DLR
German Aerospace Centre
Institute of Transport Research

Preparation of the 2003 review of the commitment of car manufacturers to reduce CO_2 emissions from M1 vehicles

Final Report of Task A:

Identifying and assessing the reasons for the CO_2 reductions achieved between 1995 and 2003

to the European Commission, Directorate-General for Environment,
for Service Contracts No.
B4 - 3040/2002/343537/MAR/C1 and 070501/2004/377441/MAR/C1

---

08 December 2004

Preparation of the 2003 review of the commitment of car manufacturers to reduce CO_2 emissions from M1 vehicles

Final Report of Task A:

Identifying and assessing the reasons for the CO_2 reductions achieved between 1995 and 2003

Contracting Periods:

B4 - 3040/2002/343537/MAR/C1: December 2002 to February 2004
070501/2004/377441/MAR/C1: March 2004 to December 2004

Contracting Partner:

German Aerospace Center e.V.,
Institute of Transport Research, Berlin

Rutherfordstrasse 2
12489 Berlin
Germany
Tel.: +49 (30) 670 55 – 211
Fax: +49 (30) 670 55 – 202

DLR - **German Aerospace Center**
Prof. Reinhart Kühne

Authors: Dipl.-Ing. Markus Mehlin
Dr. Colin Vance
Dr. Astrid Gühnemann
Sabine Buchheim M.A.

TABLE OF CONTENTS

LIST OF FIGURES……IV
LIST OF TABLES…….. VII

1 Introduction 1

2 Procedure and methods applied 2

2.1 Preliminary method considerations 2

2.2 Applied method 4

3 Database and data modification 6

3.1 Overview 6

3.2 POLK registration data 6

3.3 Segmentation of the registration data 9

4 Descriptive analysis 11

4.1 Supply side: Offered model range 11

4.2 Supply Side: Technologies applied 15

4.3 Demand Side: New car registrations and their physical characteristics 18

4.4 Demand side: Segment development 20

4.5 Demand Side: Selected segments 30

4.5.1 Lower Medium segment 30

4.5.2 Small segment 32

4.5.3 Medium segment 33

4.6 The influence of structural changes of registrations on CO_2 emissions 35

5 Survey of non-technical influences 37

5.1 Introduction 37

5.2 Survey of politically motivated influences 37

5.2.1 Fuel prices 38

5.2.2 Registration and circulation taxes 39

5.2.3 Scrapping Incentives 46

5.2.4 Labelling 47

5.2.5 EU-regulations and validity of underlying assumptions 48

5.3 Selected socio economic and demographic aspects 52

5.3.1 Income/GDP 52

5.3.2 Population density in Europe 54

5.3.3 Urban population 55

5.3.4 Distribution of Age classes in Europe 55

5.4 Other influences 57

5.4.1 Influence by lifestyle trends 57

5.4.2 Influence by the country of origin of manufacturers 57

5.5 Catalogue of non-technical influences for analysis in the econometric model 57

6 The Econometric Analysis 59

6.1 Introduction 59

6.2 Methodological Issues 59

6.3 Results: Analysis of technical factors on CO_2 60

6.4 Results: Analysis of non-technical factors on CO_2 64

6.4.1 Model Estimation 64

6.4.2 Statistical Simulation 67

6.4.3 Implications for average CO2 emissions 74

6.5 Conclusion 75

7 Summary and Conclusions 77

REFERENCES 83

ANNEX

Annex 1 Proposal for a method to identify and assess the reasons contributing to the CO_2 reduction of M1 vehicles achieved between 1995 and 2003 88

Annex 2 Share of private cars applied in the econometric analysis 93

Annex 3 Analysis of the Monitoring data 94

Annex 3.1 New car registrations 94

Annex 3.2 Physical car characteristics 99

Annex 4 Analysis of the registration data by segment from R. L. Polk Marketing Systems 109

Annex 4.1 Segment analysis 109

Annex 4.2 Conclusion of the Polk Marketing Systems data segment analysis 112

List of Figures

Figure 1: Overview of the applied procedure 5
Figure 2: Engine versions of Opel Corsa and Fiat Punto (Small segment) 12
Figure 3: Engine versions of Ford Focus/Escort and VW Golf (Lower Medium segment) 13
Figure 4: Engine versions of BMW 3 series and VW Passat (Medium segment) 13
Figure 5: Share of fuel preparation systems applied 16
Figure 6: Share of engine versions by cylinders 16
Figure 7: Share of transmission types of new registrations 17
Figure 8: Registrations by segment for all associations (EU 15) 21
Figure 9: Registrations of ACEA by segment and diesel share (EU 15) 22
Figure 10: Registrations of JAMA by segment and diesel share (EU 15) 23
Figure 11: Development of the CO_2 emissions range for the Lower Medium in the United Kingdom and France 31
Figure 12: CO_2 emissions for petrol versions of Ford Escort/Focus and Peugeot 306/307 32
Figure 13: Development of the CO_2 emissions range for the Small segment in Italy and France 33
Figure 14: Development of the CO_2 emissions range for the Medium segment in Germany 34
Figure 15: Deflated petrol prices in Europe [€ per litre, base year equals 1995] 38
Figure 16: The development of an average premium of the liability insurance and the tax on ownership in the years 1994 – 2001 39
Figure 17: Change of the annual circulation tax in Denmark (1995 to 2002) 41
Figure 18: Change of annual circulation tax in Italy (1995 to 2002) 43
Figure 19: Example for the circulation tax in the Province of Utrecht, 1999-2004. 44
Figure 20: Shifting of taxes on ownership for private cars in the UK between 1995 and 2003. 46
Figure 21: Cross domestic product per capita, at the price levels and exchange rates of 1995 [US $] 53
Figure 22: The population density in Europe in 2002. 54
Figure 23: The distribution of the age classes in Europe in the year 1992. 56
Figure 24: The distribution of the age classes in Europe in the year 2003. 56
Figure 25: Predicted CO_2 emissions for different values of height 62
Figure 26: Predicted CO_2 emission for different values of kerb weight 62

Figure 27: Predicted CO_2 emission for different values of engine power 63

Figure 28: Influence of per capita GDP in Euros on the ACEA segment shares of petrol cars in 2002 68

Figure 29: Influence of the fuel price in Euros on the ACEA segment shares of petrol cars in 2002 69

Figure 30: Influence of circulation taxes in Euros on the ACEA segment shares of petrol cars in 2002 69

Figure 31: Influence of per capita GDP in Euros on the ACEA segment shares of diesel cars in 2002 70

Figure 32: Influence of the fuel price in Euros on the ACEA segment shares of diesel cars in 2002 71

Figure 33: Influence of circulation taxes in Euros on the ACEA segment shares diesel cars in 2002 71

Figure 34: Influence of per capita GDP in Euros on the JAMA segment shares of petrol cars in 2002 72

Figure 35: Influence of the fuel price in Euros on the JAMA segment shares of petrol cars in 2002 73

Figure 36: Influence of circulation taxes in Euros on the JAMA segment shares petrol cars in 2002 73

Figures of the Annex

Figure 37: Newly registered passenger cars in large Member States (F, GER, IT, SP, UK) .94

Figure 38: Newly registered passenger vehicles in smaller Member States (A, B, DK, FIN, GR, IRE, LUX, NL, P and SW) 95

Figure 39: Development of the diesel share in large Member States (F, GER, IT, SP, UK) ..97

Figure 40: Development of diesel registrations in smaller Member States (A, B, DK, IRE, LUX, NL, P and SW) 98

Figure 41: Average mass of ACEA's new car registrations 101

Figure 42: Development of the average mass of ACEA's new car petrol registrations 102

Figure 43: Development of the average mass of ACEA's new car diesel registrations 102

Figure 44: Development of the average engine power of ACEA's new petrol car registrations 105

Figure 45: Development of the average engine power of ACEA's new diesel car registrations 105

Figure 46: Development of the average engine capacity of ACEA's new car petrol registrations 107

Figure 47: Development of the average engine capacity of ACEA's new car diesel registrations 108
Figure 48: Registrations by segment in the EU 15 110
Figure 49: Registrations by segment in Italy 111
Figure 50: Registrations by segment in United Kingdom 111

List of Tables

Table 1: POLK data of France in 1997 7

Table 2: Average specific CO_2 emissions indicated in the monitoring reports for all associations 9

Table 3: Average specific CO_2 emissions calculated by the POLK dataset 9

Table 4: Modified segments of the POLK registration data 10

Table 5: Modified segmentation including sub-groups 24

Table 6: Registrations for ACEA per segment sub-group 1996 and 2002 (EU 15) 25

Table 7: CO_2 emissions for ACEA per segment sub-group 1996 and 2002 (EU 15) 26

Table 8: Registrations for JAMA per segment sub-group 1996 and 2002 (EU 15) 28

Table 9: CO_2 emissions for JAMA per segment sub-group 1996 and 2002 (EU 15) 29

Table 10: Circulation tax rates in Germany 42

Table 11: Directives on motor vehicles relevant from 1998 to 2003 49

Table 12: Summary of taxes in Europe with indication for their use in the econometric model 58

Table 13: OLS regression of technical attributes on CO_2 emissions (selected coefficients) 61

Table 14: Comparison of percentage increases in attribute values with percentage decreases in associated CO_2 emissions between 1996 and 2002 64

Table 15: OLS pooled regression: Elasticity estimates of the determinants of car registrations (selected coefficients) 66

Table 16: Predicted changes in average CO_2 emissions (ACEA) for different values of GDP, circulation taxes and fuel prices in 2002 74

Table 17: Predicted changes in average CO_2 emissions (JAMA) for different values of GDP, circulation taxes and fuel prices in 2002 75

Table 18: Predicted changes in average CO_2 emissions (ACEA) for different values of GDP, circulation taxes and fuel prices in 2002 81

Table 19: Predicted changes in average CO_2 emissions (JAMA) for different values of GDP, circulation taxes and fuel prices in 2002 81

Tables of the Annex

Table 20: Share of private cars 93
Table 21: Diesel share in the Member States 96
Table 22: Differences of mass figures when leaving out JAMA and KAMA 99
Table 23: Differences of engine power figures when leaving out JAMA and KAMA 100
Table 24: Average engine power of ACEA'S new car registrations 104
Table 25: Average engine capacity of ACEA's new car registrations 106
Table 26: Segments of the R.L. Polk Marketing Systems data 109

1 Introduction

In July 1998, the European Commission and the European Automobile Manufacturers' Association (ACEA) reached an agreement on the reduction of CO_2 emissions from passenger cars[1]. In this agreement, ACEA commits itself to achieve an average CO_2 emission figure of 140 g/km by 2008 for all its new cars sold in the European Union. Commitments have also been concluded with the Japanese and the Korean Automobile Manufacturers' Association[2] (JAMA and KAMA), according to which they have to achieve 140 g/km by 2009.

The three commitments include a review in 2003 of the potential for additional fuel-efficiency improvements with a view to moving further towards the objective of 120 g CO_2/km by 2012. Furthermore, it is committed that the members of ACEA should achieve an intermediate target in the range from 165 to 170 g CO_2/km in 2003, JAMA's members from 165 to 175 g CO_2/km in 2003 and KAMA from 165 to 170 g CO_2/km in 2004. The targets must mainly be achieved by technological developments affecting different car characteristics and market changes linked to these developments. The European Parliament and Council Decision of 22 June 2000 establishing a scheme to monitor the average specific emissions of CO_2 from passenger cars[3] supplemented this.

The purpose of the services delivered within the contracts with the Institute of Transport Research of the German Aerospace Center (DLR) has been to provide the European Commission with information represented as tasks A and B:

- Task A: Causes for the CO_2 reduction achieved between 1995 and 2003
- Task B: Information about possibilities for further CO_2 reductions after the target years 2008 and 2009 respectively.

This report covers the results of task A. Findings concerning task B are to be found in a separate report.

Task A addresses the identification of reasons for already observed changes in CO_2 emissions and the assessment of their contribution to the total reductions achieved up to the end of the year 2003. The German Aerospace Center (DLR), Institute of Transport Research, intended to achieve a general acceptance of the applied method from all participants of the monitoring process, from the Commission as well as from the automobile manufacturers. In this regard DLR thanks ACEA for its support in providing background material and information on vehicle taxation in Europe. However, the research work was carried out independently. It aims at identifying all possible - both positive and negative - reasons for the observed changes in CO_2 emissions until 2003.

[1] Commission Recommendation 1999/125/EC
[2] Commission Recommendation 2000/303/EC and 2000/304/EC
[3] Decision 1753/2000/EC

2 Procedure and methods applied

2.1 Preliminary method considerations

According to the commitment between the car manufacturers' associations and the European Commission, the committed target of 140 g CO_2/km must be achieved by technical measures taken by the manufacturers and market changes linked to these developments. The Commission has to report the Council and the European Parliament[4] whether the reductions achieved are due to such technical measures or due to other measures such as changes in consumer behaviour which are unrelated to any technical measures adopted by the manufacturers.

Within the framework of this service contract, all possible reasons for the observed changes in CO_2 emissions until 2003 were be identified, including those not attributed to technical aspects, e.g. fiscal measures, etc. Therefore, the task was to establish a method for identifying and differentiating all reasons and subsequently assess the contribution to the CO_2 reduction of the different measures.

A literature survey and expert discussions were carried out in order to identify the key points and key difficulties in choosing and adapting a specific method to elaborate the given subject. Studies provided by the European Commission as well as publicly available material were used for this. In particular, two studies applying econometric and simulation based methods to model and simulate the impacts of technical and non-technical measures on car purchasing behaviour, could be identified.

Firstly, the "Cross Country Car Choice Model" used by COWI for its study[5] entitled "Fiscal Measures to Reduce CO_2 Emissions from New Passenger Cars" appears to be an option for elaborating the given task. In a discrete car choice model (logit) country- specific parameters are estimated based on elasticities derived from the already existing Danish Car Choice Model. The calculation of vehicle sales uses existing taxes and tax structures for 2000 and the according car sales data for the different Member States.

The promising approach of COWI and its results are judged to be taken into account as a very important contribution in this research work. However, the model comparison of one year data between the Member States does not serve as a sufficient basis here, because to identify and assess reasons for the already achieved CO_2 reduction especially the developments of individual countries between 1995 and 2003 are needed.

Another approach taken into account is the model for Economic Assessment of Sustainability Policies of Transport (ESCOT)[6] which was developed in the framework of the OECD project on environmentally sustainable transport (EST). System dynamics modelling is applied to integrate five sub-models into ESCOT (macroeconomic submodel, regional economics submodel, transport sub-model, environment sub-model and the policy implementation model.) Thus, the impact of different policy measures affecting either passenger or freight transport or both can be simulated. These measures comprise technical changes (e.g. introduction of 3l cars in the fleet) and behavioural changes (e.g. demand changes driven by price increases for fuel or for road charges).

The ESCOT model has been adjusted and applied in the DLR study[7] "New Cars' Fuel Consumption 2010 – Activation of reduction potential and the contribution to climate protection"

[4] Decision 1753/2000/EC, Article 10.
[5] Consulting Engineers and Planners [COWI], (2001): Main report December 2001.
[6] Schade et al, (2002).
[7] German Aerospace Center [DLR], (Ed. 2002).

which analyses measures influencing people to buy more fuel saving cars. However, for the application on the European scale, the data requirements of the model proved to be too high. For the mentioned study the behaviour of car purchasers (in terms of car sales data) and the parallel purchase and maintenance cost structure of new passenger cars was investigated for ten year period in Germany. This would also be necessary for at least a certain number of Member States to meet the target of the given subject here; however data and resources are not available for such a detailed investigation within the framework of this study.

As the establishment or revision of a comprehensive quantitative model to assess all reasons for the CO_2 reduction appeared not to be feasible in the framework of the contract, descriptive methods and procedures had to complement the assessment. The three most suitable methods, which have been the basis for the selection of the final method, are shortly described below.

a) Analysis of segments

Based on the notion that a buyer of a new car normally has a clear idea of the utilisation of the car given a limited financial budget (e.g. for family purposes, long distance trips, leisure activities, etc.), a composition of segments is proposed that reflects the different sizes and functionalities of cars.

For analysing these segments, several parameters (e.g. interior size, engine performance, etc.) have to be worked out to characterise cars sufficiently. Dependencies of segment portions on these parameters have to be modelled, whereby the influence on the average emissions can be calculated by varying the parameters.

The establishment of characteristic parameters raises some data problems as well as the clear segment allocation. A segment based analysis can hardly be the exclusive method used for the given task. However, depending on the data available it can be a helpful contribution.

b) Direct derivation of the CO_2 emissions by multi-parameter analysis

This procedure links the CO_2 emissions directly to the car-parameters of technical progress and of consumer behaviour. Parameters have to be identified and divided into two categories related to technologies and to consumer behaviour. A model of the average CO_2 emissions as a function of these parameters has to be developed.

The main obstacle of using this approach is the requirement for very detailed data (e.g. interior dimensions like head and shoulder room or technical figures like engine and transmission efficiency etc.) which are necessary to divide the parameters clearly into the two categories. Furthermore, these technical data have to be allocated to the data of new registration, what represents another difficulty.

c) Iterative identification of influences on consumer behaviour

Here, it is recommended to start with the fundamental question as to whether there is a change in consumer behaviour at all. Therefore, a description of the new passenger car market is proposed in order to identify market changes, i.e. changing physical characteristics or changing proportions of certain groups of cars.

In addition, possible non-technical influences have to be investigated in order to identify parallel developments which can be attributed in a plausible manner to the market changes found out.

For those groups of cars, for which a significant change has been identified, the CO_2 derivation has to be calculated by an individual procedure, e.g. by a sensitivity analysis, a country comparison or by incorporating other studies dealing with the consumer behaviour. The procedure can vary significantly depending on the way how the investigated influences are affecting consumers and on the scope of the influence, i.e. whether the whole registrations change or only a certain share of it.

2.2 Applied method

After consultation with the Commission (see Annex 1 for the submitted proposal paper) and the manufacturers' associations the final procedure was worked out and is described in the following section.

The procedure is divided into three work streams. For all these work streams an extensive review of existing data sources and the establishment of a data base have been necessary as described in Chapter 3. The first work stream represents a descriptive analysis, which includes a general description of the passenger car market (see Chapter 4) with respect to the supply side, i.e. manufacturers' offers, and to the demand side reflected by the registrations data. Market changes are identified, i.e. changing physical characteristics or changing proportions of certain groups of cars.

Based on the car market survey, hypothetical average CO_2 emission are calculated in Chapter 4.6 in order to narrow down the magnitude of the possible influences by structural changes of the car market. Several assumptions are taken, e.g. that the market shares of identified models or vehicle classes remained constant in the time period investigated, to receive order of magnitudes for the CO_2 differences. Whether these changes in the market structure are due to consumer preferences or technical influences is not stated there, however, indications can be gained in combination with the results of the work streams.

