	3,45	3,45	3,45	3,45
							0						
Average registration tax (EUR per car)	10.410	11.326	11.270	10.977	10.415	10.971	10.972	10.991	10.397	10.410	10.996	10.997	10.996
Average Circulation tax (EUR per car per year)	572	579	578	572	572	573	525	573	573	573	573	521	572
Average producers price, EUR excl. VAT	14.374	15.638	15.561	14.958	14.971	15.149	15.150	15.266	15.254	15.254	15.183	15.184	15.183
Average (lifetime) tax consists of							0						
Registration tax	10.410	11.326	11.270	10.977	10.415	10.971	10.972	10.991	10.397	10.410	10.996	10.997	10.996
Circulation tax (whole life time)	6.632	6.715	6.699	6.638	6.634	6.652	6.084	6.643	6.645	6.645	6.646	6.045	6.632
Fuel tax (whole life time)	2.878	2.335	2.903	2.305	2.871	2.297	2.864	2.285	2.291	2.291	2.277	2.278	2.277

Petrol, Netherlands	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-1,3%	-4,4%	-4,6%	-4,3%	-4,5%	-3,9%	-4,0%	-4,0%	-4,7%	-4,7%	-4,7%
Average lifetime tax revenue (EUR per car)	16.661	16.370	17.469	16.661	16.661	16.661	16.661	16.661	14.521	14.546	16.661	14.478	14.941
Average size	2,82	3,05	3,00	2,82	2,82	2,82	2,82	2,82	2,82	2,82	2,82	2,82	2,82
							0						
Average registration tax (EUR per car)	3.726	4.893	4.696	5.910	4.490	4.135	4.111	5.823	3.701	3.726	4.189	4.186	4.188
Average Circulation tax (EUR per car per year)	433	471	461	431	431	584	463	436	435	435	581	393	433
Average producers price, EUR excl. VAT	11.293	13.798	13.373	11.937	11.900	12.170	12.121	12.955	12.745	12.750	12.287	12.280	12.285
Average (lifetime) tax consists of													
Registration tax	3.726	4.893	4.696	5.910	4.490	4.135	4.111	5.823	3.701	3.726	4.189	4.186	4.188
Circulation tax (whole life time)	5.022	5.464	5.352	5.004	5.005	6.772	5.376	5.057	5.047	5.047	6.742	4.562	5.022
Fuel tax (whole life time)	7.914	6.013	7.421	5.747	7.166	5.754	7.173	5.781	5.773	5.773	5.730	5.731	5.731

Diesel, Netherlands	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,3%	-1,2%	-1,4%	-1,4%	-1,6%	-1,7%	-1,4%	-1,4%	-1,9%	-1,9%	-1,9%
Average lifetime tax revenue (EUR per car)	23.248	23.875	24.950	23.248	23.248	23.084	23.248	23.248	22.068	22.089	23.248	22.043	23.335
Average size	3,43	3,50	3,49	3,43	3,43	3,43	3,43	3,43	3,43	3,43	3,43	3,43	3,43
							0						
Average registration tax (EUR per car)	6.032	7.555	7.520	7.212	6.075	7.304	7.286	7.207	6.010	6.032	7.327	7.329	7.326
Average Circulation tax (EUR per car per year)	986	1.005	1.002	986	986	965	883	988	988	988	979	875	986
Average producers price, EUR excl. VAT	14.180	15.500	15.425	14.819	14.824	14.962	14.923	15.162	15.113	15.114	15.010	15.014	15.010
Average (lifetime) tax consists of													
Registration tax	6.032	7.555	7.520	7.212	6.075	7.304	7.286	7.207	6.010	6.032	7.327	7.329	7.326
Circulation tax (whole life time)	11.443	11.661	11.627	11.436	11.434	11.189	10.238	11.466	11.465	11.465	11.355	10.146	11.443
Fuel tax (whole life time)	5.774	4.659	5.803	4.600	5.739	4.591	5.724	4.576	4.593	4.593	4.566	4.569	4.566