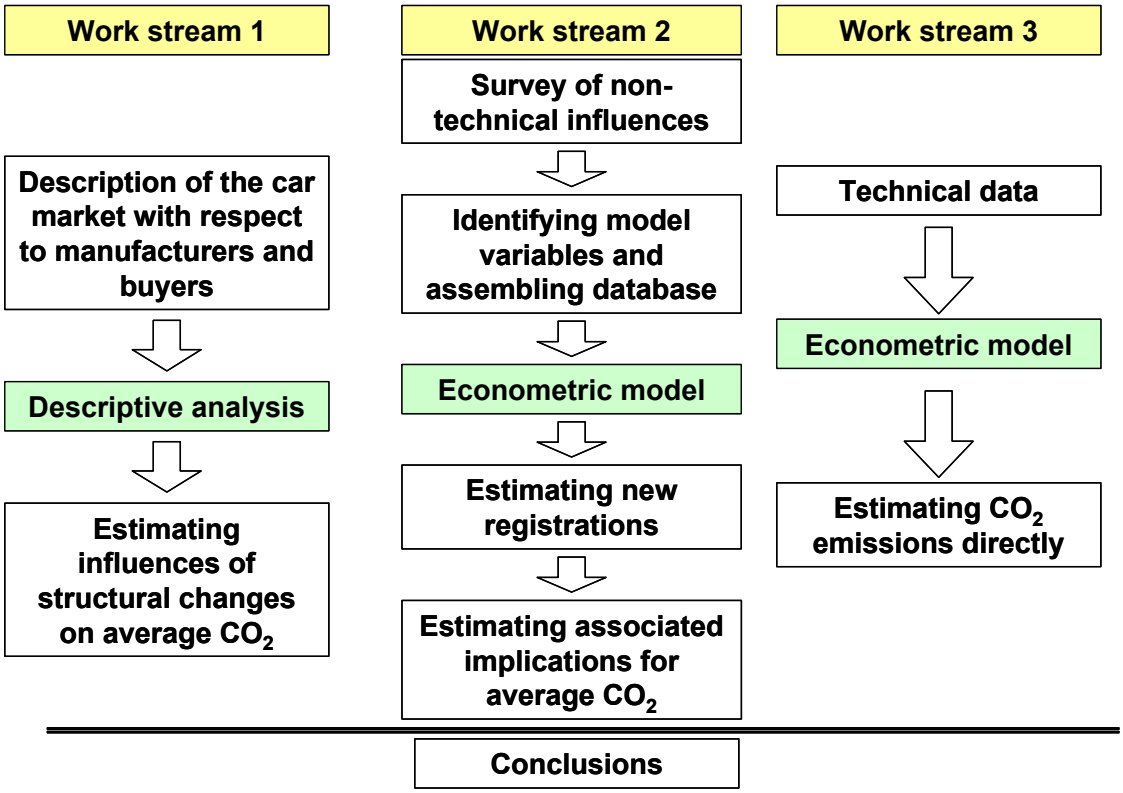
The aim of the analysis in the second work stream is to identify and – if possible – quantify non-technical influences. The first step is a qualitative analysis of all non-technical influences that could have an impact on consumers' behaviour and therefore cause CO_2 shifts (see Chapter 5). The method for the quantification is an econometric model (see Chapter 6) estimating the impact of non technical influences on the number of new car registrations. A Europe-wide survey provides information on whether there are such influences at all, including politically motivated, socio-economic and other influences. An assessment of the influences is carried out by calculating the effect on the average CO_2 emissions. Very detailed registration data of POLK form the base of the econometric model.

The third work stream uses the detailed registration data as well as an econometric model and is integrated in Chapter 6. Here, the relation between the technical attributes of new registrations like length, engine power etc and the CO_2 emissions values is estimated. Herewith, it is not intended to estimate a definite influence of the technical attributes on CO_2 emissions in the sense of Article 10, but results will be useful to assess and interpret the findings of the influences of the non-technical influences.

Finally, the findings of all three work streams are summarised in Chapter 7, set in relation to each other and carefully interpret it with regard to the influence of non-technical measures on the consumer behaviour and the average CO_2 emission.

An overview about the applied procedure is given in Figure 1:

Figure 1: Overview of the applied procedure



For a thorough discussion on the driving factors for market changes it is further necessary to analyse the registration data on the level of market segments. Based on the notion that a buyer of a new car normally has a clear idea of the utilisation of the car given a limited financial budget (e.g. for family purposes, long distance trips, leisure activities, etc.), a segmentation scheme is applied that reflects the different sizes and functionalities of cars. Carrying out the given subject by new registrations aggregated to CO_2 classes is not regarded as an appropriate method since the relation to the consumers is hardly given, though it would be difficult to assess any influence on consumers. Detailed information on the segmentation scheme is provided in Chapter 3.3.

3 Database and data modification

3.1 Overview

The basis for the market analysis is the data of the monitoring reports. They represent the official figures and are therefore used as reference values to confirm and modify other sources, especially the used POLK data (see below). Furthermore, the monitoring data are analysed in order to investigate physical changes in the new car registrations. Further information on the monitoring data can be found in the annual monitoring reports by the European Commission.

Because the monitoring data do not provide sufficient information to assess the reasons for the achieved CO_2 reduction, the data base is supplemented by new cars' registrations; data of POLK Marketingsystems[8] are used. In contrast to the monitoring data, detailed information on the registrations including model names and characteristics is provided on Member-State level. POLK data are the major base for the analysis in this work and are described more in depth in the following sections.

Besides the data bases of the Monitoring reports and POLK, several other sources are used to gain information about the technical development, manufacturers' model range and the consumer behaviour. These sources include catalogues of new cars published by the German drivers' association ADAC, the Motor-Presse Stuttgart and also brochures and car magazines. Proceedings of technical conferences and technical research reports provide more detailed information on the technologies applied.

For the survey of the non-technical influences, data from the ACEA tax guide, Eurostat and the Worldbank are used in the main. Especially to confirm and complete information on taxes several other studies on vehicle car taxation in Europe are used.

3.2 POLK registration data

For the more in-depth description of the passenger car market data of POLK are used providing registration data for each country by a very detailed version breakdown. These data are also used for the econometric models. A sample of data for France by 1997 is shown in the following table.

[8] The company's name changed from Marketingsystems to POLK/Marketingsystems to presently POLK. The latter is used in this report.

Table 1: POLK data of France in 1997 (Column "y_1997-c" indicates the number of registrations)

Manufacturer name	Model name	Description 1	Description 2	Segment	y_1997_c	Price	Price date	CO2 Emission pro KM in Gramm	Fuel cons. urban (EC80)	Fuel cons. 56mph (EC80)	Fuel cons. 75mph (EC80)	Fuel cons. urban (EC93)	Fuel cons. extra urban (EC93)	Fuel cons. combined (EC93)	Fuel cons. Euromix (EC80)
Alfa Romeo	145	1.3	1.3l,66kw,5vits,3ptes	3	48	82500	01.08.1996	0	10.1	6.3	8.2	0	0	0	8.2
Alfa Romeo	145	1.3 "L"	1.3l,66kw,5vits,3ptes	3	15	87500	01.08.1996	0	10.1	6.3	8.2	0	0	0	8.2
Alfa Romeo	145	1.4 Twin Spark 16V	1.4l, 76 kw, 5-speed, 3-door	3	435	82500	24.10.1997	0	10.1	6.3	8.2	10.7	6.3	7.9	8.2
Alfa Romeo	145	1.4 Twin Spark 16V "L"	1.4l, 76 kw, 5-speed, 3-door	3	145	88200	24.10.1997	0	10.1	6.3	8.2	10.7	6.3	7.9	8.2
Alfa Romeo	145	1.6 "L"	1.6l,76kw,5vits,3ptes	3	85	96500	01.08.1996	0	9.6	5.7	7.8	0	0	0	7.7
Alfa Romeo	145	1.6 Twin Spark 16V "L"	1.6l, 88 kw, 5-speed, 3-door	3	319	98200	24.10.1997	0	0	0	0	11	6.4	8.1	0

Transmission type	Number of speeds	Body style	Cubic capacity	Number of doors	Driven wheels	Fuel type	KW	Transmission type (Standard)	Number of cylinders	Engine type	Length in mm	Width in mm	Height in mm	Kerbweight in kg	GVW in kg	Payload in kg	No. of seats (standard)	No. of seats (alternative)
M	5	HB	1351	3	F	PLS	66	M	4	B	4093	1712	1427	1140	0	0	5	0
M	5	HB	1351	3	F	PLS	66	M	4	B	4093	1712	1427	1140	0	0	5	0
M	5	HB	1370	3	F	PLS	76	M	4	R	4093	1712	1427	1135	0	0	5	0
M	5	HB	1370	3	F	PLS	76	M	4	R	4093	1712	1427	1135	0	0	5	0
M	5	HB	1596	3	F	PLS	76	M	4	B	4093	1712	1427	1140	0	0	5	0
M	5	HB	1598	3	F	PLS	88	M	4	R	4093	1712	1427	1185	0	0	5	0

The differentiation of the POLK data is mostly more detailed than on version level. E.g. registrations for the Alfa Romeo 145 1.4 Twin Spark 16V are differentiated for the equipment level ("L"), other models are also differentiated according to the transmission type or the number of doors. These variations, which are below the version level that is attributed to the engine size but reflected in a separate row of the POLK data set, is denoted as an "observation" for the analysis.

The data set of POLK comprises the years 1995 to 2002. The complete set of data for 2003 will be available in the late summer or autumn of 2004. As the development of the average CO_2 emissions from 2002 to 2003 shows only a slight decrease in comparison to previous years, the main influencing factors can be assumed for the period before, which is covered by the data set. Moreover, as there were no other data available providing comparably detailed information, the restriction to the period until 2002 seems to be justifiable.

The POLK data provide an excellent source to analyse the car market and to incorporate it into a model estimating consumers' behaviour. However, extensive modifications were necessary to be able to use this data set. Changes in model names, different sources POLK

used and several more reasons are responsible for this. The main adjustments and modifications DLR applied to the data set were:

- CO_2 and fuel consumption figures: The available CO_2 figures are taken as provided, fuel consumption figures according to Directive 93/110/EC were converted to CO_2 considering the factors indicated in the Monitoring Reports, fuel consumption according to Directive 80/1268/EC were multiplied by 1.09 into new Directive values.

  Within an intensive review of the data, observations with implausible CO_2 emissions were identified. For those observations with more than 500 registrations implausible figures were corrected using data from other countries or years or other sources like car magazines and auto catalogues from car drivers clubs (e.g. ADAC). The association of emission values from other sources is possible due to the detailed model description in the POLK dataset.

  Observations with less than 500 registrations and implausible emissions were rejected.

  For approximately 7 % of all registrations from 1995 to 2002 figures on CO_2 emissions or fuel consumption were missing. For observations with more than 6000 registrations the missing values were entered in the same way as for the implausible figures.

  Differing units such as miles per gallon were converted.

- Data on car prices: An extended check became necessary with regard to the car prices. As POLK had transferred technical and price data from other countries to the country of registration, the wrong currency was transferred as well. These observations could be identified for 1995 to 2002 and these prices were rejected. A transformation into the according currency was not possible because of the differing net prices.

  Observations with technical and price data from other countries could not be identified in 1995 (the column indicating this transfer is not available for this year). Therefore, price data for 1995 could not be used for all Member States.

  Concerning the technical details transferred in this way, method and result seemed to be correct.

- Segmentation scheme: Modifications to POLK's segmentation scheme have been applied with regard to vans and Pick-Ups, see the segmentation section below.

- Some more findings from the review of the data set are: The POLK segmentation can not be used for Italy in 1995 because all cars are identified as Off-Road. For Portugal and Spain registrations with respect to Off-Road cars are missing in the early years.

- The correction factor of 0.7 % applied in the Monitoring reports from 2001 is not incorporated here because of excessively onerous difficulties ensuring consistency with other sources.

The substantial modifications DLR applied to the dataset resulted in registrations and emission figures that are very close to the data of the monitoring reports. Skipping implausible and unknown observations led to shortfall of registrations up to 5 % in comparison to the official data. However, it was successfully managed to correct and complete POLK data to only slight CO_2 emission deviations shown in the second table beyond. Systematic deviations appeared for 1995 as the missing registration accounts for 10 % of the total registrations and the average CO_2 emissions are implausibly high. Therefore, the 1995 data are considered for certain analyses only, where the correct content of them could be confirmed.

Table 2: Average specific CO_2 emissions indicated in the monitoring reports for all associations

	1996	1997	1998	1999	2000	2001	2002
Petrol	186	184	182	180	178	173	172
Diesel	178	175	171	165	163	156	157
Total	**184**	**182**	**180**	**176**	**172**	**167**	**166**

Table 3: Average specific CO_2 emissions calculated by the POLK dataset

	1996	1997	1998	1999	2000	2001	2002
Petrol	186.4	184.3	182.6	180.5	176.8	174.9	173.0
Diesel	175.7	174.2	170.9	165.3	160.6	158.3	156.5
Total	**184.0**	**182.1**	**179.7**	**176.2**	**171.5**	**168.9**	**166.4**

3.3 Segmentation of the registration data

The passenger car classification of POLK consists of 13 segments plus unspecified cars. It is based on car models, which means that one specific model is always attributed to the same segment, independent of engine power or price of the various versions. Generally, POLK uses the common known classification of “Small”, “Lower Medium”, etc. Regarding official segmentation schemes such as that of the German car registration agency (KBA) as well as former studies of DLR, the segmentation is regarded plausible and coherent. However, some modifications have been necessary in order to fulfil the needs of this research work:

- Lower Medium cars, indicated as “High Volume” body style were associated to the “Car Derived Vans”. Cars concerned here are e.g. Opel Zafira, Citroen Xsara Picasso, Toyota Corolla Verso etc. Their transport capacity and functionality is different to the common Lower Medium car and is closer to the original segment “Car Derived Vans” comprising e.g. Mercedes Vaneo, Renault Kangoo etc.
- The segments “Off-Road” and “Pick-up” are grouped since the few Pick-up cars have the same technical base and characteristics as the Off-Roaders.
- The segment “Micro Van” (e.g. Piaggio, Daihatsu Hijet) was rejected because of its very few registrations and cars noted there associated to Small or Car Derived Vans.
- “Non car derived vans”, e.g. Mercedes Sprinter, Fiat Ducato, are grouped together with “MPV”, e.g. Chrysler Voyager, Renault Espace, because their functionalities are similar and for most of the Non car derived vans technical data are missing at all.

This modified POLK segmentation is used for the econometric model estimating registrations in relation to non-technical influences (second pillar) in order to group the results in a reasonable way after analysing every single observation independently (see chapter 6). For the CO_2 emission model (third pillar) the segmentation is not applied.

The following Table 4 shows the remaining 10 segments and gives examples for the models included:

Table 4: Modified segments of the POLK registration data

Segment	Example		Segment	Example
Mini	Fiat Seicento, VW Lupo, Peugeot 107, Daewoo Matiz, Daihatsu Cuore		Luxury	Mercedes S-Class, BMW 7 series
Small	Peugeot 206, Ford Fiesta, Kia Pride, Toyota Yaris		Sport	Audi TT, Fiat Coupe, Toyota Celica, Opel Calibra
Lower Medium	Opel Astra, Renault 19/Megane, Hyundai Accent, Honda Civic		Off-Road	Toyota RAV4, Suzuki Vitara, Mitsubishi Pajero, BMW X5, Land Rover
Medium	VW Passat, Mercedes C-Class, Volvo S 60, Nissan Primera, Citroen Xantia		Car Derived Vans	Fiat Doblo, Peugeot Partner, Opel Zafira, Mazda Premacy, Nissan Alm. Tino
Upper Medium	BMW 5 series, Citroen XM, Toyota Camry, Audi A6		MPV (Multi Purpose Vehicles)	Ford Galaxy, Peugeot 806/807, Toyota Avensis Verso, Kia Carnival

For the description of the passenger car market, this segmentation was regarded as too inaccurate. A shift of registrations from lower to higher powered cars or vice versa within the same segment is not represented. Especially the Medium segment (e.g. BMW 3 series or Audi A4) shows a large variety of engine versions, and also the Off-Road segment is very scattered when recalling the range from a Suzuki Vitara 1.6 l, 69 KW to a Range Rover with up to 4.3 l and 210 KW. Therefore, sub classes were incorporated in most of the segments separating the higher powered from the lower powered versions.

4 Descriptive analysis

Before analysing possible influences on new car purchases the passenger car market is described in general terms. This description serves as a background for the following econometric analyses as well as a direct input for the descriptive analysis. Initially, the supply side of the passenger car market is described by engine versions and the body types for the cars offered between 1995 and 2003 (see Chapter 4.1). These two aspects are assumed to be most relevant for peoples' choice of a certain model version.

Chapter 4.3 to 4.5 describe the demand side of the passenger car market. This comprises an analysis of the trend in the physical attributes of registrations and the share of segments and engine power classes. Furthermore, a closer look is given into the development of certain segments and Member States, including the range of CO_2 emissions.

The structural changes of the passenger car market found out will then be analysed for their influence on total average CO_2 emissions in Chapter 4.6.

4.1 Supply side: Offered model range

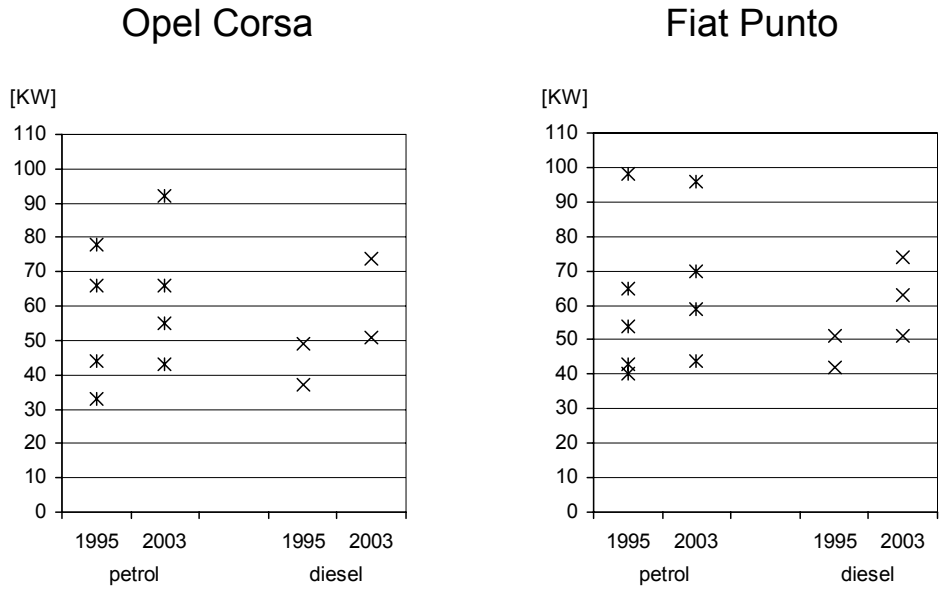
At the first glance, the variety in body types would not be relevant for the task given in this study, rather equipment packages do. Offering more convertibles or coupes does not affect CO_2 emissions in principle. When going more into details, things change. So called Mini Vans (in this study named Car Derived Van) are offered in nearly every carmakers' model range, and the trend to offer at least one SUV (in the segmentation here still called Off-Road) is obvious. Since these body styles show a higher weight and aerodynamic drag than the conventional saloons (sedans) they should be analysed.

As in the other chapters the segments are used here for structuring the description. For every segment the car types most sold were analysed to show the offered model range. The indicated figures for engine power represent the versions mainly sold in these years. Overlapping cases, i.e. when manufacturers offered an old and new engine version with a slight power difference simultaneously are ignored here. Extraordinary sport versions with very few registrations are neglected as well. In nearly every segment there is a variety of offered body types like Hatchback, Saloon, Estate and Coupe. In this respect, fundamental changes could not be observed, but general increases in a segment's offer and nearly new segments themselves appeared and are given in the following paragraphs.

In the smallest of the segments, the **Mini** segment, only few brands offered cars in 1995 as there were PSA (106/AX), Renault (Twingo) and Fiat (Cinquecento). They provided some petrol versions in the range of 30 to 55 KW and - with the exception of PSA - no diesel. With the introduction of the VW Lupo - Seat Arosa twins, Ford Ka and the Smart, the Mini segment has grown up significantly until 2003 and represents more than a niche as it did before. Some stronger versions were available and most of the manufacturers offer nowadays diesels.

In the **Small** segment the power of the lower motorised petrol versions remained steady at slightly above 40 KW from 1995 to 2003, only few manufacturer had 33 KW base versions in 1995. In contrast, the power of the mid and upper versions was generally raised. Power figures of the diesel versions experienced a substantial increase. Two diesel versions were offered mostly while the low powered one by 2003 often exceeds the strong version of 1995. As typical examples Figure 2 shows the offered engine versions of the Opel Corsa and the Fiat Punto.