Petrol, Portugal	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO_2 effect			-0,3%	-1,5%	-1,6%	-1,7%	-1,8%	-2,0%	-1,8%	-1,8%	-1,9%	-2,0%	-2,0%
Average lifetime tax revenue (EUR per car)	5.348	4.987	5.452	5.348	5.348	5.348	5.348	5.348	4.627	4.631	5.348	4.624	4.700
Average size	2,54	2,63	2,62	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54	2,54
							0						
Average registration tax (EUR per car)	2.236	2.534	2.504	2.955	2.459	2.254	2.251	2.955	2.232	2.236	2.327	2.305	2.312
Average Circulation tax (EUR per car per year)	35	37	36	34	34	95	53	35	35	35	89	29	35
Average producers price, EUR excl. VAT	10.568	12.120	12.043	11.675	11.621	11.393	11.370	11.787	11.750	11.750	11.582	11.498	11.522
Average (lifetime) tax consists of													
Registration tax	2.236	2.534	2.504	2.955	2.459	2.254	2.251	2.955	2.232	2.236	2.327	2.305	2.312
Circulation tax (whole life time)	401	427	422	397	396	1.102	610	405	405	405	1.032	331	401
Fuel tax (whole life time)	2.712	2.026	2.526	1.997	2.493	1.992	2.488	1.988	1.991	1.991	1.989	1.988	1.988

Diesel, Portugal	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,8%	-3,0%	-3,0%	-2,6%	-2,8%	-2,4%	-2,2%	-2,2%	-2,7%		-3,0%
Average lifetime tax revenue (EUR per car)	9.200	9.316	9.683	9.200	9.200	9.200	9.200	9.200	8.707	8.710	9.200		8.997
Average size	3,67	3,76	3,74	3,67	3,67	3,67	3,67	3,67	3,67	3,67	3,67		3,67
							0						
Average registration tax (EUR per car)	6.583	7.136	7.074	7.102	6.665	6.741	6.727	7.077	6.580	6.583	6.909		6.888
Average Circulation tax (EUR per car per year)	31	32	31	30	30	60	24	31	31	31	46		31
Average producers price, EUR excl. VAT	15.950	16.928	16.960	16.766	16.757	16.554	16.583	17.049	16.933	16.934	17.013		17.070
Average (lifetime) tax consists of													
Registration tax	6.583	7.136	7.074	7.102	6.665	6.741	6.727	7.077	6.580	6.583	6.909		6.888
Circulation tax (whole life time)	355	369	365	345	344	698	277	359	358	358	533		355
Fuel tax (whole life time)	2.262	1.811	2.245	1.753	2.191	1.761	2.196	1.764	1.768	1.768	1.758		1.753

Petrol, Sweden	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,8%			-2,2%	-2,5%	0,0%			-3,1%	-3,2%	-3,2%
Average lifetime tax revenue (EUR per car)	7.814	6.299	7.365			7.814	7.814	0			7.814	6.100	6.100
Average size	3,69	3,83	3,80			3,69	3,69	0,00			3,69	3,69	3,69
							0						
Average registration tax (EUR per car)	-	-	0			0	0	0			0	0	0
Average Circulation tax (EUR per car per year)	150	155	154			294	200	0			297	150	150
Average producers price, EUR excl. VAT	16.263	18.325	18.070			17.416	17.368	0			17.339	17.291	17.291
Average (lifetime) tax consists of													
Registration tax	-	-	0			0	0	0			0	0	0
Circulation tax (whole life time)	1.735	1.797	1.781			3.409	2.324	0			3.443	1.735	1.735
Fuel tax (whole life time)	6.079	4.503	5.584			4.405	5.490	0			4.371	4.365	4.365