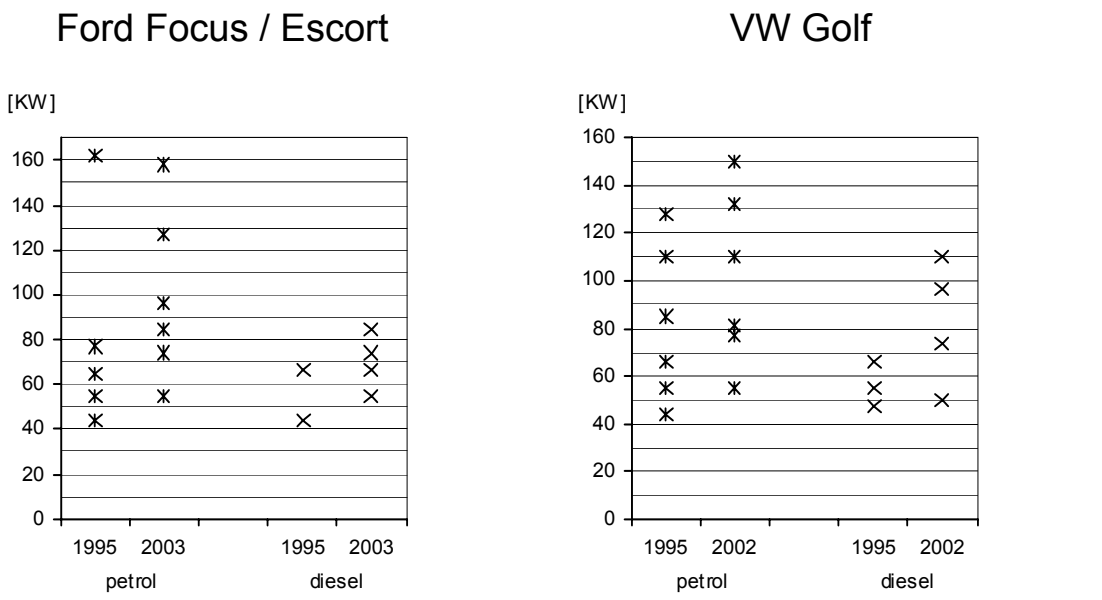
Figure 2: Engine versions of Opel Corsa and Fiat Punto (Small segment)



Some brands offer cars in the Small segment for the first time during the investigation period, especially the “premium” ones with the Mini of the BMW Group and the Audi A2. Therefore, a significant increase of offered models can be stated for this segment.

For cars of the **Lower Medium** segment a clear increase in power can be stated. Power outputs were stretching from approximately 45 KW to 90 KW in 1995, increasing to a range of 55 KW to good 100 KW in 2003. Significant changes appear in the diesel section of this segment. Not only power increased remarkably but also the number of available versions. Offers were expanded from 2 versions (nearly 50 to 66 KW) in the base year to three or four versions (topped by 90, even 110 KW) in the major review year of 2003. Figure 3 illustrates the model range of the Volkswagen Golf and the Ford Escort/Focus. Similar to the Small segment an increase of brands offering cars in this segment can be stated. The Audi A3, Mercedes C-Class Sportcoupe and – depending on ones view – the Mercedes A-Class supplemented the segment with alternatives ranging in the upper price range. In contrast, new cars of KAMA (Kia Rio, Shuma) completed this segment on the lower price level.

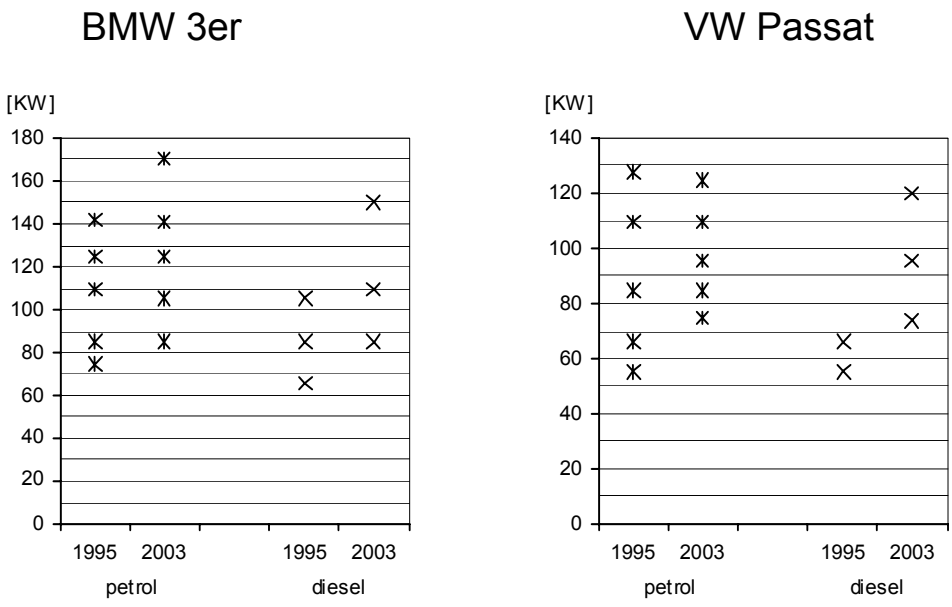
Figure 3: Engine versions of Ford Focus/Escort and VW Golf (Lower Medium segment)



2002 was selected because of the renewed Golf in 2003

The development in the **Medium** segment was similar to the Lower Medium since the power increased in general as well. Base versions of almost 55 to 60 KW (both petrol and diesel) were disposed during the investigation period. By 2003 the low engined versions produced approximately 80 KW for both fuel types. In the case of diesel additional high engined versions were available in 2003. This trend can be followed by the examples of the BMW 3 series and the Volkswagen Passat. Medium sized cars did not experience expanding offers in general.

Figure 4: Engine versions of BMW 3 series and VW Passat (Medium segment)



The trend in engine versions of the **Upper Medium** and the **Luxury** segments was similar to the Medium segment. A general shift to stronger powered petrol cars came up, accompanied by an even higher shift upwards regarding the diesel versions. Especially for the Luxury class more diesel versions have been made available whereas in the Upper Medium the availability was already high in 1995.

The **Off-Road** segment has expanded remarkably in the investigation period. New models could be observed in both, the smaller as well as the larger Off-Roads. The latter was the particular subject of German manufacturers, e.g. launching the ML-Class (Mercedes), the X5 (BMW) and the Touareq (Volkswagen). With respect to their performance and luxury equipment standard they can be also be seen as competitors with the Luxury segment.

For small and mid-size Off-Roaders an increasing range of models can be stated as well, especially concerning brands of JAMA and KAMA. Here, the Mitsubishi Pajero Pinin, the Honda HR-V and CR-V and some other more models entered the market.

Car derived vans like Opel Zafira and Renault Scenic were rarely available in 1995. Until 2003 a bunch of models were launched by nearly every manufacturers. Japanese and Korean manufacturers participated in this development to a high degree, e.g. with the Toyota Corolla Verso, the Mazda Premacy or the Hyundai Trajet. Since the technical base of this car derived vans is mostly a model of the Lower Medium segment the engine versions of them are nearly identical, excepted by the base and highest powered version mostly. When including models like Renault Kangoo or Fiat Doblo, which are also available as a commercial version and represent a kind of simple equipped car, the available price and power range starts significantly lower.

The number of versions of the bigger **vans (MPVs)** like Renault Espace and Fiat Ulysse did not increase concerning single models. The offered models went up slightly considering e.g. Mercedes V-Class and Mazda MPV. Similar to the Medium and Upper Medium cars, especially the engine power of the diesel versions increased. However, MPVs often share the engine with these type of cars.

Sports cars and cabriolets are increasingly supplied, especially in the lower and Medium power and price range.

More important seems to be the launching of high volume cars technical based on the Small segment like the Toyota Yaris Verso and the Opel Meriva. They dispose of the same variability and space advantage to their technical base as the car derived vans do, merely the option for a sixth and seventh seat is not given. Currently Toyota offers a “Verso” version, i.e. a high volume version, for its Small (Yaris), Lower Medium (Corolla) and Medium (Avensis) sized car, supplemented by the Previa called large MPV. Summing up, for nearly every size class of cars a van or high volume is established obviously.

A contrary trend appears when one looks into cooperations and mergers of manufacturers, which provide the possibility to share engines and other relevant technical modules. For instance, cooperation of Ford and PSA (and the take-overs by Ford) resulted in shared platforms and engines, so the same or very similar diesel engines are used in several Ford models, Jaguar, Land-Rover, Mazda, Volvo, Citroen and Peugeot. The same situation occurs when looking at General Motors with regard to Opel, Saab, Suzuki and Fiat as well. However, manufacturers are emphasizing the different characters of their brands and follow the strategy to address different consumer groups with the different cars. Therefore, nearly all similar versions or models can be treated separately.

It can be concluded that

- the number of engine versions increased, especially for diesel cars
- In nearly all segments there is a trend to higher engine power

- Some Small cars keep their base version
- The trend to higher power is very significant for diesel
- The number of body styles offered has increased remarkably during the investigation period
- Lots of niches were discovered and served

4.2 Supply Side: Technologies applied

Between 1995 and 2003 car manufacturers introduced several technologies to lower fuel consumption. At the same time consumer needs led to additional features, which had a negative impact on cars' efficiencies. Both developments are shortly described in the following section highlighting on engine technologies, transmission types and vehicle weight. For influence by regulations see Chapter 5.2.5.

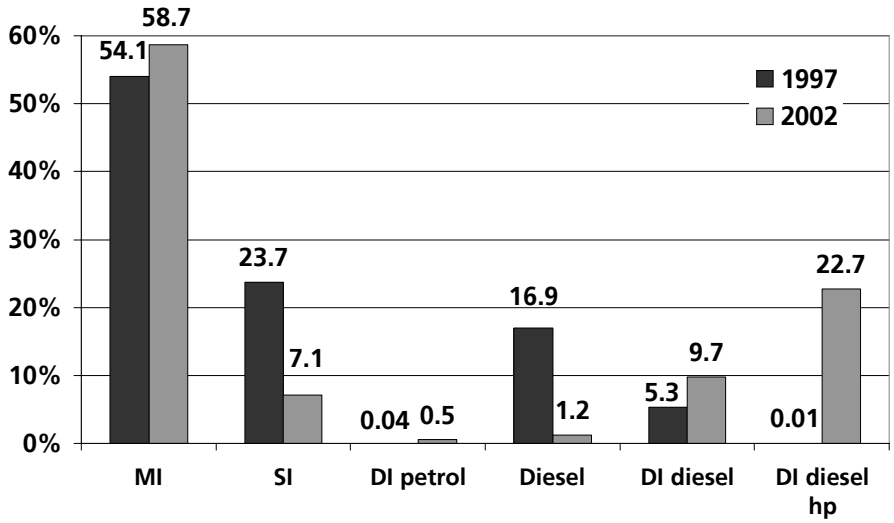
Engine technologies

Since 1995 the petrol engines have experienced a number of improvements, as there is the use of new lightweight materials, electronic control systems for ignition and fuel injection and reduced internal friction. For the given time period, the change from the singlepoint to the multipoint injection as well as the introduction of variable valve train, direct injection and port deactivation is important. While the multipoint injection was introduced in the majority of petrol cars, the other technologies are only scarcely available. Mostly there are only single versions with the advanced combustion technologies offered.

Concerning the direct injection of diesel cars, a clear picture appears. In 1995 only Volkswagen/Audi offered some versions of its TDI, all other manufacturers started in the following years. In 2003 nearly all segments and models were equipped with direct injection engines, partly by the second and third generation with high pressures.

In Figure 5 the shares of different fuel preparation systems are given. Due to a lack of this information for 1995 and 1996, data of 1997 are taken. It appears that nearly all petrol cars used a multipoint injection in 2002, but the share of petrol direct injection engines is still very low. Concerning the diesel, indirect injections are removed nearly completely and even the first generation of the direct injection systems plays only a minor role in 2002.

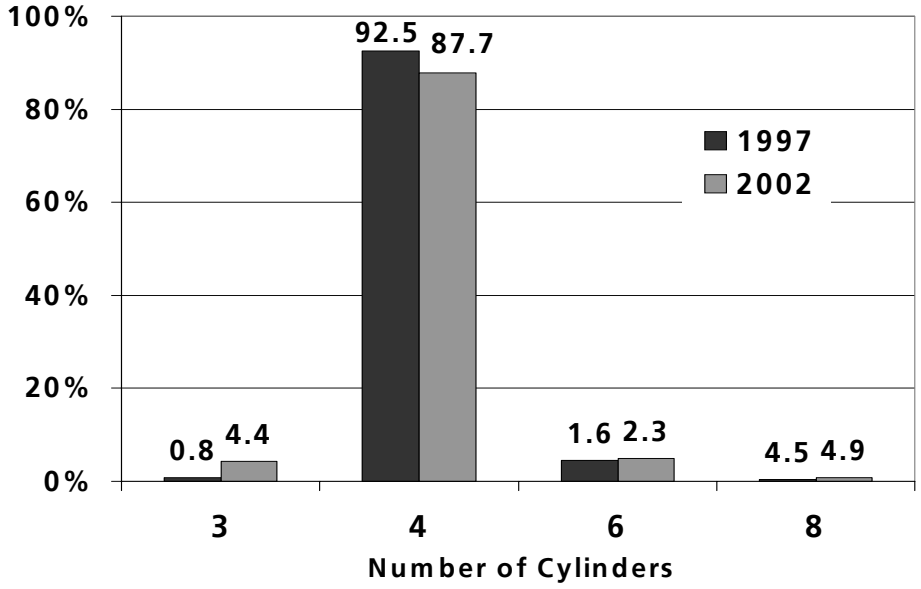
Figure 5: Share of fuel preparation systems applied



MI: Multipoint injection; SI: Singlepoint injection; DI: Direct injection;
DI diesel hp: high pressure diesel

A kind of downsizing can be recorded when looking into the number of cylinders. The share of new registered cars with three cylinders increased remarkable from 1997 to 2002. Since the engine capacity did not change significantly, but the engine power has increased, a downsizing in terms of higher efficiency per cylinder can be stated (see Figure 6).

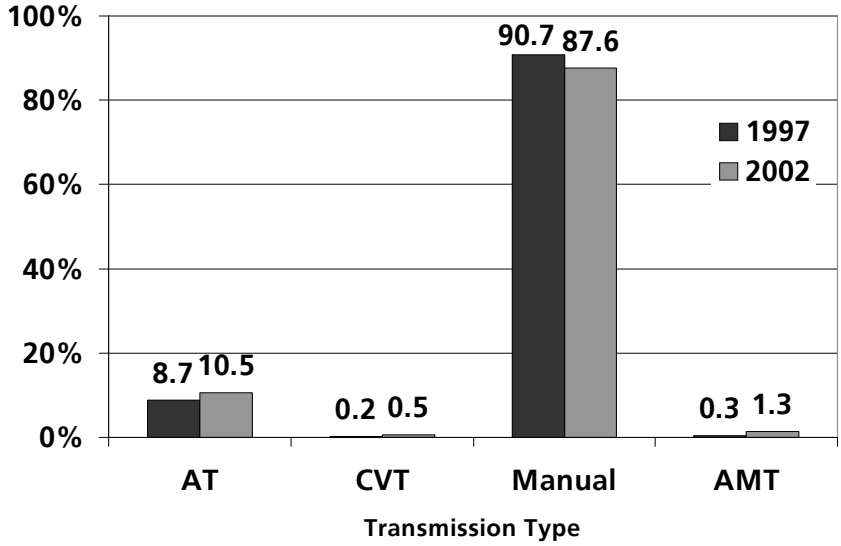
Figure 6: Share of engine versions by cylinders



Transmission technologies

A number of improved gearboxes were introduced into the market during the investigation period, e.g. the automated manual transmission and continuously automatic transmissions. Beside higher comfort they should eliminate the fuel consumption penalties in comparison to the manual gearboxes, especially for the lower segments. The potential to be found in literature is from 3 % (improved 6 gear manual transmission) up to 10 % when a conventional automatic transmission is replaced by an advanced automatic gearbox. However, when looking into the share of gearboxes of new registrations (see Figure 7) it appears that only the improvements of manual gearboxes could have had a substantial influence on CO_2 emissions.

Figure 7: Share of transmission types of new registrations



AT: Automatic transmission (conventional), CVT: Continuously variable transmission, AMT: Automated manual transmission

Vehicle weight

A crucial aspect of car technology is always the weight. According to the Monitoring reports the average weight was around 1.100 kg in 1995 and increased by nearly 100 kg until 2002. Several comfort and safety features that contribute to the increase can be clearly identified (additional weights according to Mercedes-Benz's Upper Medium E-Class by 1996[9]):

Driver and front passenger airbags:	8.5 kg
Sidebags:	5.0 kg
Anti-block braking system:	2.8 kg
Electronic stability program	0.2 kg
Electric sunroof:	20.7 kg
Air conditioning:	2.4 kg
Electric windows:	4.1 kg
Central locking system:	2.6 kg

[9] Motor Presse Stuttgart, (1997).

In 1995 Anti-block braking systems and airbags did not belong to the standard equipment for most of the cars. Only the higher powered versions and Upper Medium segment cars were equipped. The mentioned comfort features were neither included in the majority of cars in 1995 but their share has increased remarkably until 2003. When calculating the additional fuel consumption, a frequently published benchmark of 0.3 to 0.5 litre[10] per 100 km for 100 kg additional weight could be used which would result in an impact on average CO_2 emissions of about 1.5 to 2 g/km for an additional weight of 15 - 20 kg (see also Chapter 5.2.5, Influence by improved safety performance). However, light materials, new body designs and reduced weight of additional features partly compensated the growth in kerb weight. For instance, Audi announced for its Medium segment A4 a weight increase of 160 kg due to comfort, safety and improved emission standards but a reduction of 110 kg through light materials on the other hand (comparing the 1994 model with the 1999 model).

To which extend the technologies mentioned above have contributed individually to the achieved CO_2 reduction can hardly be calculated. Single efficiency values of technical units would be necessary associated to the share of cars applied with, leading to an accurate Tank-to-Wheel analysis. An alternative would be to compare versions that are offered with and without a specific technology. However, this causes difficulties arising from the fact that manufacturers introduce by majority not only a single technology but a bundle of measures including modifications at the whole drivetrain including the transmission. Moreover, the introduction of new technologies is often accompanied by new equipment standards leading to changing weights.

Alternatively the influence of technical attributes on CO_2 emissions will be analysed by means of an econometric model in chapter 6.3. There, average values of all newly registered cars are taken into account.

4.3 Demand Side: New car registrations and their physical characteristics

The monitoring system (Decision 1753/2000/EC) provides objective data on new registrations and a range of vehicle characteristics. They include specific emissions of CO_2, fuel types, mass, engine power and engine capacity. These data have been analysed in detail and results can be found in the Annex 3 of this report. Main findings are summarised below und are then used for selected analyses of car types and segments in Chapter 4.5.

The analysis of the monitoring data was generally intended to identify any indications whether there have been significant changes in the behaviour of new car purchasers between 1995 and 2003. Actually, results have to be interpreted carefully as the choice of the consumers is closely interrelated on the offered model range of the manufacturers and is therefore not free in ignoring or accepting new technologies.

The average weight of newly registered M1 vehicles increased in all Member States in the analysis period, the CO_2 emissions were decreasing in all Member States. The decrease of the CO_2 emissions was very stable for all Member States. In some Member States, developments seem to be interrelated. For example, in the case of Denmark, the strong drop in diesel CO_2 emissions seems to correspond with the decreasing weight figures and the diesel registrations numbers.

For Italy a parallel development appears for 1996/1997, when the strong CO_2 decrease rate (4.5 %) corresponds with the decrease in average weight and overall registrations were increasing by about 35 % simultaneously. Therefore, more vehicles with a lower weight have

[10] These technical values correspond to the model estimations in chapter 6 on the sensitivity of CO_2 emissions to changes in the kerb weight. These are observed on the market and already incorporate mitigation measures by technological improvements.

been registered during that year. This indicates that there might be non-technical reasons for this temporary development.

In the UK a strong engine power increase occurs in 2002, but the CO_2 emissions decreased. When comparing developments of the whole investigation period a correlation can not be stated in the same manner, because the increase in engine power is constant as well as the decrease in CO_2 emissions. However, total registrations of diesel cars rose in the UK by 2002, unlike in most other Member States. Therefore, the high increase in engine power 2002 seems to correlate with the high increase in registrations.

The most significant developments identified from the Monitoring reports between 1995 and 2002 are as follows:

- Italy: a 40 % increase of registrations in 1997; continuous and steep increase of diesel registrations, more than four times more diesel in 2002 compared to 1995.
  An extraordinary decrease of vehicle mass can be stated in the year 1997; afterwards the average mass per vehicle was increasing again. For petrol and diesel, the development is similar.

  In 1997 the average engine power decreased remarkably compared to 1996. In the main, petrol vehicles were causing that decrease. After 1997 the total increase occurred because of increasing diesel values.