Diesel, Sweden	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-0,9%			-3,3%	-3,5%				-3,7%	-3,6%	-3,6%
Average lifetime tax revenue (EUR per car)	12.194	11.539	12.359			12.194	12.194				12.194	11.193	11.193
Average size	4,01	4,10	4,07			4,01	4,01				4,01	4,01	4,01
							0						
Average registration tax (EUR per car)	-	-	0			0	0				0	0	0
Average Circulation tax (EUR per car per year)	659	678	673			745	669				746	659	659
Average producers price, EUR excl. VAT	19.529	21.163	20.978			20.375	20.368				20.449	20.451	20.451
Average (lifetime) tax consists of													
Registration tax	-	-	0			0	0				0	0	0
Circulation tax (whole life time)	7.646	7.863	7.807			8.639	7.760				8.649	7.646	7.646
Fuel tax (whole life time)	4.548	3.676	4.552			3.555	4.434				3.545	3.547	3.547

Petrol, UK	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-1,6%			-4,9%	-4,8%				-4,6%	-4,6%	-4,6%
Average lifetime tax revenue (EUR per car)	11.824	8.869	10.392			11.824	11.824				11.824	9.287	9.287
Average size	3,10	3,30	3,23			3,10	3,10				3,10	3,10	3,10
							0						
Average registration tax (EUR per car)	-	-	0			0	0				0	0	0
Average Circulation tax (EUR per car per year)	231	167	162			451	309				449	231	231
Average producers price, EUR excl. VAT	18.607	21.755	20.997			19.553	19.572				19.695	19.695	19.695
Average (lifetime) tax consists of													
Registration tax	-	-	0			0	0				0	0	0
Circulation tax (whole life time)	2.676	1.942	1.879			5.233	3.584				5.212	2.676	2.676
Fuel tax (whole life time)	9.148	6.927	8.512			6.590	8.240				6.612	6.612	6.612

Diesel, UK	Basis		Fuel tax sensitivity					Budget constraint sensitivity					
			Fuel tax	Registration tax		Circulation tax		Registration tax			Circulation tax		
	1999	2008	Fuel tax up	Reg tax	Reg + fuel tax	Circ tax	Circ + fuel tax	Std 2008	Reg + Circ	Reg	Std 2008	Reg + Circ	Circ
CO2 effect			-1,9%			-4,5%	-4,4%				-4,3%	-4,3%	-4,3%
Average lifetime tax revenue (EUR per car)	12.248	9.887	11.623			12.248	12.248				12.248	10.185	10.185
Average size	3,60	3,73	3,67			3,60	3,60				3,60	3,60	3,60
							0						
Average registration tax (EUR per car)	-	-	0			0	0				0	0	0
Average Circulation tax (EUR per car per year)	236	182	180			415	255				414	236	236
Average producers price, EUR excl. VAT	22.357	24.511	24.005			23.297	23.314				23.360	23.361	23.361
Average (lifetime) tax consists of													
Registration tax	-	-	0			0	0				0	0	0
Circulation tax (whole life time)	2.738	2.117	2.092			4.817	2.959				4.801	2.738	2.738
Fuel tax (whole life time)	9.510	7.770	9.531			7.431	9.289				7.448	7.447	7.447

G. Consulted literature

The following essential documents were produced in the course of the study

- Passenger Car Taxation (8 December 2000)
- Technological Progress (8 December 2000)
- Overview of Modelling Strategy (7December 2000)
- Principles for Segmentation of Cars (8 December 2000)
- Inception report (February 2001)
- Interim report (first version) (April/May 2001)

In addition, documents prepared by EU DG-ENV have also provided valuable contributions in the process of delineation and further scoping of the tasks to be conducted by the Consultant. In this relation other valuable contributions also from other participants of the Sub Group (in writing or in terms of presentations and/or commenting at the meetings) should be mentioned as well. However, the following two documents have been essential in directing the scope of the work[26].

- Discussion Paper on Passenger Car Fleet Segmentation to be used within the model runs on Fiscal Framework Measures (KHZ.20.10.2000)
- Discussion Paper on Fuel Efficiency related Progress of Passenger Car Technology and associated Costs to be used within the model runs on Fiscal Framework Measures. (KHZ 23.10.2000)

Lastly, the below document constituted and essential part of the proposal submitted by the Consultant for this study

- Energy Efficiency of Passenger Cars - Car Choice Model (A paper presented by COWI A/S at the 1999 "Traffic Days" symposium at Aalborg's University).

In addition, a number of other sources have been consulted. Among the most relevant ones are:

- "ACEA Tax Guide - Motor Vehicle Taxation in Europe", ACEA, 1999.
- "ACEA Tax Guide - Motor Vehicle Taxation in Europe", ACEA, 2000.
- "Reducing CO_2 emissions from Passenger Cars in the European Union by Improved Fuel Efficiency: An Assessment of Possible Fiscal Instrument",

[26] individual sub-group members have also provided valuable oral and written contributions to the process

DRI Global Automotive Group, London, European Commission DG XI, 1995.

- "Fair and Efficient Pricing in Transport - the Role of Taxes and Charges", Oscar Faber, Amsterdam Free University, European Commission DG TREN, 2000.

- "Modelling the Factors Which Influence new Car Purchasing", Institute for Transport Studies, University of Leeds

- "Fuel Economy Labelling and Possible New Financial Measures to Stimulate the Sale of Fuel Efficient Passenger Cars", Netherlands Ministry of Environment, 2000.

H. Vocabulary

The below provides a list of words and concepts that are commonly used in this report. Words highlighted in *italics* are explained elsewhere in this list. The list explains how the words and concepts are interpreted and used in the context of this study, and hence this list should in no way be viewed as generic one. The list is not comprehensive, rather it aims to explain and define key and complex words and concepts.

Average circulation tax	See *average lifetime tax revenue*
Average lifetime tax revenue	The calculation of lifetime tax revenue is explained in *budget neutrality*. In presenting model results, the focus is however on average values in general and consequently also on the average lifetime tax revenue. The motivation for this is that the model is constructed in such a way that the total amount of sold vehicles remain unchanged no matter the level of taxes or any other assumed change. Furthermore, the core of the study is centred around the average CO_2 emission per car sold. Therefore, and to ease interpretation and comparability of results, other relevant results of the *fiscal policy measures scenario* are also provided as average (per vehicle) values. This mentioned inability of the model to assess changes in total demand in terms of number of vehicles could imply that the model does not capture certain market distortion effects. For example, the car manufacturing industry may be affected by a reduction in the number of cars sold, and that effect is not captured directly by the model. Similarly, consumers' welfare can be affected by tax induced cost increases that are so high that some people who would otherwise have bought a new car decide not to. On the other hand though, it is very important to note the extreme importance of the *budget neutrality* constraint in this regard. This constraint actually ensures that the order-of-magnitude of the assumed changes in the *fiscal policy measures scenario*s remain within a level which render it highly unlikely, if not impossible, that such extreme effects would occur to any significant extent.
Average registration tax	See *average lifetime tax revenue*
Average size	See *average lifetime tax revenue*.
Base year	The base year is the year for which data are collected on vehicle sales, socio-economics and taxes. The base year has been established as 1999. However, data on actual vehicle cover the last half of 1999 and the first half of 2000. These data proved to be more consistent and up-to-date. *Socio-economic* data are collected for the most recent year for which it exists. *Elasticities* are used that were established in 1997 based on an extensive analysis of Danish data.
Baseline	The baseline is the starting point for the analyses of *fiscal policy measures scenarios*. The baseline is constructed based on the *elasticities* of the model, the data collected on car sales in 1999/2000, data on taxes and tax systems currently in force and known to go into force in the near future together with the most recently available *socio-economic* data for each country. The baseline

furthermore assumes that the average emissions of the sales of new vehicles comply with the target of 140g/km. To include this, the establishment of the baseline takes into account also the costs of the *technological progress* required to achieve this emission reduction.