- France: a 20 % decrease of total registrations in 1997. France recorded a continuously high engine power increase especially for petrol cars.

- Germany: Registrations drop by 13 % in 2000; generally, fewer cars were registered by 2002 compared to 1995.

  Germany and Austria are the only Member States showing a mass decrease in 2000 and 2001, whereas the petrol and diesel development is similar. In the year before, an extraordinary increase occurred in Austria. At least for Germany, this development is similar to the development of the total registrations.

- Spain: highest overall growth rate in registrations of the large Member States and strong increase of the diesel share.

- UK: unusual increase of registrations in 2002 (whereas in most countries numbers went down in that year)

  Unusual increase of petrol registrations (higher values 2002 than 1995), decrease of diesel until 2000; Diesel cars experienced a power increase well above average by 2002.

- Denmark: Decreasing registrations after 1998, 20 % less registrations 2002 compared to 1995. Strongest diesel increase of all countries when comparing 1995 to 2002. The development for petrol and diesel concerning mass is not similar. The average mass of the diesel registrations is decreasing after 1997 and drops below the value of 1995 in 2000 and 2001.

  For the average engine power of diesel cars an unusual development can be stated. Values increased in 2002 just by 9 % compared to 1995, which is the lowest increase of all Member States. Total and petrol values are within the average range though.

- In Portugal a constantly high power increase appeared for diesel cars.

As a result, changes of the structure of the new passenger car fleet in certain countries can be stated, which are most certainly caused by changes in consumers' behaviour to a certain extend. For these Member States a more detailed analysis would be needed. However, with regard to limited resources a selection has to be done with regard to the impact on the CO_2

average in Europe. Considering the share of registration of these countries in Europe as well as the share of certain segments, the Lower Medium segment is selected for further investigations for Spain, France and the United Kingdom. Furthermore Small cars in Italy are subject of the following sections.

4.4 Demand side: Segment development

As the description of the offered model range in the previous section shows, the number of engine versions have increased during the investigation period and especially the engine power of diesel versions was boosted. In this section, the registrations per segment are analysed in order to find out whether purchasers had followed the given trend or not.

Preliminary set of segmentation data

Initially, a preliminary set of segmentation data covering the years 1995 to 2001 provided by POLK is analysed. Characteristic trends of individual Member States occurring from these data are summarised below. Since the main analyses for the given task is carried out with in-depth data enabling a more reasonable segmentation[11], results at full length concerning the preliminary data set are to be found in Annex 4.

In Germany, the shares of the Mini and Lower Medium segments are relatively high. In addition, the share in the Luxury-segment is highest in the EU15. In Italy, the smaller segments are still dominant. Mini, Small and Lower Medium share nearly 80 % of total new registrations (2001) while registrations of Medium and Upper Medium vehicles decreased during the investigation period. For France it can be observed that, in contrast to other Member States, no increase occurred in the Mini segment and the share of MPVs is constantly high (approx. 5 %). In Spain, the greatest concentration is recorded in the Lower Medium segment, which has more than 45 % of all registrations. A significant characteristic of registrations in the United Kingdom is the relatively even distribution of segments: Three segments (Lower Medium, Small and Medium) range between 20 and 35 %; all other segments are below 5 %.

Austria shows a very high portion of Off-Road and MPV, but Belgium has the highest share of MPV of all Member States. Portuguese registrations of Small segment cars decreased strongly while there were increases for Lower Medium and Medium.

Disaggregated registration data

In order to further analyse the shift to stronger powered cars and general increase of available versions in certain segments, the segmentation analysis above is supplemented by the analysis of disaggregated registration data, provided by POLK as well. This segmentation scheme is described in Chapter 3.3 but is distinguished from the preliminary data by a separated segment for Car Derived Vans like the Opel Zafira, Renault Scenic etc. and allows some substantial modifications (see Chapter 3.2). Therefore, the Lower Medium does not show an increases but a decrease when applying the detailed and modified data. This can be explained by attributing a number of models to the Car Derived Vans rather than to the Lower Medium segment itself.

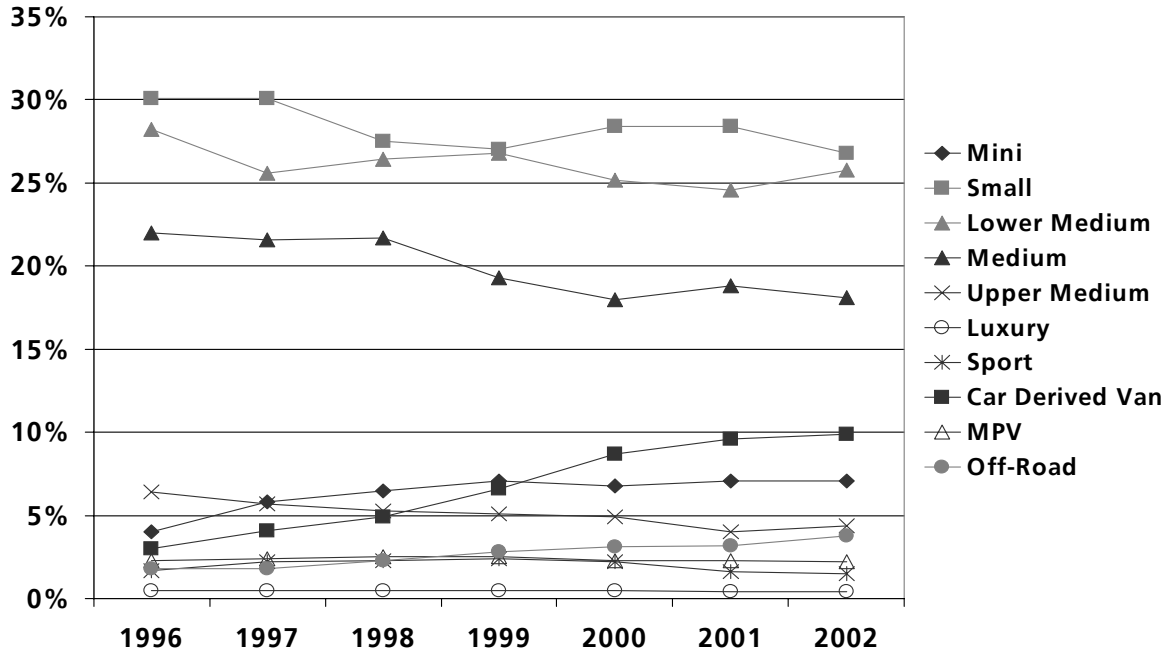
The structural development including all manufacturers associations can be seen in Figure 8. Cars of the Small and the Lower Medium segments dominate the new registrations and mirror each other to some extent, but the combined total of the two underwent a decrease of its

[11] The segmentation of the preliminary data set is not identical but similar to the in-depth data provided by POLK for the main analysis (see modifications by DLR and description in chapter 3.3).

market share from approximately. 58 % in 1996 to 53 % in 2002[12]. Moreover, slumps are recorded for the Medium and Upper Medium segment (22.0 % to 18.1 % for Medium and 6.4 to 4.4 % for Upper Medium). Luxury, Sport and Multi Purpose Vehicles (MPV) decreased slightly, though it is noted that these segments already comprised a relatively low share of the overall market.

Large increases can be seen in particular for Car Derived Vans, which more than tripled, and also for Off-Road (doubling) and Mini.

Figure 8: Registrations by segment for all associations (EU 15)



ACEA

When analysing the structural development for the European manufacturers separately (see Figure 9), similar findings as for the total fleet are revealed. Medium and Upper Medium cars are slightly less affected from the negative trend. The share of Off-Road cars ranges are only half the level observed for all associations, but show the same increasing trend.

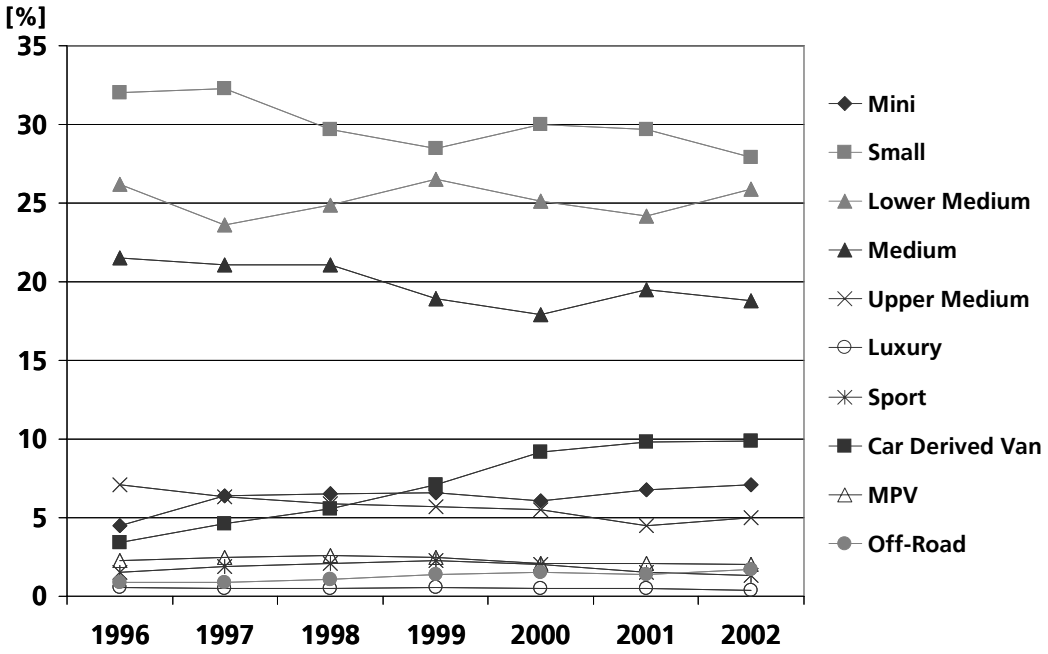
For ACEA's fleet an overall increase of the diesel share of 23.9 % in 1996 to 43.0 % in 2002 is recorded. With regard to the diesel share of each segment an above average value can be stated for Medium, Upper Medium and Car Derived Vans, as seen in Figure 9. There diesel share doubled in the time period of investigation. The increase of diesel cars in the Lower Medium segment is lower but still above the average.

For Small and Luxury cars, a doubling in the diesel share can be seen but on a level below the average diesel share. Diesel versions in the Mini segment just entered the market.

Off-Road cars and MPVs had already a very high level of nearly 50 and 60 % diesel cars, respectively, in 1996 and increased it further to approximately 72 and 81 % in 2002.

[12] As substantial inconsistencies occurred for figures by 1995, all the following comparisons are related to the period from 1996 to 2002.

Figure 9: Registrations of ACEA by segment and diesel share (EU 15)



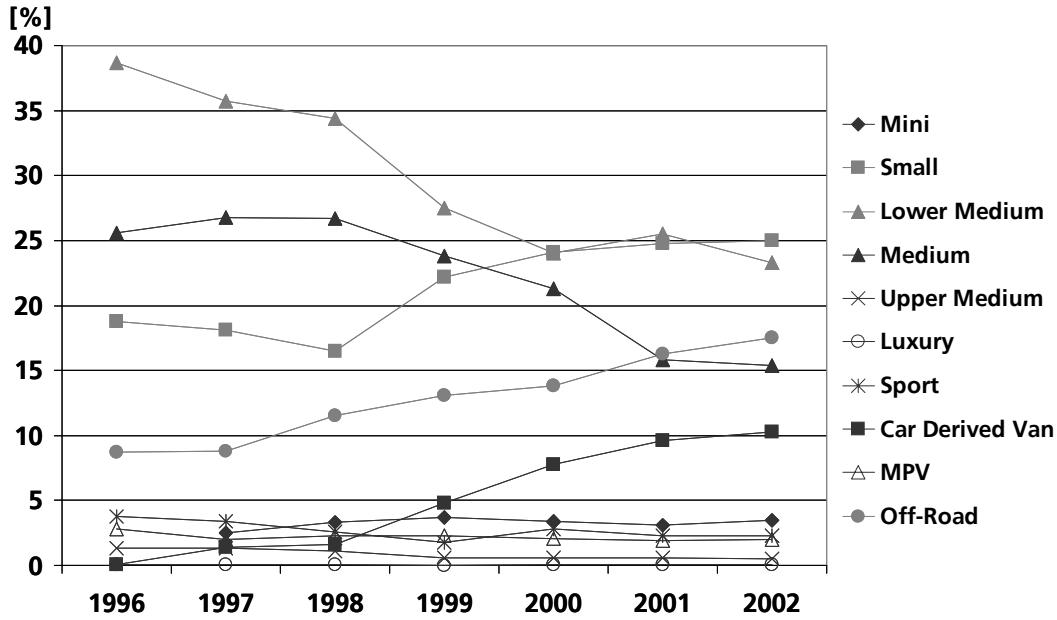
Share of Diesel	1996	1997	1998	1999	2000	2001	2002
Mini	-	-	0.9%	2.5%	3.8%	5.9%	4.6%
Small	14.0%	13.8%	16.4%	19.9%	22.9%	24.9%	27.2%
Lower Medium	29.1%	13.2%	32.3%	36.9%	43.4%	44.9%	48.3%
Medium	32.7%	23.3%	38.0%	44.6%	48.9%	53.8%	59.4%
Upper Medium	30.1%	27.1%	32.6%	39.4%	45.4%	49.2%	57.3%
Luxury	12.9%	14.1%	14.5%	11.0%	29.8%	37.6%	31.9%
Sport	-	-	-	-	-	-	
Off-Road	58.6%	45.3%	46.8%	47.6%	58.6%	59.8%	71.9%
MPV	48.3%	28.6%	56.5%	63.7%	72.0%	74.3%	80.6%
Car Derived Van	27.6%	30.2%	34.3%	36.8%	43.6%	52.5%	56.1%

JAMA

The development of the segment structure of the Japanese manufacturers is presented in Figure 10. Significant is the relatively high share of Off-Road cars, which accounted for almost 9 % in 1996 and increased to nearly 18 % in 2002. A stronger increase but on the same level as ACEA is recorded for the Car Derived Vans, which were introduced at the beginning of the investigation period and reached almost 10 % market share in 2002. Cars belonging to the Small segment increased in that time as well (18.5 % to 25.0 %) while the Lower Medium and Medium segments combined experienced significant losses from 65 % to 39 %. The market share of the other segments was mostly below 3 %.

Diesel cars were less important for JAMA than for ACEA considering their share of registrations. However, JAMA's overall diesel share followed the general trend and increased from 10.2 % in 1996 to 22.1 % in 2002. All segments for which diesel engines have been available contributed to this development, only Off-Road cars had a lower increase rate, however, at a higher level.

Figure 10: Registrations of JAMA by segment and diesel share (EU 15)



Share of Diesel	1996	1997	1998	1999	2000	2001	2002
Mini	-	-	-	-	-	-	-
Small	-	-	-	-	-	-	-
Lower Medium	5.7%	5.6%	6.7%	9.7%	12.5%	18.2%	14.3%
Medium	14.0%	14.9%	15.6%	17.7%	20.2%	14.3%	25.9%
Upper Medium	-	-	-	-	-	-	-
Luxury	-	-	-	-	-	-	-
Sport	-	-	-	-	-	-	-
Off-Road	42.8%	41.1%	39.6%	36.4%	40.1%	38.9%	46.6%
MPV	23.7%	5.4%	25.9%	14.7%	8.8%	35.5%	56.2%
Car Derived Van	-	-	35.4%	14.3%	19.9%	27.5%	34.3%

The detailed registration data and its segmentation scheme are modified further by introducing sub-groups based on engine power. The power classes are established on the basis of the market offer analysis. They divide the segments either at the approximate average of the offered versions' engine power or at a significant limit from which emission go up extraordinary. Table 5 presents the segments and its sub-groups.

Table 5: Modified segmentation including sub-groups

	Petrol	Diesel
Mini	< 45 KW	-
	≥ 45 KW	
Small	< 60 KW	-
	≥ 60 KW	
Lower Medium	< 80 KW	< 65 KW
	≥ 80 KW	≥ 65 KW
Medium	< 110 KW	< 80 KW
	≥ 110 KW	≥ 80 KW
Upper Medium	< 110 KW	< 110 KW
	≥ 110 KW	≥ 110 KW
Luxury	< 180 KW	-
	≥ 180 KW	
Sport	< 110 KW	-
	≥ 110 KW	
Off Road	< 130 KW	< 90 KW
	≥ 130 KW	≥ 90 KW
MPV	< 110 KW	< 80 KW
	≥ 110 KW	≥ 80 KW
Car derived vans	< 80 KW	< 80 KW
	≥ 80 KW	≥ 80 KW

From analysing the registrations of the established car groups (see Table 6) and their changes, a development corresponding to the supply side appears as a clear trend towards buying higher engined cars can be observed. With regard to the amount of ACEA's registrations, the trend towards higher power resulted in a loss of the lower powered groups, e.g. the lower powered Small, Lower Medium and Medium cars amounted to 74.4 % of all petrol cars in 1996, but to only 59.3 % in 2002. The increasing share of offered Car Derived Vans and Mini segment cars is reflected in a general growth of registration for both power classes of these segments.

Loss and growth for diesel cars are much more significant than for petrol cars when looking into the proportion within the fuel types. While the lower powered groups of Lower Medium and Medium accounted for 41.6 % of all diesel cars in 1996, their share dropped to 9.5 % in 2002. This slump was less enormous in absolute terms (approx. 0.55 millions) but affected by the overwhelming boost of higher powered diesel cars, which achieved a growth of 1.8 million cars for Lower Medium and Medium. Concerning the Car Derived vans, registration figures reflect clearly the emerging character of the segment.

Table 6: Registrations for ACEA per segment sub-group 1996 and 2002 (EU 15)

Change of registrations for petrol cars				
	1996	**2002**	**Change**	**Change %**
Mini < 45 KW	465356	567135	101779	21.9%
Mini ≥ 45 KW	4092	218174	214082	5231.7%
Small < 60 KW	2752629	2079684	-672945	-24.4%
Small ≥ 60 KW	92842	277773	184931	199.2%
Lower Medium < 80 KW	1680330	1226588	-453742	-27.0%
Lower Medium ≥ 80 KW	240978	352254	111276	46.2%
Medium < 110 KW	1415691	646245	-769446	-54.4%
Medium ≥ 110 KW	80484	248832	168348	209.2%
Upper Medium < 110 KW	309836	56259	-253577	-81.8%
Upper Medium ≥ 110 KW	199632	190944	-8688	-4.4%
Luxury < 180 KW	30648	8094	-22554	-73.6%
Luxury ≥ 180 KW	20706	26481	5775	27.9%
Sport < 110 KW	117671	30758	-86913	-73.9%
Sport ≥ 110 KW	36687	120450	83763	228.3%
Off-Road < 130 KW	24585	19152	-5433	-22.1%
Off-Road ≥ 130 KW	16068	37224	21156	131.7%
MPV < 110 KW	93937	31825	-62112	-66.1%
MPV ≥ 110 KW	26282	13124	-13158	-50.1%
Car Derived Van < 80 KW	241091	353989	112898	46.8%
Car Derived Van ≥ 80 KW	13830	150361	136531	987.2%
Total	7863375	6655346	-1208029	-15.4%
Change of registrations for diesel cars				
	1996	**2002**	**Change**	**Change %**
Mini	0	38272	38272	
Small	464517	878933	414416	89.2%
Lower Medium < 65 KW	441911	176154	-265757	-60.1%
Lower Medium ≥ 65 KW	348498	1299017	950519	272.7%
Medium < 80 KW	586418	303849	-282569	-48.2%
Medium ≥ 80 KW	139674	1005911	866237	620.2%
Upper Medium < 110 KW	219424	133080	-86344	-39.4%
Upper Medium ≥ 110 KW	0	199304	199304	
Luxury	7595	16230	8635	113.7%
Off-Road < 90 KW	48491	36556	-11935	-24.6%
Off-Road ≥ 90 KW	9013	107355	98342	1091.1%
MPV < 80	92172	23730	-68442	-74.3%
MPV ≥ 80	20228	162826	142598	705.0%
Car Derived Van < 80 KW	96966	574024	477058	492.0%
Car Derived Van ≥ 80 KW	0	71277	71277	
Total	2474907	5026518	2551611	103.1%

Table 7 and Table 8 present average CO_2 emissions by segment for the years 1996 and 2002 and the associated percentage change over that time interval. By combining these figures with the share of registrations by segment (which can be calculated from Table 6), it is possible to calculate the overall CO_2 emission reductions across all segments for ACEA automobiles. For the case of petrol cars, a total reduction of 7.3 % is achieved (186.5 to 172.8 g CO_2 per km), compared with a reduction of 11.0 % for diesel autos (173.1 to 154.1 g CO_2 per km) for the time period between 1996 and 2002. The most significant reduction with regard to petrol cars can be found for some small and large segments: For Off Road and Small, for example, as well as for the classes of Mini and Luxury, reduction rates ranging from 6.5 to 17.6 % are recorded.

As in the case of petrol cars, the smaller segments of diesel cars show the highest CO_2 reduction rates, reaching around 20 %. For nearly all of the larger car segments, average reduction rates of 10 to 12 % are recorded. Weaker improvements in reducing emissions are observed for the higher powered Lower Medium and Medium cars, what affects substantially the total result because of the high registration numbers in these groups.

Table 7: CO_2 emissions for ACEA per segment sub-group 1996 and 2002 (EU 15)

Change of CO_2 for petrol cars (g/km)			
	1996	**2002**	**Change %**
Mini < 45 KW	155.2	145.2	-6.5%
Mini ≥ 45 KW	185.4	156.0	-15.8%
Small < 60 KW	163.8	146.3	-10.7%
Small ≥ 60 KW	185.3	169.1	-8.8%
Lower Medium < 80 KW	184.7	168.6	-8.7%
Lower Medium ≥ 80 KW	194.8	194.6	-0.1%
Medium < 110 KW	205.9	193.3	-6.1%
Medium ≥ 110 KW	230.3	230.5	0.1%
Upper Medium < 110 KW	229.0	220.0	-3.9%
Upper Medium ≥ 110 KW	243.7	246.9	1.3%
Luxury < 180 KW	277.7	279.3	0.6%
Luxury ≥ 180 KW	326.9	290.1	-11.3%
Sport < 110 KW	192.4	188.4	-2.1%
Sport ≥ 110 KW	272.3	252.6	-7.2%
Off-Road < 130 KW	303.7	250.4	-17.6%
Off-Road ≥ 130 KW	384.1	338.6	-11.8%
MPV < 110 KW	246.7	230.8	-6.5%
MPV ≥ 110 KW	287.6	285.7	-0.6%
Car Derived Van < 80 KW	179.8	174.6	-2.9%
Car Derived Van ≥ 80 KW	213.0	194.3	-8.8%

Change of CO_2 for diesel cars (g/km)			
	1996	**2002**	**Change %**
Mini	0.0	96.7	
Small	154.6	124.6	-19.4%
Lower Medium < 65 KW	167.7	133.1	-20.6%
Lower Medium ≥ 65 KW	157.4	144.0	-8.5%
Medium < 80 KW	175.8	151.7	-13.7%
Medium ≥ 80 KW	173.4	164.0	-5.5%
Upper Medium < 110 KW	196.7	176.4	-10.3%
Upper Medium ≥ 110 KW	0.0	198.3	
Luxury	254.3	224.9	-11.6%
Off-Road < 90 KW	249.7	228.0	-8.7%
Off-Road ≥ 90 KW	291.8	258.2	-11.5%
MPV < 80	203.6	183.8	-9.7%
MPV ≥ 80	215.2	188.1	-12.6%
Car Derived Van < 80 KW	177.9	157.6	-11.4%
Car Derived Van ≥ 80 KW	0.0	163.8	

From the segmentation analysis, a first conclusion for the ACEA fleet can be drawn that a trend towards higher powered cars, in particular among diesel cars, and towards an increase in the number of versions appeared. Reductions in the specific CO_2 emissions are observed for all segments, with the tendency of above average reductions for petrol segments which gained market shares. Furthermore, for the most important segment – Small cars – high specific CO_2 reductions were recorded both for petrol and diesel.

Moreover, a negative influence of the increasing shares of Car Derived Vans can be excluded in this step already. Technically, these cars are based on Lower Medium cars, but the interior space they offer has to be compared at least with the Medium segment. However, as emissions from Car Derived Vans are very close to the emissions of Lower Medium (petrol) or Medium (diesel) in 2002, an impact of these cars could only be accounted for by the argument that they have to be compared with the Lower Medium segment.

JAMA

When reviewing the development for JAMA, similar findings emerge. Sub-groups with higher engine power show remarkable increases in registrations, in particular Mini, Small and Lower Medium for petrol and Lower Medium and Medium for diesel. However, these figures display also a gap in the model range of 1996 and a certain complement until 2002. For Car Derived Vans, there was nearly no offer in 1996.

Differing from the ACEA trend, Off-Road cars of JAMA show more registrations and higher increasing rates in the lower power subgroup. Generally, Off-Road cars comprise much more registrations of the Japanese cars than Off-Roads of ACEA's new registrations. The higher importance of a certain segment also applies to the Lower Medium in 1996, when its shares reached nearly 40 % of all petrol cars.

Reductions in CO_2 emissions of Japanese cars show nearly the same characteristic as for ACEA cars, i.e. above average reductions for Small and Off-Road (only petrol). With regard to diesel cars in total, the reduction of JAMA cars is nearly twice as high as for ACEA. Since

almost 37 % of JAMA's diesel fleet are Off Road cars (ACEA: below 3 %) the high average diesel emission of JAMA, which is 26 g higher than for ACEA, is not surprising.

Table 8: Registrations for JAMA per segment sub-group 1996 and 2002 (EU 15)

Change of registrations for petrol cars				
	1996	**2002**	**Change**	**Change %**
Mini < 45 KW	17188	11800	-5388	-31.3%
Mini ≥ 45 KW	0	42069	42069	
Small < 60 KW	213450	244820	31370	14.7%
Small ≥ 60 KW	5869	108672	102803	1751.6%
Lower Medium < 80 KW	364007	197603	-166404	-45.7%
Lower Medium ≥ 80 KW	66207	107419	41212	62.2%
Medium < 110 KW	259430	152539	-106891	-41.2%
Medium ≥ 110 KW	573	22496	21923	3826.0%
Upper Medium < 110 KW	8678	722	-7956	-91.7%
Upper Medium ≥ 110 KW	7213	7195	-18	-0.2%
Luxury < 180 KW	836	108	-728	-87.1%
Luxury ≥ 180 KW	715	1022	307	42.9%
Sport < 110 KW	37648	30028	-7620	-20.2%
Sport ≥ 110 KW	7451	5325	-2126	-28.5%
Off-Road < 130 KW	54294	136005	81711	150.5%
Off-Road ≥ 130 KW	4029	6848	2819	70.0%
MPV < 110 KW	24890	11155	-13735	-55.2%
MPV ≥ 110 KW	151	2505	2354	1558.9%
Car Derived Van < 80 KW	0	52535	52535	
Car Derived Van ≥ 80 KW	1146	51321	50175	4378.3%
Total	1073775	1192187	118412	11.0%
Change of registrations for diesel cars				
	1996	**2002**	**Change**	**Change %**
Mini	0	0	0	
Small	1931	29744	27813	1440.3%
Lower Medium < 65 KW	26150	1218	-24932	-95.3%
Lower Medium ≥ 65 KW	0	49754	49754	
Medium < 80 KW	42220	7443	-34777	-82.4%
Medium ≥ 80 KW	0	53711	53711	
Upper Medium < 110 KW	0	0	0	
Upper Medium ≥ 110 KW	0	0	0	
Luxury	0	0	0	
Off-Road < 90 KW	22870	79409	56539	247.2%
Off-Road ≥ 90 KW	20779	45226	24447	117.7%
MPV < 80	6320	316	-6004	-95.0%
MPV ≥ 80	1444	17245	15801	1094.3%
Car Derived Van < 80 KW	0	37429	37429	
Car Derived Van ≥ 80 KW	0	16690	16690	
Total	121714	338185	216471	177.9%

Table 9: CO_2 emissions for JAMA per segment sub-group 1996 and 2002 (EU 15)

Change of CO_2 for petrol cars (g/km)			
	1996	**2002**	**Change %**
Mini < 45 KW	136.5	134.8	-1.2%
Mini ≥ 45 KW		37.1	
Small < 60 KW	54.9	142.5	-8.0%
Small ≥ 60 KW	181.4	145.4	-19.9%
Lower Medium < 80 KW	175.4	163.8	-6.6%
Lower Medium ≥ 80 KW	190.0	183.4	-3.5%
Medium < 110 KW	194.4	185.8	-4.4%
Medium ≥ 110 KW	237.3	226.0	-4.8%
Upper Medium < 110 KW	233.7	223.4	-4.4%
Upper Medium ≥ 110 KW	263.3	246.2	-6.5%
Luxury < 180 KW	282.8	291.0	2.9%
Luxury ≥ 180 KW	286.0	288.8	1.0%
Sport < 110 KW	193.7	194.6	0.5%
Sport ≥ 110 KW	230.3	239.6	4.0%
Off-Road < 130 KW	241.7	210.9	-12.7%
Off-Road ≥ 130 KW	370.8	314.8	-15.1%
MPV < 110 KW	260.6	217.9	-16.4%
MPV ≥ 110 KW	312.6	248.0	-20.6%
Car Derived Van < 80 KW		170.3	
Car Derived Van ≥ 80 KW	221.6	186.4	-15.9%
Change of CO_2 for diesel cars (g/km)			
	1996	**2002**	**Change %**
Mini	-	-	-
Small	167.2	115.7	-30.8%
Lower Medium < 65 KW	167.3	180.9	8.1%
Lower Medium ≥ 65 KW	0.0	153.2	
Medium < 80 KW	172.5	156.9	-9.1%
Medium ≥ 80 KW	0.0	161.7	
Upper Medium < 110 KW	-	-	-
Upper Medium ≥ 110 KW	-	-	-
Luxury	-	-	-
Off-Road < 90 KW	309.2	200.2	-35.3%
Off-Road ≥ 90 KW	316.0	270.6	-14.4%
MPV < 80	260.8	244.0	-6.5%
MPV ≥ 80	304.1	179.1	-41.1%
Car Derived Van < 80 KW	0.0	155.8	
Car Derived Van ≥ 80 KW	0.0	166.9	

4.5 Demand Side: Selected segments

In this chapter a closer look is given to the development of the segments with the most registrations, i.e. the Lower Medium, Small and Medium segment. The analysis focuses on these countries that influence the European CO_2 emission average at most, i.e. Germany, France, Italy, Spain and the United Kingdom. After analysing segments, some reference models are reviewed in order to clarify and interpret findings from the segment analysis.

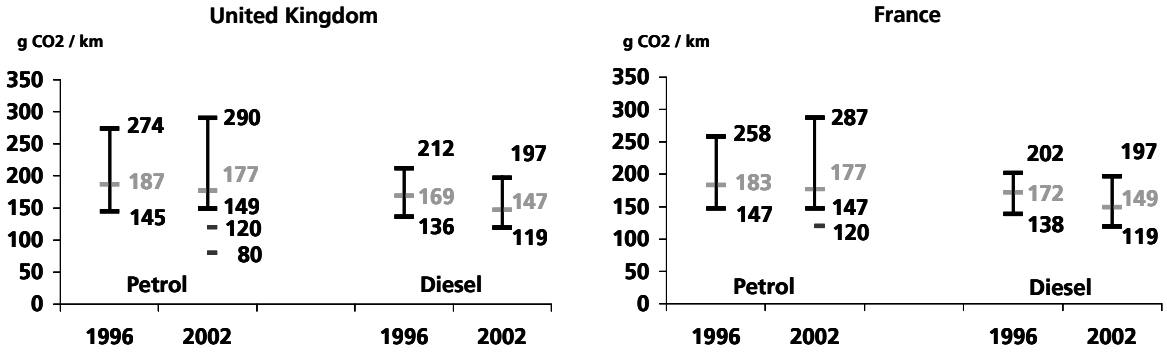
4.5.1 Lower Medium segment

Accounting for approximately one third of all new registrations in the 15 European Member States, the Lower Medium segment is the most popular one. Countries selected for this analysis are the United Kingdom, France and Spain because they have the highest shares of this segment among the five big European Member States.

The range of possible CO_2 emissions for available petrol versions did not change significantly from 1996 to 2002; just some higher emitting versions were added. The lowest value is nearly constant, slightly below 150 g CO_2 per km. Only by incorporating the hybrid cars Toyota Prius (120 g) and Honda Insight (80 g) in 2002 the lower bound would decrease. Both were registered only rarely, 48 times the Honda and 291 times the Toyota in the UK by 2002. Considering the constant range of possible CO_2 emissions, it is remarkable that the mean value of all sold versions shows a decrease. This is indicated in Figure 11 for the United Kingdom and France. In both Member States the average CO_2 emission value decreased to 177 g/km, this means a reduction rate of 5.3 % for the UK and 3.3 % for France compared to 1996. A similar development appears also for Spain, where the lower limit of CO_2 emissions decreased by 3.3 % to 147 g/km, but the average dropped by 5.4 % to from 184 to 174 g/km.

The development of the minimum and maximum CO_2 emissions of diesel cars is even more similar than for petrol for the United Kingdom, France and Spain. Here, a clear decrease of the version with the lowest emission figure can be stated. As the CO_2 emission range of Lower Medium diesel cars started by nearly 140 g/km in 1996, the lower bound was almost 120 g/km in 2002. The average values of all newly registered diesel cars decreased to the same extend, i.e. by 13 to 14 %. They range on the same level as the lowest petrol version in 2002.

Figure 11: Development of the CO_2 emissions range for the Lower Medium in the United Kingdom and France
(Grey figures indicate the average emission of all sold versions; 120 g and 80 g for petrol in 2002 represents the Toyota Prius and Honda Insight respectively)

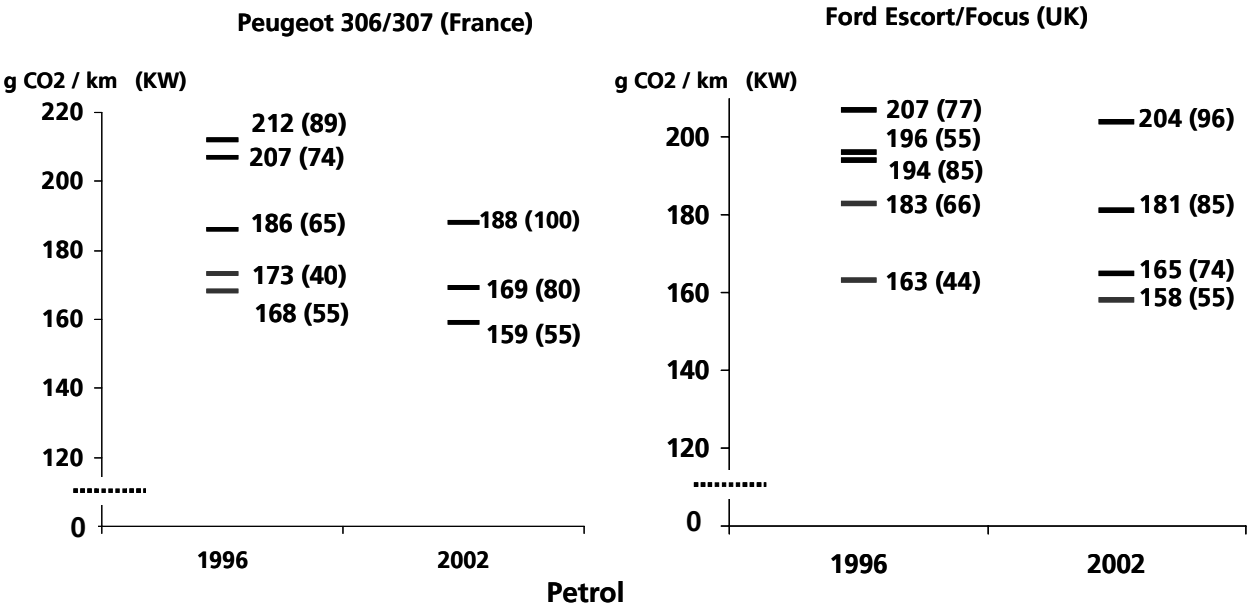


Without any further investigations, from this analysis of the Lower Medium segment it could be concluded that consumers are obviously tending to buy petrol versions closer to the base model, i.e. the model with the lowest CO_2 emissions. In contrast, diesel purchasers still prefer versions in the middle range of the CO_2 bandwidth, however benefiting from an evident over-all CO_2 decrease for diesel cars in this segment.

In order to interpret the findings above, individual models are analysed with regard to their engine versions (KW) and the associated CO_2 emissions. For France the Peugeot 306/307 is taken and for the United Kingdom the Ford Escort/Focus. Figure 12 indicates the CO_2 emissions of the most sold petrol versions supplemented by their engine power. Firstly it could be seen that some versions have higher emissions than others but do not have a higher engine power (e.g. Peugeot 40 KW in 1996), what results mostly from offering engines of different development status.

In the main, it appears that the emission range for the important versions up to 80 KW was reduced significantly. For both models an engine power of almost 80 KW can be provided by approximately 170 g CO_2/km in 2002, whereas emissions went up to around 190 g for the same power category in 1996. At the same time, the average engine power off all new registrations has increased remarkably: From 64 to 76 KW for the Peugeot and from 61 to 84 KW for the Ford. Therefore, it can be concluded that people do not tend to buy base versions with low emissions, rather emissions of the most popular power categories were reduced in particular. For the taken reference cars emissions get closer to the segment's minimum value. A very similar development was also observed for the Volkswagen Golf in Germany.

Figure 12: CO_2 emissions for petrol versions of Ford Escort / Focus and Peugeot 306 / 307



When reviewing some Japanese models, the lower number of available engine versions and especially the lack of diesel cars have to be noted. However, results from above are confirmed by the Japanese models. According to the average engine power of all sold petrol cars, in 2002 people still buy either the base version (Mazda 323 and Toyota Corolla for Germany) or the version at the second power level (Honda Civic in the UK).

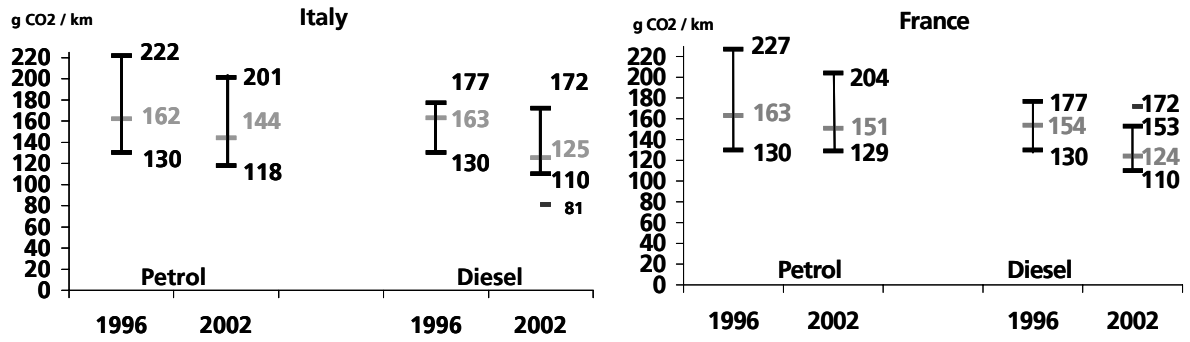
4.5.2 Small segment

Cars of the Small segment are most important in Italy and France. The range of CO_2 emissions of all newly registered cars as well as the average value are shown in Figure 13. In Italy few petrol versions with very low emissions have been added during the investigation period, but they were not available in all European Member States, e.g. not in France as Figure 13 shows. However, the mean CO_2 emission of Small segment petrol cars decreased by 11.0 % in Italy and by 7.4 % in France, thus, being well above reduction rates for the Lower Medium segment.

Due to the restricted numbers of offered models and versions concerning diesel in 1996, the results can not been interpreted like for petrol. Generally speaking, CO_2 emissions of diesel cars in 2002 are not only much below diesel in 1996 but also much below the petrol versions.