Boundary conditions

In this study, the term boundary conditions is used as an expression for the constraints which must be taken into account in the calculations of *CO_2 efficiency* of various *fiscal policy measures***.** The boundary conditions to consider in this study relate to: 1. *Budget neutrality*, 2. Diesel share, and 3. *Downsizing*. The calculation of the effects of any fiscal policy measure should thus be done under the constraint that it does not violate the boundary conditions.

Break-even for diesel cars

The break-even for diesel is a calculation, which estimates the size of the required shift from petrol vehicles to diesel vehicles, which would be necessary to achieve the 120g/km target through such a re-distribution alone. The break-even for diesel is a highly hypothetical and unrealistic assumption.

Budget neutrality

Budget neutrality occurs whenever a change in taxes and/or tax structures does not imply any change in net revenues for the government. In this study, the relevant budget is calculated only for the new vehicles in question and is defined as:

- Registration tax revenue plus circulation tax revenue (over the lifetime of the vehicles) plus fuel tax revenue (over the lifetime of the vehicle) minus any *CO_2 incentive* provided.

Thus, the budgetary implications of any assumed fiscal policy change is assessed using this definition, and the *boundary condition* on budget neutrality is set according to this definition of revenue, i.e. defined so that it requires that this revenue should remain unaltered.

Car Choice Model

The Car Choice Model was originally developed to enable detailed analyses of the demand in Denmark for private passenger cars. The model is a logit model, which combines data on socio-economics, vehicle sales and vehicle costs to derive detailed information on the demand for private passenger cars.

Change factor

The change factor is an expression of the assumed change to current levels of taxation in the *fiscal policy measures scenarios.* A change factor of 1.1 would thus indicate that the scenario assumes an increase by 10% compared to the current level and a change factor of 2 would indicate a doubling (100%) increase compared to the existing level.

CO_2 based tax structure

A CO_2 based tax structure is used as an expression for a tax system, which largely relates taxes and tax levels to energy use and CO_2 emissions. CO_2 incentive

CO_2 effect

The CO_2 effect (relative to 2008 base) is a key output of the model calculations of the effects of the *fiscal policy measures scenarios*. The CO_2 effect calculates the achieved reduction in CO_2 emissions in relative terms compared to the *baseline*. At the EU level, the *baseline* is 140g/km, but at the individual country level, the baseline is different. It is namely assumed that the 140g/km will be achieved by means of similar relative reductions in all EU Member States compared to 1997. Countries with above average emissions in 1997 will thus be assumed to continue to have above average emissions in 2008 and vice versa.

CO_2 effectiveness	The CO_2 effectiveness of a given tax system is indicated by its ability to affect the average CO_2 of new passenger cars. The more this average can be reduced as a result of a given change in the tax system, the more CO_2 effective is the system said to be.
CO_2 efficiency	See *CO_2 effectiveness*
CO_2 element	In establishing the *fiscal policy measures scenarios*, study allows for both the adding of a CO_2 element or a differentiated CO_2 element. This means that these specific scenarios assume that the existing systems are maintained as they are, but that a further element is added to them and that it is one which is strongly related to CO_2 emissions.
CO_2 reduction relative to 2008 base	See *CO_2 effect*
Community Reference Tax System (common yardstick)	This term is used to for the common calculation tool and its inherent approach (*the car choice model* including the approaches taken to its use in the context of this study) that is used to calculate the *CO_2 effectiveness* of any given *fiscal policy measure*.
Company car	Company cars are cars that are purchased under the taxation rules that apply to such cars (which may be different from country to country). These rules would typically include taxation of the individual of the ownership and/or use of the car as a benefit in kind, and the taking into account of the purchase and running costs in the accounts of the company. Company cars are to some extent used for company related purposes, but may also be used for private purposes. The distinction between company cars and *private cars* becomes relevant, because the factors underlying the purchase decision are different as reflected in different tax systems. Company cars generally tend to be bigger and more powerful than private cars.
Dealer's price	Dealer's price is the price of the vehicle excluding all taxes, charges and subsidies.
Diesel share	This means the share of diesel cars in the total purchase of new cars. Diesel share is one of the *boundary conditions*. It has been made operational as follows: Any *fiscal measure* is allowed to involve a (maximum) increase of 100% in the share of diesel cars. However, the share must in no case exceed 50%. Some countries however already exceed this limit of 50%, and in these cases, the share is not allowed to increase any further.
Downsizing	Down-sizing is used as an expression for the case where the purchase of new cars is affected by (a change in) *fiscal policy measures* or other external factors