Figure 13: Development of the CO_2 emissions range for the Small segment in Italy and France

(Grey figures indicate the average emission of all sold versions; 81 g for Diesel in 2002 represents the Audi A2 3L, 138 registrations, 172 g the Fiat Palio, 584 registrations)



When reviewing the Fiat Punto in Italy more in detail, a nearly constant average engine power of new petrol registrations occurs (45 KW in 1996 and 47 KW in 2002), what is very close to the base versions in both years. The mean emission value dropped significantly from 159 to 138 g because versions up to 60 KW have only 142 g in 2002 but 170 g in 1996.

The same result as for the Fiat Punto in Italy was found for the Nissan Micra in the UK. From the available versions, the base version is the most popular one, what can be seen by the average registrations' engine power which is only 2 or 3 KW above. However, improvements in CO_2 emissions could not be observed in this case, remaining over the whole period around 150 g/km.

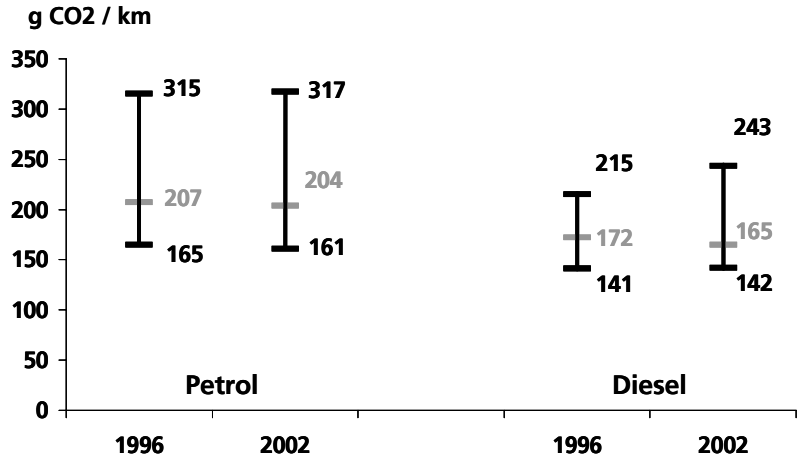
4.5.3 Medium segment

The Medium segment accounts for the third highest share of registration in Europe, but with the exception of Sweden it does not represent the majority of registrations in any country. Concerning the most important countries with respect to the European average emission value, Germany was selected for the analysis. Here, approximately 15 % of newly registered cars belong to the Medium segment.

The development of the CO_2 emission range (see Figure 14) shows only slight changes from 1996 to 2002 for petrol cars as well as for diesel cars. For the mean values decrease rates are only marginal and for diesel a remarkable extension of the model range towards higher emissions becomes obvious.

Figure 14: Development of the CO_2 emissions range for the Medium segment in Germany

(Grey figures indicate the average emission of all sold versions)



When recalling the development of the segments including the power sub-groups in section 4.4 for EU 15, results for Germany seems to be corresponding. The low CO_2 improvements for petrol cars recorded there and the significant shift towards higher powered diesel cars can be followed in Germany. Some more clarification can be gained from a look into the models representing the lower limits of CO_2 emissions. With regard to petrol, it is a base version of Opel with only 55 KW in 1996. Such low engined versions have been skipped by all manufacturers and the 161 g CO_2/km in 2002 were emitted by a 90 KW version of a Volvo model. With regard to diesel, things are a different. The minimum value is represented by the Volkswagen/Audi direct injection which was already available in 1996. The 66 KW engine was used for a number of models in different segments, by what the similar minimum value for the analysed Lower Medium segment can be explained. An improved version of this engine is still in use in 2002, providing 74 KW then, and remained at the lower bound of its segment.

Considering a model, for which a direct injection diesel engine was not available in 1996, a decrease of CO_2 emissions appears. Taking one of the most popular Medium segment cars, the BMW 3 series, the shift to the lower fuel consuming but more power providing direct injection engines can be seen. 3 diesel versions were available in 1996 (66 / 85 / 105 KW) as well as in 2002 (85 / 110 / 135 KW). The average of all sold versions was in both years very close to the mid ranging version, i.e. consumers followed the trend of the offered model range, however, by a reduced CO_2 value from 200 to 148 g/km. Concerning the petrol versions of the BMW 3 series, a similar consumer behaviour appears, as the average engine power ranges between the second (318i) and third (320i) power level in 1996 as well as in 2002. But the according absolute engine power increased from 95 to 116 KW and the average emission decreased from 203 to 195 g CO_2/km.

4.6 The influence of structural changes of registrations on CO_2 emissions

As shown above and in the Phase 1 report, the structure of registrations, which is given by the share of segments in all registrations, has changed in some Member States. Furthermore, there appeared a trend towards a broader range of body styles and car concepts. Here, the question arises as to what the average CO_2 emission value would have been, if such trends had not emerged. The scale of these influences is calculated in this section.

The analyses presented below aim at calculating hypothetical average CO_2 emissions under certain assumptions in order to provide a scope of CO_2 differences that can be attributed to structural changes.

At first, the frequently mentioned shift to larger vans is analysed for Belgium and Austria, the two countries that had the highest increase rates for these types of cars. The influence on CO_2 emission is figured out by attributing the share of these vehicles in 1995 to the structure in 2002. Cars remaining from the decreased share in 2002 are considered with the overall CO_2 average in 2002. In Belgium, the share of Multi Purpose Vehicles such as Chrysler Voyager or Renault Espace and Car Derived Vans such as Opel Zafira and Toyota Picnic increased from 3.3 % to 6.4 % in 2002. If the share of these cars had not changed, the total average emission in Belgium would have been 159.0 g CO_2 per km instead of 159.8 g CO_2 per km. For Austria, an impact on CO_2 emissions of 0.6 g can be attributed to the growth of MPVs and car derived vans from 4.7 to 6.4 % of total registrations. Since these countries influence the European average only slightly the view is widened to all Member States in the following sections.

Due to the data inconsistencies in 1995, data of 1996 are used for the European wide calculations. The detailed segmentation with sub-groups related to the engine power enables not only to calculate the influence of the shift to other segments but also to consider the trend to stronger powered cars within a segment. The following cases are analysed:

1. The influence of the overall change in the structure of new registrations is calculated by attributing the segment shares of 1996 to the average emissions per segment in 2002. Through this, the influence of improvements in CO_2 emissions within the segments and power categories on the total emissions can be assigned without being misrepresented by the change of the market structure. Here, the share of diesel cars is fixed by 1996 as well.

   ACEA: For petrol cars, holding shares of segment and power groups fixed does not influence the average emission as it remains approximately constant at 173 g. For the diesels, the fixed segment shares lead to a reduction of approximately 5 g, resulting in an average of 148.9 g CO_2 per km. Here, the upcoming very strong diesel engines are reflected, which are certainly very efficient in comparison to the petrol alternatives, but introduced higher power and emission levels in the diesel market in general.

   However, since the overall diesel share is kept constant at the low level of 1996, the lower diesel emission does not reduce the overall emissions of petrol and diesel combined but increases it by 2.2 g from the original value of 164.8 (2002) to **167.0 g/km**.

   JAMA: As with ACEA, holding the shares of segment and power groups fixed, does not affect the average petrol emission of JAMA (below half a gram). Diesel emissions, however, unlike to ACEA, jump up from 180.5 to 193.7 g/km. Here, the absence of relatively low emitting diesel segments like Small and Car Derived Vans is reflected. Due to the low proportion of diesel cars (the applied share for 1996 is 10.2 %), the overall average emission for JAMA changed only slightly by 0.7 g to **174.7 g/km**.

2. Improvements in diesel technology and the lower diesel fuel price have probably caused the increasing share of diesel cars in Europe. To a certain extent, the growth can be attributed to the technical improvements of the cars. Therefore, case 1 (keeping the segment shares fixed by 1996) is calculated again but the diesel share by 2002 is applied in order to figure out what would have been the influence of the actual growing diesel share if the segment/power structure had been constant

   ACEA: If in addition to case 1 the increasing diesel share is taken into account, the increased average emission value would be overcompensated as the total emissions of ACEA's fleet would then be reduced by 4.5 g CO_2/km. This means that the total average CO_2 emissions would have been 2.3 g lower (**162.5 g/km**) than the original value if specific CO_2 reductions and the diesel share had developed as they did but the segment structure remained constant.

   JAMA: Due to the contrary emission levels of JAMA (diesel higher than petrol) in comparison to ACEA (diesel lower than petrol) the average value would increase further by 2.6 g to **177.3 g/km** if the increasing diesel share is taken into account. Therefore, the total average CO_2 emissions would have been 3.3 g higher than the original value if specific CO_2 reductions and the diesel share had developed as they did but the segment structure remained constant.

3. As described in Chapter 4.4, the CO_2 reduction rates were not the same for all cars. For the larger cars, above average reduction rates are recorded in contrast to the mid size cars, especially the petrol fuelled. In order to identify the influence of the more or less successful reductions in the different segments, an even reduction for all cars is assumed, i.e. the average reduction achieved between 1996 and 2002 is applied for all segments. Only the petrol and diesel reductions are distinguished.

   ACEA: Results of this calculation do not show a significant effect for the ACEA fleet as the average emission increased only marginally by **0.3 g/km**.

   JAMA: In the case of JAMA cars a higher effect of **6.6 g/km** is calculated. This is mainly due to the eliminated influence of the over average reduction of Off-Road cars, which hold a significant market share in the JAMA fleet.

Assuming that the structural changes of the market are associated exclusively with changes in consumer behaviour rather than with technical changes and, moreover, that the shift to diesel cars is associated with consumer behaviour as well, the isolated result of the technical change indicated would be 167.0 g CO_2/km for ACEA and 174.7 g CO_2/km for JAMA. If in addition the increase of diesel share is taken into account indicating a maximum technical potential for consumers purchasing the 1996 segment structure but the 2002 diesel share, total emissions of ACEA's new registrations would then be 2.3 g/km lower than monitored. However, these are only maximum values that serve to point out the scope and it is unlikely that consumer behaviour dampened the effect of technological progress considering the results of the segment and car model analysis in the previous sections. There, it was found that consumers change their behaviour in clear consistency to the trend that was supported by the offered model range of the manufacturers. Purchasing behaviour changed in concert with the development towards higher engine power as well as to relatively new established segments. As this is a general result from the segment- and model analysis, conclusions with respect to very outstanding versions in terms of engine power or CO_2 emissions, can not be derived.

For JAMA, the corresponding interpretation is that the reduction due to technology alone was greater than the monitored value, but that this reduction was to some extent offset by the higher diesel share in the 'big cars' segments.

5 Survey of non-technical influences

5.1 Introduction

At first, an overview of influences, which can affect consumers' behaviour in general, is given. It contains politically motivated measures, socio-economic trends and other possible influences on the new passenger car market.

Politically motivated

- Fiscal measures influencing
  - car purchase (e.g. registration tax),
  - car ownership costs (e.g. circulation tax),
  - car running costs (e.g. fuel tax including diesel-petrol differentiation).
- Introduction of Labelling
- Scrapping incentives
- EU-regulation from other fields affecting fuel consumption (e.g. concerning emissions and safety)

Caused by socio-economic trends and consumer preferences

- Economic influences: higher or lower income level of people
- Demographical influences: more senior car purchasers
- Social influences: more (young) female car purchasers
- Trends in lifestyle and car ownership (e.g. higher share of MPV and Off-Road cars etc.)

Other influences

- Active influence on the market by extraordinary promotion for certain cars (e.g. phase-out models or sale for manufacturers´ employees)
- Stimulation of customers´ interest by extending or changing the model range (diversity of automobile supply)

Based on this general overview, data were collected to establish variables for the econometric model. With particular regard to the taxes, Member States were analysed identifying those which were affected by relevant changes. The results of the survey of non-technical influences are given in the following chapters.

5.2 Survey of politically motivated influences

The survey of politically motivated influences aims at identifying significant changes in the tax system between 1995 and 2003 for the individual European countries in terms of the tax level and the tax system. Remarkable changes are set into relation with the numbers and the structure of the new registered cars in the econometric model in Chapter 6. Other politically motivated measures than taxes, e.g. fuel efficiency labelling and scrapping incentives are considered as well.

When reviewing car taxation, company cars have to be differentiated from private cars. Besides taxation of cars registered for commercial use, the private use of them is differently taxed as well as it is considered as a personal benefit. Due to the complexity of tax structures

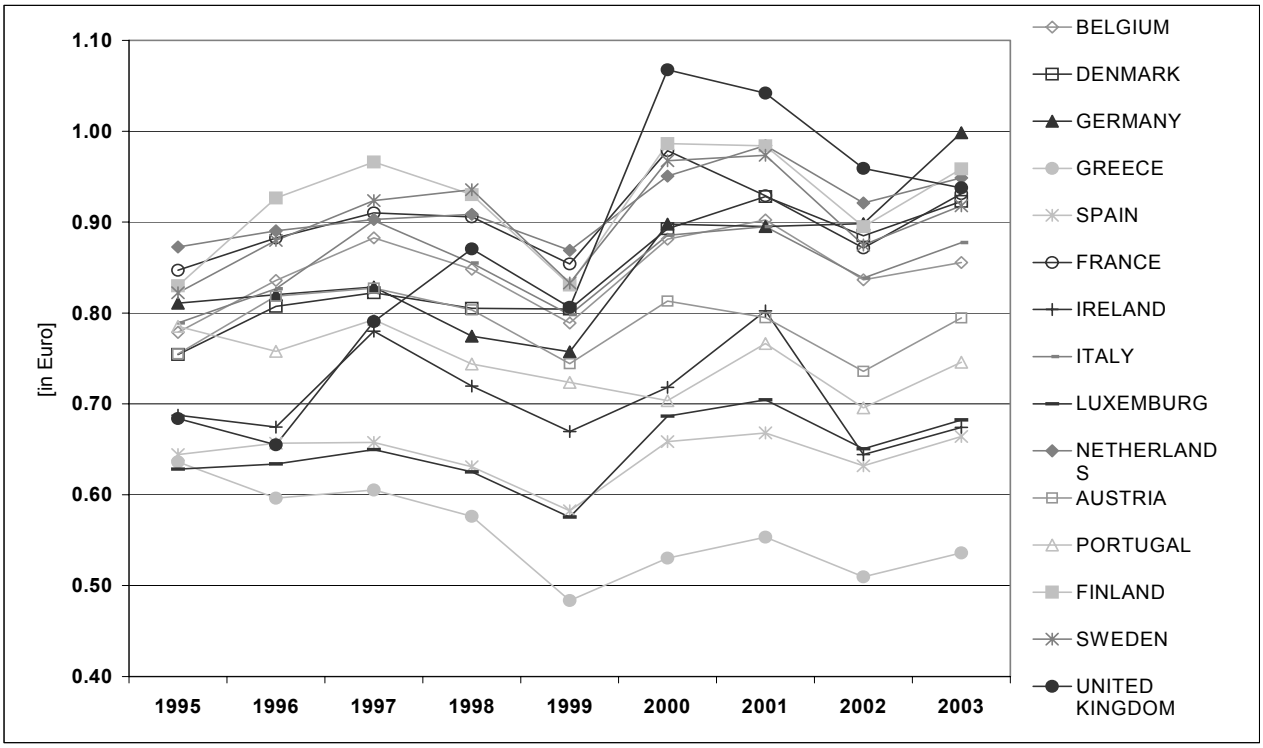
for non-private cars a transformation in a format suitable for an econometric model was not possible. Therefore, in the model estimation for taxes only private cars are considered.

The first analysis of politically motivated influences in the phase 1 report revealed that significant changes in the tax system occurred in a few number of countries in Europe. Especially the tax system in the UK is to mention where the annual circulation tax is directly related to the CO_2 emissions instead of the engine size since March 2001. Denmark changed the tax base in 1997 from a weight-based to a fuel-consumption-based tax. The fuel tax was raised in several EU member states significantly, especially in Denmark, Germany and the UK. All these findings were checked and are described and completed with the other Member States in the following paragraphs.

5.2.1 Fuel prices

Fuel prices include a high share of taxes and are therefore highly influenced by policy measures. For consumers the total price of fuel is relevant. For Europe very different developments can be observed. The deflated petrol price increased strongly in the UK, remained approximately constant in a number of Member States and decreased in Greece.
Petrol prices given in Figure 15 as well as the analogue diesel prices are considered in the econometric model to assess the impact on car registrations.

Figure 15: Deflated petrol prices in Europe [€ per litre, base year equals 1995]



5.2.2 Registration and circulation taxes

Registration and circulation taxes are described per Member State. According to the subject of this investigation, only taxes with relation to new cars are indicated. So this summary can not be used as a comprehensive overview about the tax situation for the total vehicle stock in the European Member States. Besides fuel taxes, the fiscal burden which has to be carried due to car ownership is mainly the registration tax and the circulation tax. In countries where special taxes or individual fiscal incentives turn up that seem to be relevant, these are reported. The main sources of information are the ACEA Tax Guides (1995 – 2003). Additional sources are identified in the place they occur.

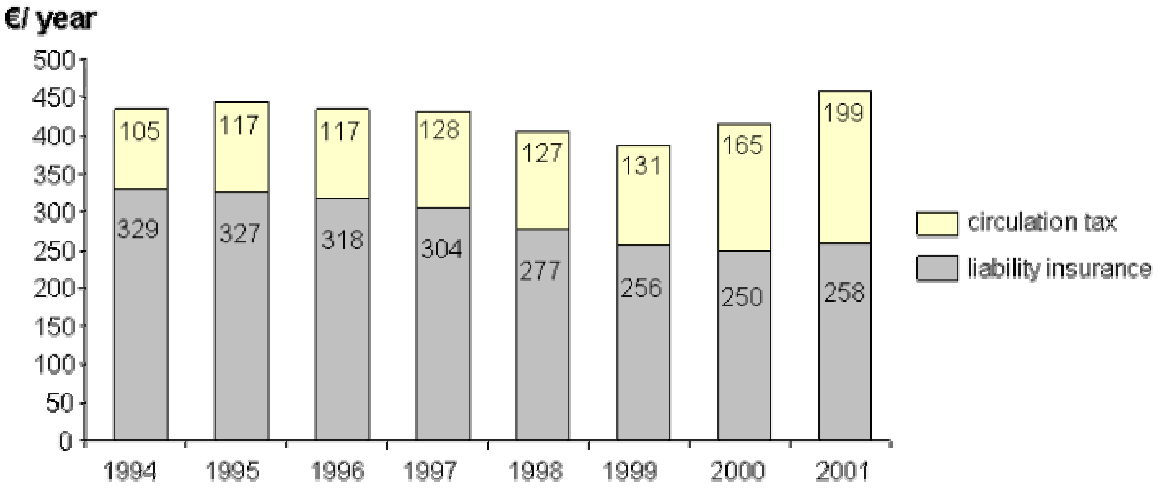
Taxes which have finally been incorporated in the econometric analysis are summarised in Table 12 of chapter 5.5.

Austria

The registration tax is regarded to be negligible. The fuel consumption tax (Tax on ownership, Normverbrauchsabgabe, NoVA) is levied on the purchase price on new cars. A further circulation tax for cars with gross weight below 3,500 kg has to be paid together with the auto liability insurance.

Even though the circulation tax has increased over the years, the burden for car owners rose only moderately because in the same time the costs for the liability insurance fell (see Figure 16). Because of the changeless tax conditions the Austrian taxes on ownership are not considered in the model estimation.

Figure 16: The development of an average premium of the liability insurance and the tax on ownership in the years 1994 – 2001



Source: bmvit (2002)

Belgium

In Belgium a registration tax is levied on new cars. Because of the constant amounts, the registration tax was regarded to be negligible in this context. Because of its constant situation the Belgium circulation taxes were regarded to be negligible as well. A review of available resources showed inconsistency concerning a special municipal tax. For this reason this tax is also omitted.

Denmark

Registration Tax

The registration tax in Denmark rank among the highest in Europe. So the car owner has in fact to pay more than the purchase price for the registration.

Calculation base for the registration tax is the sales price of the car inclusive VAT. A base amount (34,400 DKK in 1995 increasing to 59,500 DKK in 2002) is taxed by 105 %, for the remaining price value a tax of 180% must be paid.

Circulation Tax

In 1997 the Danish annual circulation tax was changed from a weight based system to a new system using fuel efficiency as a base. The former system divided all cars into six curb weight classes and differentiated between petrol and diesel. For the lowest weight class (less than 600 kg) the tax rate was 183 € for petrol and 280 € for diesel. Above the highest weight class that ranged up to 2,000 kg (requiring 730 € for petrol and 1,121 € for diesel) the annual tax was calculated directly (0.41 * weight in kg for petrol and 0.62 * weight in kg for diesel[13]).