in such a way that consumers tend to purchase (demand) smaller cars than they would do otherwise. To operationalise this term, this study has defined eight *segments* of car types so that any demand change within a given segment, e.g. mini cars, would not be considered as down- or upsizing, whereas a change from one segment to the other would.

Elasticities

Price elasticities are numeric expressions of the consumers' preferences for the various vehicle types and the sensitivity of this to price changes. The elasticities are determined by the *socio-economics* of the car buyer. In this model, the elasticities are expressed as probabilities.

Fiscal policy measures scenarios

The core of the study is the fiscal policy measures scenarios. The scenarios assume that taxes and/or tax systems that are related to vehicles are changed compared to the *baseline*. The purpose of the fiscal policy measures scenarios is to analyse the *CO_2 effectiveness* of existing systems and to analyse the extent to which changes would be required to bring average CO_2 emissions down from the 140g/km to 120 g/km.

Fuel taxes

Fuel taxes are taxes that are imposed on fuels. In this study, the term "fuel taxes" is also used to express the revenue from fuel taxes. In assessing *budget neutrality,* the revenue from fuel taxes is calculated as the existing fuel tax/litre times the litre/km times the average mileage per year times the lifetime of the vehicle. Average mileage is a country specific estimate, and the lifetime is assessed to be 13.4 years.

Logit model

A statistical model often used to analyse the influence on consumers choice of other variables. In the logit model this influence is modelled as affecting the probabilities that the consumer will make a certain choice. The logit model works by assigning “utility” to each alternative. The higher the “utility” the more likely an alternative is to be chosen.

Market distortion

Market distortion is used as an expression for the situation where changes in taxes and tax structures lead to changes in turnover and profitability of the car industry and in the welfare of consumers. Any change will inevitably cause some distortions compared to the current situation. In this study, market distortions are indicated by the calculation of the effect on *average dealer's price* and *average size.* The less these indicators change as a result of an assumed change in taxes and/or tax systems, the less distortion does the assumed change involve.

Model calibration

The *Car Choice Model* is a model first developed and used in a Danish context. The use of it in the context of this study assumes that the applied *elasticities* have a generic applicability at the EU level. This has been tested (as part of model validation process) with a satisfactory outcome. Model calibration is relevant in order to ensure the applicability of the model in the context of each specific country. The first step in the calibration process compares the model's estimate of vehicle sales in 1999 with the actual sales (as indicated in the data that we have). Deviations are thereafter analysed and combined with a review of the data and assumptions used and the relevant modifications are undertaken to make sure that the model provides the best possible reflection of the country in question.

Private car — The model differentiates between private cars and *company cars.* Private cars are cars that are purchased under taxation schemes that apply to such cars. Purchase decisions are thus based on the taxation systems that apply to car purchase in general, and not the specific regulations and systems that apply to *company cars*. The individual person or family make the decisions on private car purchases, whereas decisions on *company cars* purchases may be made by the company in question, and will be influenced by the specific taxation rules that apply in these cases to the company and to the individual using the car.

Rebound effect — The rebound effect is used as an expression for the fact that once energy efficiency of vehicles increase, the running costs of vehicles decline and consequently there will be a move in demand less energy efficient vehicles. The rebound effect is relevant in the calculation of the *baseline.* The baseline assumes that average emissions of new passenger cars is reduced to 140g/km. It is assumed that this is achieved by means of *technological progress*, which provides the necessary improvement in energy efficiency. Comparing realised average emissions in 1995 with the target of 140g/km. would indicate that a reduction by 25% in emissions would suffice to achieve the 140g/km. However, this level has not taken the rebound effect into consideration, and consequently, the required reduction will actually exceed the 25%. The required reduction has been calculated to be 28% instead.