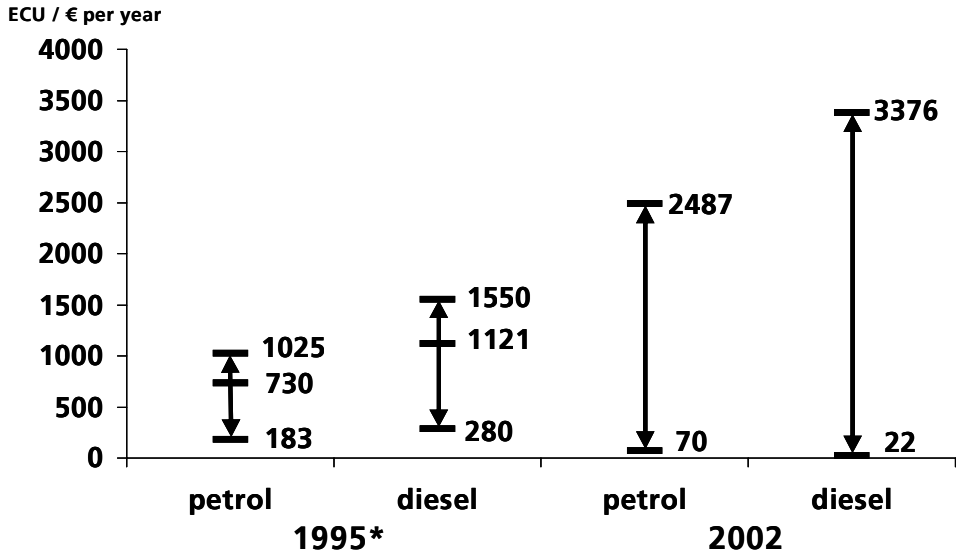
Since 1997 the annual circulation tax is based on the fuel efficiency. 24 efficiency classes were established, ranging from an annual tax of 59 € for a petrol efficiency rate of more than 20 km/l up to 2,315 € for less than 4.5 km/l. The classification for diesel comprises 27 classes ranging from 46 € for a fuel efficiency of more than 32 km/l up to 3,201 € annual tax for little efficiency, less than 5.1km/l. Until 2002 tax rates increased moderately.

Due to the changed system the average tax for petrol cars did not decrease as much as the average diesel tax[14].

The aim of this so-called green vehicle tax was to provide incentives for the purchase and use of more fuel-efficient cars. The lowest annual taxation rate for both petrol and diesel was significantly lowered to 59 € instead of 183 € and 46 € instead of 280 € respectively. Moreover, the range of annual tax amount has spread (see Figure 17).

[13] Consulting Engineers and Planners [COWI], (2003).
[14] Consulting Engineers and Planners [COWI], (2003).

Figure 17: Change of the annual circulation tax in Denmark (1995 to 2002)



* 730 € and 1,121 € represent the highest weight class up to 2,000 kg. The tax rate for cars with more than 2,000 kg curb weight is calculated by the formulas 0.41*curb weight for petrol and 0.62*curb weight for diesel. Here, the taxes for cars weighing 2,500 kg are given: 1,025 € for petrol and 1,550 € for diesel.

Source (Data): Consulting Engineers and Planners [COWI], (2003) and European Automobile Manufacturers Association [ACEA], (2003)

Finland

Because of the unchanged tax conditions the Finish taxes on ownership and registrations are not considered in the model estimation.

France

Because of the relatively small tax levels, the registration tax in France was not taken into consideration.

Until 1999 the circulation tax for private cars was calculated with respect of the fuel consumption and the engine power, further depending on which region (Departement) the car was registered in. For cars younger than 5 years, the tax rate increases in ten steps.

The French circulation tax for private cars was abolished from December 2000.

The tariff varies heavily from one department to another. In the category with the lowest engine rating it varied in 1995 from 22 € (Department of Marne) to 48 € (Department of Eure and Loire). In the tax category with the maximum of engine rating the tariff in the same year ranged between 1114 € (Department of Marne) and 2272 € (Department of Eure and Loire).

Due to the situation that France is divided into 99 Departments, each having individual tax amounts, a simplifying selection was made for the model estimation. The data used in the model estimation refer to the Department of the city of Paris. The price level of Paris lies a little bit substandard. In Paris, a small car in 2000 had to pay a tax rate of 41 €. A big car made his owner pay 1,928 €. The tax rates for the years 1996 to 1999 base on the data of the years 1995 and 2000, which were deflated using a consumer price index obtained from the OECD that set 1995 as the base year.

Germany

There is no registration tax in Germany, only about 25 € are charged for registration.

The German circulation tax for is mainly cylinder capacity related. The tax amount is fixed for each 100 cm³ started, that means the cylinder capacity is always rounded to the next lower 100 cm³ value. For state-of-the-car cars in terms of exhaust gas treatment, tax rates are lower than for cars with a less sophisticated standard. In Table 10 the annual rates of circulation tax from 1995 to 2003, which are applied in the econometric model are shown.

Table 10: Circulation tax rates in Germany
applied for covering the majority of new registrations in the given years.

	Euro 1 1995, 1996	**Euro 2** 1997, 1998	**Euro 3** 1999 - 2003
petrol	6.75 € per 100 m³	6.14 € per 100 m³	5.11 € per 100 m³
diesel	18.97 € per 100 m³	14.83 € per 100 m³	13.80 € per 100 m³

Source: German Federal Finistry of Finance (2004), (data)

Since 1997 the German government rewards owners of fuel saving cars with fiscal incentives. Cars with CO_2 emissions below 120 g/km ("5-liter-car") registered before January 2000 and cars with CO_2 emissions below 90 g/km ("3-liter-car") and in service before January 2006 are benefited with a temporary tax relief. The tax relief can amount up to 266 € and 511 € respectively. This incentive becomes effective from the day of the registration and lasts until the end of the year 2005 unless the maximum amount is reached before[15]. These incentives are considered in the model estimation

Greece

Because there was no change in the registration tax in the last years and a constant development of the circulation tax is recorded, Greece is not considered in the econometric model for estimating influences of taxes.

Italy

Until December 1997, the Italian taxation system for the annual circulation tax was based on the engine ratings referring to "fiscal horse power". "Fiscal horse power" was an artificial rather than technical value indicating the engine rating, which was calculated by a mathematical formula based on the engine capacity. It is denoted as "HP".

The former Italian car tax system had 40 steps. For a small car e.g. Fiat Cinquecento 1,1, in the year 1995 the owner had to pay approx. 72 €[16] annually. For a big car, e.g. Mercedes S 500, the annual tax amounted to approx. 607 €.

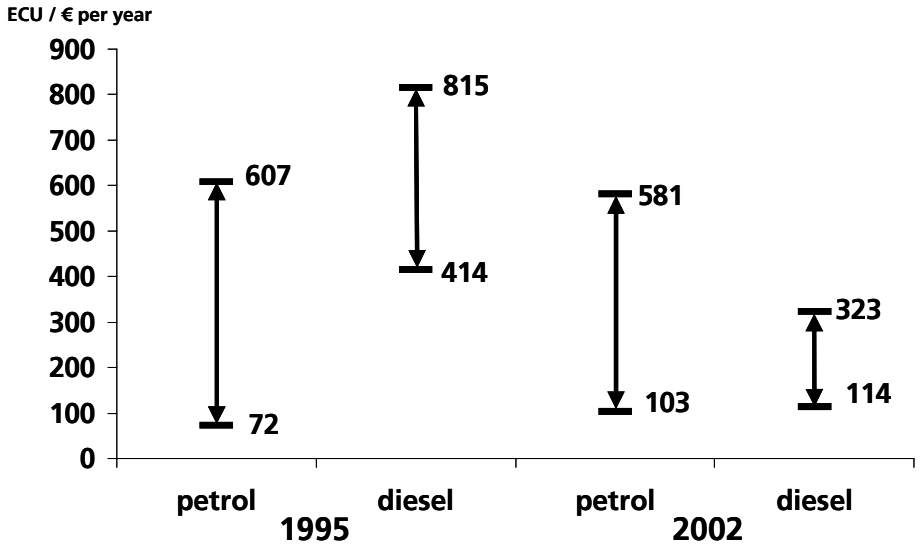
From January 1998 the base of the taxation system was changed. The previous engine rating calculation was replaced by a direct calculation based on the engine power. According to the new taxation system the rate of circulation tax amounts to 2.58 € per kW in 1998[17]. This means, that a small car with 40 kW (e.g. Fiat Seicento 1,1), which is comparable with the

[15] German Federal Ministry of Finance, (2003).
[16] As the Euro was not introduced until January 1, 1999, here the forerunner currency ECU is meant, calculated with the exchange rate of 1 ECU = 2059.96 Italian Lira
[17] This tariff is still valid in 2003.

Cinquetcento from 1995, now costs approx. 103 €. The big Mercedes (225 kW) amounts then to approx. 580 €.

A diesel surtax on the circulation tax was levied on cars in 1995 to compensate the very low price for diesel fuel. As a consequence, the tax costs for a small diesel car summed up to approx. 414 €[18], for a big car the annual car taxes amounted to approx. 815 €[19]. From January 1996, the diesel surtax has been abolished for new private cars.

Figure 18: Change of annual circulation tax in Italy (1995 to 2002)



Ireland

Because the registration tax remained exactly unchanged during the last ten years, it was not considered for the model estimations. The circulation tax is approved over years and did not change in the relevant time and is thus neglected as well.

The Netherlands

The Dutch registration tax is calculated on the net list price, including profit margins but exclusive of taxes. From 1995 to 1999, the tax formulas were:

- petrol cars: 0.452 x net list price – 1,556.88 ECU[20]
- diesel cars: 0.452 x net list price – 586.24 ECU[21]

In 2000 the tax free amount for diesel cars was cancelled and a malus added instead.

- diesel cars: 0.452 x net list price + 328 €

The conditions for petrol cars remained the same.

From 1 May 2000 on, the list price could be reduced for the tax calculation by approx. 317 € if the car was equipped with cruise control or a board computer. A reduction of approx. 45.50 € applied to cars equipped with an econometer. In 2001 and 2002, the amounts for tax

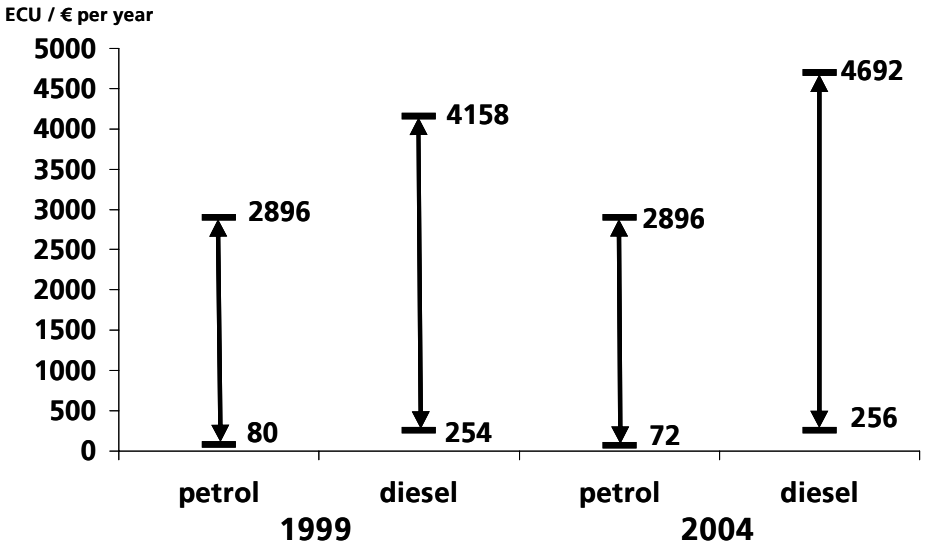
[18] see above
[19] see above
[20] ECU is calculated with the exchange rate on January 2, 1997, 1 ECU = 2.18 Dutch Gilder.
[21] see above

deductions were expanded and given for side airbags and road guidance (navigation) systems in addition. As the registration data for this analyse do not include indication on these features, the tax deduction can not be considered.

The Dutch circulation tax is measured according to three parameters: dead weight, type of fuel used and the province the owner lives in. The tax rates rise each 100 kg, starting from 550 kg. This taxation system is approved over years (at least since 1997).[22]
The data used in the model estimation are from one specific province, the province of Utrecht. The tariff for a small car with a dead weight up to 550 kg in Utrecht in 2003 was burdend with 68 € (petrol) or 248 € (diesel) respectivley. The more heavy cars with about 2000 kg caused costs in the amount of 952 € (petrol) or 1660 € (diesel) respectively.

Since July 2001, the Dutch government gave fiscal incentives to buyers of cars, which apply to the EU 4 standard. A further incentive was offered from January 1st, 2002. It rewarded purchasers of fuel efficient cars by adding a relative component to the EU-directive on fuel labelling. All passenger cars were arranged in seven fuel efficiency categories. The label shows the relative fuel consumption in a particular colour, which indicates whether the vehicle uses more or less fuel than the average fuel consumption for vehicles of a similar size[23].
Buyers of of passenger cars with the label for the highest fuel efficiency (A-label) received a 1000 € incentive, buyers of cars with labels in the second best category received 500 €.
In January 2003 the government abolished the fiscal incentives for fuel efficient cars and clean cars because of budgetary reasons.

Figure 19: Example for the circulation tax in the Province of Utrecht, 1999-2004.



Source (data): Fiscal authorities of the Nederlands, 2004.24; ACEA, 2000.

[22] Official Publications of the European Community Office, (2000); http://europa.eu.int/comm/taxation_customs/publications/info_doc/taxation/txinventory/tax_inventory17ed_de.pdf (June 2004)
[23] International Energy Agency; http://spider.iea.org/workshop/frei-it/novem.pdf, (July 2004)
[24] Fiscal authorities of the Netherlands; http://www.belastingdienst.nl/reken/mrb/index.htm, (June 2004)

Portugal

Car taxes in Portugal remained stable during the investigation period and are not considered in the estimation model. It is not assumed that influence on consumers changed.

Spain

The Spanish registration tax[25] for passenger cars is calculated on the purchase price of the car excluding VAT and on the engine capacity. Furthermore a distinction is drawn between petrol cars and diesel cars, giving them different limit values for their taxation rates. This system is approved over years. For vehicles with a purchase price below 24,488.58 €, there are two tax rates:

- 7 % for petrol cars with an engine capacity below 1,600 cm³ and for diesel cars with an engine capacity below 2,000 cm³,
- 12 % for petrol cars with an engine capacity of 1,600 cm³ or more and for diesel cars with an engine capacity of 2,000 cm³ or more.

Until 1996 extra tariffs of 5 to 9 % were made for four-wheel driven cars with a purchase price higher than 24,488.58 €
In 2003 the Special Tax has been transferred to the local authorities (Comunidades Autónomas) allowing them to increase the tax rate by up to 10% and to modify some other significant tax aspects (exemptions, deductions, etc.) Therefore the rate can rise:
to 7.7 % for petrol vehicles below 1,600 cm³ and diesel vehicles below 2000 cm³
to 13.2 % for other vehicles depending on the tax policies of each regional government.

Like the registration tax, the circulation tax in Spain lies in the hands of the local authorities. Until 1999 there were four tax classes basically. In 1999 a fifth class was created. For each class a minimum amount is set.

The relevant data used in the econometric model estimation are the tax rates from Madrid. 1996 in Madrid cars in the lowest tax class had to pay 17.45 €[26] per year, in the highest class 123.94 €[27]. In 2003, a small car in Madrid cost nearly the same, 19.25 €; but cars in the highest class had to face a rise of the tax rate to 170.80 €.

Sweden

Sweden does not take taxes or charges on the registration of cars. The Swedish annual road tax depends on the curb weight for passenger cars. The second tax criterion is the fuel type used. Because there were changes neither in the tax system nor in the tax rates, the Swedish road tax was regarded to be negligible and was not taken into consideration in the calculations.

United Kingdom

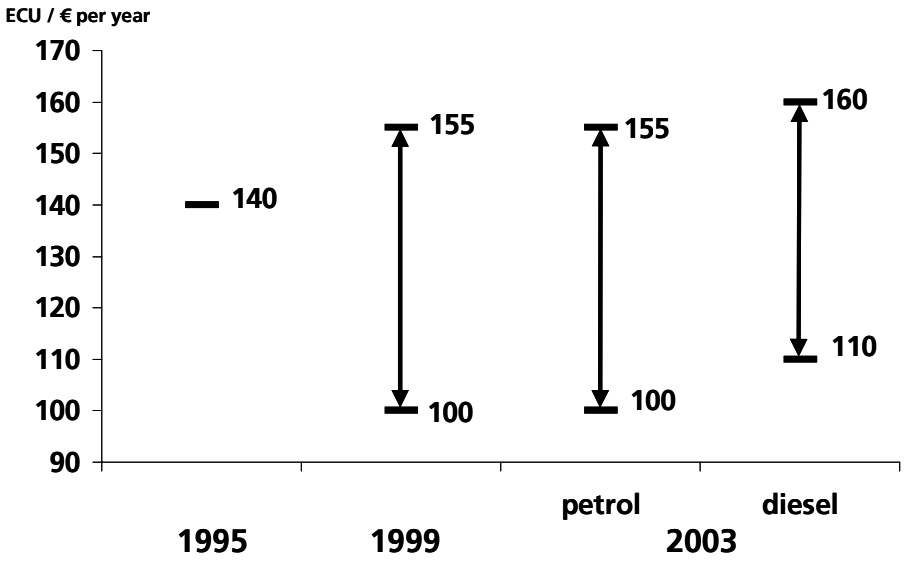
During the period from 1995 to 2003 the circulation tax system for private cars has changed nearly twice in the United Kingdom. In 1999, the uniform tax, which was a flat rate of 150 £ for all cars, was replaced by a graduated system, based on the engine capacity. This annual tax system, started from June 1999, distinguished between cars with engine capacity above and below 1100 ccm. Cars with an engine capacity of 1100 ccm or less had to pay 100 £, cars with an engine capacity above 1100 ccm had to pay 155 £ per year.[28]

[25] the so-called “Special Tax” (Impuesto especial sobre determinados medios de transporte)
[26] As the Euro was not introduced until January 1, 1999, here the forerunner currency ECU is meant, calculated with the exchange rate of 1 ECU = 158.99 Spanish Peseta.
[27] see above
[28] Consulting Engineers and Planners [COWI], (2003)

Since March 2001 up to now, the taxation system became more sophisticated: cars registered before March 2001 are further on taxed by engine capacity, the rates applied to the 1200 ccm breakpoint until June 2001 and to the 1500 ccm breakpoint from July 2001. New cars become classified according to the CO_2 emissions and fuel type (diesel or petrol)[29].

The CO_2 emission tax rises in four steps from less than 150 CO_2 g/km (110 £/ 100 £ per year for diesel/ petrol) to the class of more than 185 CO_2 g/km, which claims 160 £/ 155 £ per year for diesel cars or petrol cars respectively.

Figure 20: Shifting of taxes on ownership for private cars in the UK between 1995 and 2003.



Source: Consulting Engineers and Planners [COWI], (2003); ACEA (2003)

5.2.3 Scrapping Incentives

From 1995 to 2003 several European countries gave incentives to car owners for scrapping their old cars. The intention behind this scheme was to reduce the number of large, high polluting cars and to encourage car purchasers to choose a vehicle that fulfils the up to date EC requirements of exhaust emissions. Usually, these campaigns are temporary. Three groups of scrapping schemes can be identified. In the first group the scrapping incentive is paid without any conditions concerning the replacement of the scrapped car. In the second group the incentive is related to the special conditions concerning the replacement car. A third group offers indirect scrapping incentives.[30]

The Norvegian scrapping scheme from 1996-1997 can be classified to the first group. Norway gave a bonus of the equivalent of US$880 (1997) for the scrapping of any vehicle over 10 years of age and secured a net increase of 150,000 in scrapping (above those that would have been scrapped without the scheme).[31]

[29] Alternative fuel cars also have their own category: from 90 £ for an emission below 150g CO_2/km up to 150 £ for more than 185g CO_2/km.
[30] WORLDBANK, (2002).
[31] see above

One example for the second group is Greece. In Greece in the years 1991-1992 the bonus was paid only if the replacement vehicle had a catalytic converter.