Revenue neutrality — See *budget neutrality*

Segmentation — The vehicles on the market are grouped into 10 segments, each of which contains vehicles that contain key features - within a certain range. The segments that are used derive from the definitions made by Marketing Systems. The segments are: mini, small, lower medium, medium, upper medium, luxury, sport, off-road, MPV<4.7 m, and MPV>4.7

Size — If consumer's reaction to changes in the taxes and/or the tax system is to change the size of the car that they buy, this can be said to reflect a change in their welfare compared to the *baseline*. Furthermore, changes like this may also have repercussions on the car manufacturing industry. Thus, an assessment of the extent to which this would be a result of the *fiscal policy measures scenarios* also needed to be included in the results of the scenario analyses. In order to do this, all cars within a given *segment* are provided with a numeric value between 1 and 6 as an indication of their relative size (compared to the other segments). Sport cars are provided with "6", whereas mini cars are categorised as "1". The average size of vehicles sold is thus calculated as the sum for all segments of the number of cars sold within a given segment times their size (the number between 1 and 6 assigned to this segment) - and divided by the total number of cars.

Socio-economics — The *elasticities* that are used in the model distinguishes between various groups of car purchasers. They are thus categorised according to certain socio-economic features. In categorising the purchasers, the following characteristics are taken into account: sex, family structure and income.

Target year — The target year is the year when it is assumed that the140 g/km. will be achieved. The target year has been defined as 2008. The analyses of the *fiscal policy measures scenarios* are calculated for 2008.

Tax differentiation — Tax differentiation occurs when tax rates or tax levels differ in more than proportional terms according to certain criteria. For example, a value based registration tax can increase once the value of the car exceeds a certain amount.

Technical potential — The technical potential is a calculation which estimates the maximum CO_2 reduction that can be achieved without affecting the distribution of the sales of new vehicles among *segments*. In calculating the technical potential it is simply assumed that all cars sold within a given *segment* are of only one type: namely the most energy efficient one in the segment. The technical potential calculation compares the outcome of this highly hypothetical and unrealistic situation with the actual sales that would occur in the *baseline.*

Technological improvement — see *technological progress*

Technological progress — The study assumes that the agreement between the Commission and the automobile industry (ACEA; KAMA and JAMA) to achieve a CO_2 efficiency gain resulting in an average 140g/km in 2008 by means of technological progress will be fulfilled. To implement this assumption in the *Car Choice Model (The Community Reference Tax System)*, certain assumptions have to be made on the costs and structure of the realisation of the agreement. Basically, it is assumed that the costs of the agreement would result in a 5% increase in the price of the car, with a lower limit of 1,000 EUR and an upper limit of 2,000 EUR. This cost estimate relates to a reduction down to 140g/km compared to the level in 1997. It is assumed that the reduction will be effectuated in a proportional manner between vehicle types compared to current CO_2 emission levels.

Vehicle fleet — This study is only concerned with the purchase of new passenger cars. Consequently, the term "vehicle fleet" is used as an expression for the total composition and amount of new vehicles sold.

What-if model — The calculation tool that is used in this study (based on the *car choice model*) is a what-if model. This means that it compares the "current" situation *(the baseline)* with a situation where it is assumed that taxes and charges have changed, but everything else remains the same. The model thus provides an answer to the question: what would happen to the demand for vehicles if the costs of buying and running vehicles change as a result of changes in the fiscal regime (i.e. taxes and charges). It should be noted that *the baseline* assumes that the 140g/km target has been achieved. The baseline is thus not the actual current situation. Rather, it is an assessment of the situation in 2008 (*the target year*), which assumes that the situation in 2008 is similar to the current situation with one single exception. It is namely assumed that the average emission of new passenger cars is 140g/km (and takes into account the costs of achieving this - cf. *technological progress)*. The what-if approach also implies that the model cannot be interpreted as a prognostic or a forecast model.