France also offered incentives for replacement: from October 1, 1992 until December 31, 1992, the French government offered consumers 2,000F towards the purchase of a new car for replacement of an old vehicle. A second incentive period was initialized from February 1994 until June 1995. This time the government offered individuals a payment of 5,000F for the scrapping of an old car (10 years and older) connected with the purchase of a new car. As the average purchase price of a new car in France was about 80,000F, these subsidies were substantial. Only a short time later, in September 1995, a bonus of 5,000F was paid as scrapping subsidy for small and 7,000F for larger cars for 1 year ending September 30, 1996.

Further European countries that have offered scrapping incentives are Denmark (1994-95), Ireland (1995-97), Italy (1997-98) and Spain (since 1994)[32]. As it is unclear to which of the newly registered cars a scrapping incentive should be attributed, it is difficult to empirically isolate its influence. Further compounding this difficulty is an absence of data on individual consumer choices and the reasons underlying these choices. Nevertheless, preliminary analyses were conducted to capture scrapping incentive effects by analyzing differences in registrations before and after the dates of their introduction for particular countries. No significant influences with respect to the effect on registrations could be identified using the available data. It is therefore not possible to state any significant impact of scrapping incentives on average CO_2 emissions for the period under study.

5.2.4 Labelling

According to the European Directive for information on fuel consumption 1999/94/EC, all member states of the EU are required to introduce fuel economy label for cars. The ambition of the directive was to give the car purchasers standardized information about the fuel consumption of a car. The hope behind was, that the purchase decisions could become influenced from the labelling.

All of the “old 15” member States comply with the Directive: Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Ireland, Luxembourg, the Netherlands, Portugal, Sweden and the United Kingdom. Sizeable results of the labelling are hard to find. Denmark reports an increasing of the percentage of class A, B and C cars from 1998 to 2002, whereas the percentage of class D, E, F and G is decreasing. The effectiveness of the directive can not be assessed separately, because the fiscal measures may have a dominant influence on this development.

A study on the effectiveness of the Directive 1999/94/EC comes to the conclusion, that the major facts in vehicle purchase decision are car reliability, safety qualities, comfort and cost/price. Also size, engine power and manufacturers’ image are regarded to be important. Fiscal measures as well could show an impact. E.g. the Irish registration tax, which is engine capacity based and divided into two classes (of cars below 1,400 cm³ and above), could have led to the result, that 50 % of the new registered cars in the country have an engine capacity below 1,400 cm³. Fuel consumption and environmental impact are ranked in the middle or at the end of the purchaser’s priority list. The role of fuel consumption is only being seen as an expense factor, not in interrelation to environmental protection[33].

[32] TIS, (2002).
[33] ADAC, (2004).

The prospect of only marginal effects due to car labelling within the observed period led to the decision to neglect this influence in the model estimation and to concentrate on other influences.

5.2.5 EU-regulations and validity of underlying assumptions

Validity of underlying assumptions

The commitments of the Automobile Manufacturers' Associations are based on a number of assumptions, which have been considered crucial for the achievement of the CO_2 targets as well as for maintaining a competitive automobile industry. These assumptions concern the

- Availability of enabling fuels
- Distortion of competition
- Promotion of car CO_2-efficient technologies
- Acceptance of innovations

Availability of enabling fuels

The Associations attributed great importance to the availability of fuels with a sufficient quality to enable the application of technologies needed for the industry to achieve its CO_2 commitments. In particular, ACEA explained to the Commission services[34] that fuel-efficient lean-burn engine technologies need to use after-treatment systems (NOx traps, particulate filters and conventional catalysts) in order to meet CO_2 and tailpipe emissions at the same time. Therefore "Zero Sulphur Fuel" (less than 10 ppm sulphur) would be required as sulphur contaminates after-treatment systems and significantly reduces their efficiency.

The Commission drew attention to the "zero sulphur fuels" proposal[35], which should guarantee that the required fuels would be available in sufficient quantities throughout the Community from 2005 onwards. Based on this proposal, Directive 2003/17/EC of the European Parliament and of the Council of 3 March 2003 entered into force. Therefore, the problem of fuel specifications to achieve the CO_2 commitments has not been raised by the associations anymore.

Promotion of car CO_2-efficient technologies

Concerning fiscal measures, ACEA signalled its concern about anti-diesel policies in a number of countries, especially about the UK government's policy of high taxation of diesel. The exchange of letters with information and results of an independent study between ACEA and the Commission is noticed in the Monitoring reports.

The developments of fuel prices and circulation taxes of the UK are considered in the econometric analysis in chapter 6. Thus, the results presented in chapter 6.5 and 7 include the UK tax policy. Furthermore, chapter 4.6 addresses the influence of the change to diesel cars in the EU. Given the small magnitude of these influences on the EU level, a separate investigation of the influence of taxation in the UK would not change the results significantly.

The car industry claimed that the End-of-Life Vehicle Directive will have adverse implications for the fuel efficiency of cars, as the use of certain light materials may be limited[36]. The Commission believes that the EOL Directive will not have such adverse effects. However, no

[34] COM (2000) 615 final
[35] COM (2001) 241 final
[36] COM (2002) 693 final

evidence could be found from public available sources, that the ELV Directive influences direct CO_2 emissions of new passenger cars.

Concerning the other assumptions on the distortion of competition and the acceptance of innovations, relevant problems were not raised during the Monitoring process. Other indications for changes with regard to these assumptions could not be found.

Influence by other EU-regulations

The focus of this survey is set on regulations which were implemented in the time frame from 1998 and 2003 and could therefore possibly influence CO_2 emissions after the arrangement of the commitment on CO_2 reductions in autumn 1998. The EU directives as to be seen in the following table can be divided into two groups: directives concerning environment protection and directives regarding safety aspects.

Directives concerning the environment protection include mandatory tailpipe emissions limits and on-board diagnostics (OBD) for emission control. As a benefit for the environment, the End-Of Life Directive regulates the production of waste and the minimizing of ecological damage through end-of life vehicles (see section above). Moreover, a directive adaptation gives assignments about the installation of exhaust systems, related to the permissible sound level emitted by motor vehicles.

The safety related directives are adaptations and amendments of consisting directives as well. They have several different subjects: improvement of the protection of occupants of motor vehicles in the event of a frontal impact, the adapting to technical progress of safety belts and restraint systems, the protection of pedestrians in the event of a collision with a motor vehicle and a type-approval for devices for indirect vision.

Table 11: Directives on motor vehicles relevant from 1998 to 2003

Reference	Title	Subject	Effective	Impact on CO_2
1998/69/EC	Amendment of Directive 70/220/EEC	air pollution by emissions	Mainly by 2000 and 2005	Not relevant because contents were already known when signing the commitment on CO_2 reduction.
1999/98/EC	Adaptation of Directive 96/79/EC	safety, protection of occupants of motor vehicles (certification procedure for the dummy lower leg and foot)	MS shall bring into force by 30 September 2000 at the latest.	Evidence for influence on CO_2 emissions could not be identified.
1999/101/EC	Adaptation of Directive 70/157/EEC	permissible sound level and the exhaust system of motor vehicles	MS shall bring into force not later than 31 March 2000.	Evidence for influence on CO_2 emissions could not be identified.
1999/102/EC	Adaptation of Directive 70/220/EEC	air pollution by emissions, On-board diagnostics (OBD)	2000 (new types), 2001 (all vehicles)	Evidence for influence on CO_2 emissions could not be identified.

2000/3/EC	Adaptation of Directive 77/541/EEC relating to safety belts and restraint systems of motor vehicles	safety, safety belts and child restraint systems	MS shall bring into force by 30 September 2000 at the latest.	Evidence for influence on CO_2 emissions could not be identified.
2001/1/EC	Amendment of Directive 70/220/EEC	air pollution by emissions, On-board diagnostics (OBD)	2000 (new types), 2001 (all vehicles)	Evidence for influence on CO_2 emissions could not be identified.
2003/97/EC	Type-approval of devices for indirect vision, amending Directive 70/156/EEC and repealing Directive 71/127/EEC	safety, devices for indirect vision	before 24 January 2005	Evidence for influence on CO_2 emissions could not be identified.
2003/102/EC	Protection of pedestrians and other vulnerable road users before and in the event of a collision with a motor vehicle and amending Directive 70/156/EEC	protection of pedestrians	MS shall bring into force by 31 December 2003 at the latest.	Evidence for influence on CO_2 emissions could not be identified
2000/53/EC	Directive on end-of life vehicles	Environment, reduction of waste through scrapped cars	MS shall bring into force by 21 April 2002.	Evidence for influence on CO_2 emissions could not be identified

Based on information available for public, no evidence for influencing direct CO_2 emissions of the measures listed above e.g. by affecting the powertrain efficiency, curb weight or aerodynamic resistance, could be found.

Influence by improved safety performance

The safety performance of cars has become a key element of buyers purchasing decision.

There are two directives on frontal respectively side impact which had an impact on the weight of the cars from 1 October 1998, namely:

- Directive 96/79/EC of the European Parliament and of the Council of 16 December 1996 on the protection of occupants of motor vehicles in the event of a frontal impact and amending Directive 70/156/EEC.
- Directive 96/27/EC of the European Parliament and of the Council of 20 May 1996 on the protection of occupants of motor vehicles in the event of a side impact and amending Directive 70/156/EEC.

But these Directives were already approved in 1996 and therefore known by manufacturers when they made their Commitments. Passenger cars complying with these Directives meet in the European New Car Assessment Programme (EuroNCAP) the two stars rating. Such cars, however, are nowadays lagging far behind the safest cars on the market which have five stars.

As the European Commission encouraged the introduction of safer cars by promoting EuroNCAP, corresponding influences on CO_2 emissions are described in this section. It focuses on influences causing higher CO_2 emissions directly. Indirect influences with respect to various allocations of research and development budgets, either to safety- or to fuel saving aspects, are not considered here.

The assessment of EuroNCAP is based on a frontal, side and a pole crash test as well as on a series of tests to replicate accidents involving pedestrians. An impact on CO_2 emissions can be expected from additional weight due to

- changes in the body structure and
- additional safety equipment (e.g. airbags, belt pre-tensioners).

Negative impacts with respect to aerodynamics due to changes of the front design for better pedestrian safety appeared to be very low and quantified information could not be obtained so far.

Additional weight due to chances in body structure

Concerning the body structure, there is no evidence that cars, which are new designed with respect to the current crash tests, have a higher weight. As their bodies are redesigned also with regard to other aspects than safety, the isolation of this effect is not possible. For cars, which are improved by additional bars or traverses during the production, some additional kilograms could be mentioned explicitly. However, it can be stated that nearly every car was totally renewed between 1995 and 2003.

Additional weight due to additional safety equipment

The increasing safety requirements led to a growth of additional equipment necessary for competitive restraint systems. The most important are as follows:

- Airbags for driver and front passenger, side-impact airbag. For some cars 2nd-row side-impact airbags, head protection airbags (curtains) and knee protection airbags are available.
- Antilock Braking System (ABS)
- Belt pre-tensioners
- Electronic stability programs
- Corresponding sensors and control units
- Rear head restraints and three-point seat belts for all rear passengers

In 1995 these safety items did not belong to the standard equipment for most of the cars. Only the higher powered versions and Upper Medium and Luxury segment cars were equipped. To estimate the additional weight resulting from this development the example of Mercedes-Benz's Upper Medium type "E-Class" by 1996 is taken[37]:

- Driver and front passenger airbags: 8.5 kg
- Sidebags: 5.0 kg
- Anti-block braking system: 2.8 kg
- Electronic stability program 0.2 kg

[37] Motor Presse Stuttgart, (1997).

Safety equipment is improved continuously like all other technologies with respect to functionality as well as to weight. E.g. for the Anti-block braking system of Bosch[38] a weight reduction from 2.6 kg in 1995 to 1.6 kg in 2003 could be achieved. Therefore, the indications for the weight above have to be reduced to certain extend. Including other equipment for which weight figures are not available, a total additional weight with respect to safety of 15 to 20 kg is assumed.

In order to quantify the influence of the additional weight due to safety equipment on CO_2 emissions, several publications on the relation of vehicle weight to fuel consumption are used.

Based on the experience of the development of the Lupo "3 litre", Volkswagen published a reduction in fuel consumption of 8 % resulting from a 10 % lower weight[39]. For very small cars in general Volkswagen indicated 4 to 5 % lower fuel consumption related also to a 10 % reduction of weight[40]. Based on the actual weight and emissions of these cars, a CO_2 reduction of approximately 12 g and 6 g respectively per 100 kg and km can be calculated here.

DaimlerChrysler mentioned a relation of 3 % reduction in fuel consumption due to a weight reduction of 10 % for its Small segment car A 140 as well as for the luxury S 500[41]. Taking into account real weight and emission figures, this means a reduction of CO_2 emissions of nearly 5 g per 100 kg for both types.

In summary, a CO_2 emission increase in the range of 0.8 to 2.4 g/km can be found out by assuming an additional weight of 15 to 20 kg due to safety measures taken voluntarily by the manufacturers.

5.3 Selected socio economic and demographic aspects

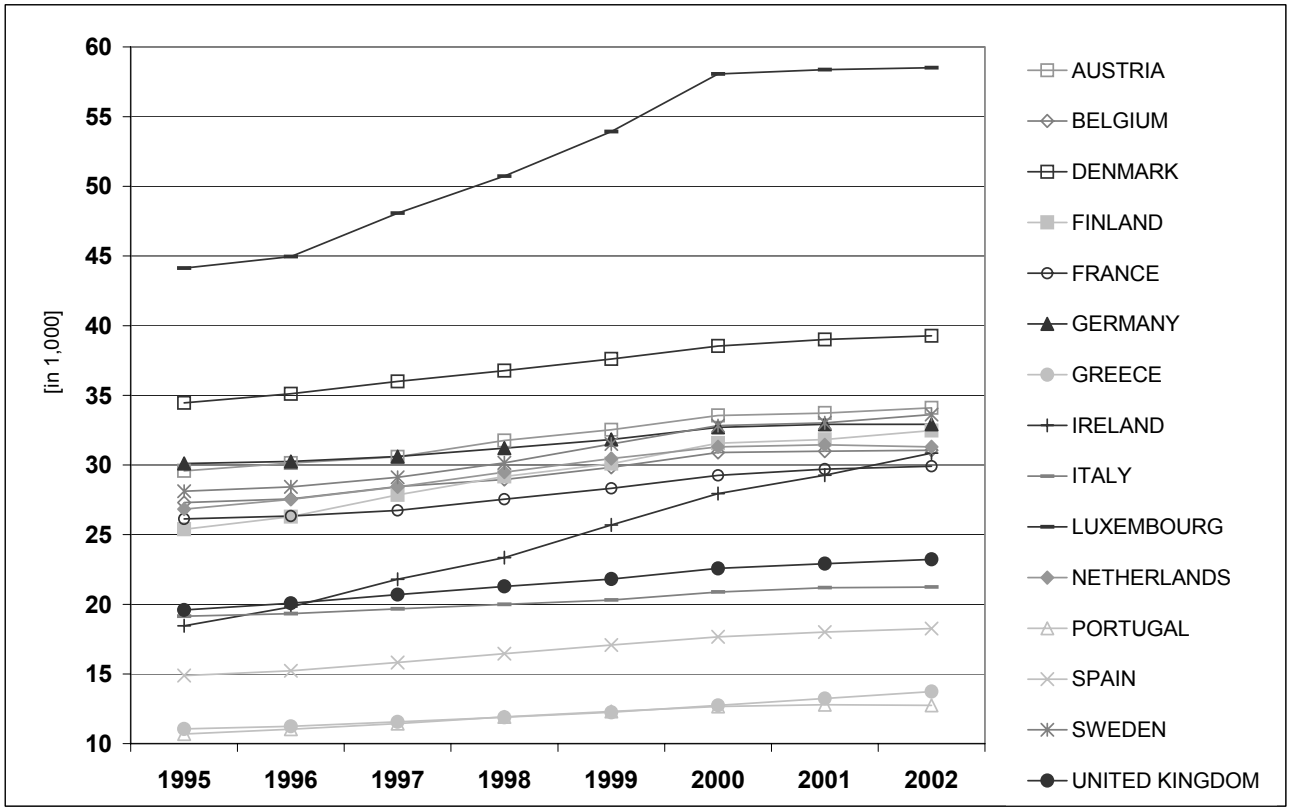
Environmental stewardship requires recognition not only of technical advances and fiscal measures, but also of the socioeconomic traits of the population at large. Knowledge about people, where they live, how much they earn, their age distribution, and other traits can lead to a better understanding of the developments in the car sector. Below are provided some selected socio economic and demographic background information about the European population.

5.3.1 Income/GDP

A number of socio-economic trends can influence the behaviour of new car purchasers (see list in chapter 2). Especially the increasing incomes in certain Member States are significant. They can drive the market towards larger cars or versions with better equipment or higher engine power. As a consequence, the average CO_2 emission could potentially increase due to changed consumer behaviour. The influence of temporal and cross-sectional variability in GDP per capita, shown in figure 14, is analyzed in a subsequent chapter.

[38] Bosch, (2003).
[39] Josefowitz, Köhle, (2002).
[40] Friedrich, Gänsicke, (2001).
[41] Heil, (2001).

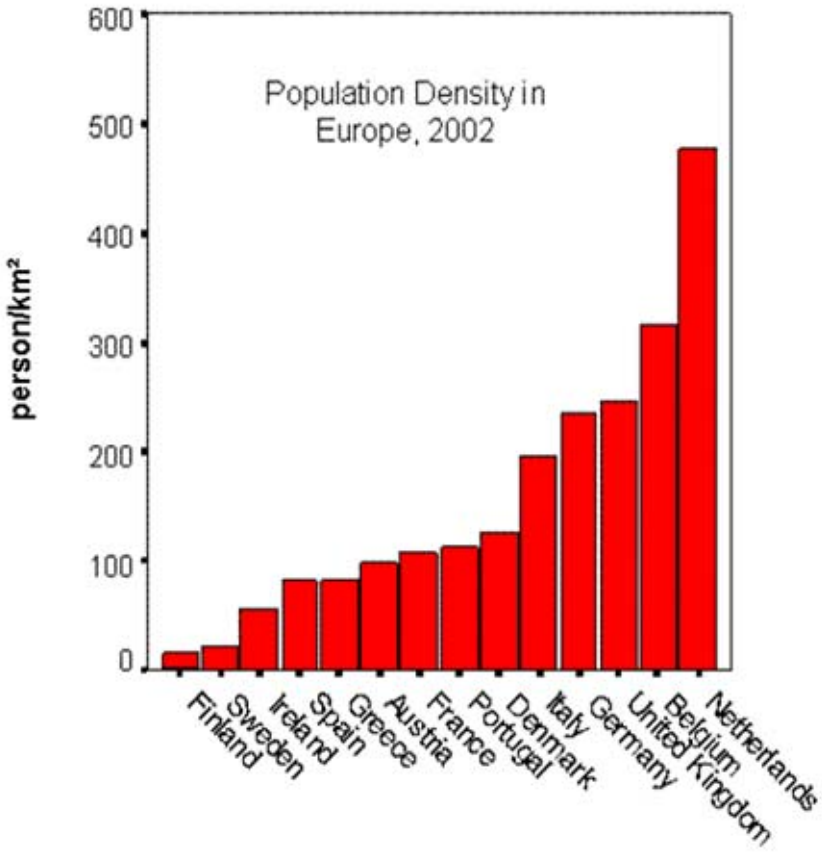
Figure 21: Cross domestic product per capita, at the price levels and exchange rates of 1995 [US $]



5.3.2 Population density in Europe

One of the greatest differences between the European countries is the population density. Six countries (Finland, Sweden, Ireland, Spain, Greece and Austria) have a comparatively low population density, which is below 100 persons per km². In four countries (France, Portugal, Denmark and Italy) the population density lies between 100 and 199 persons per km². In Germany and the United Kingdom, 200 to 299 persons have to share one km². The groups with 300 to 399 persons per km² and 400 to 499 persons per km² have only one member each: in Belgium 314 and in the Netherlands 477 persons live on one km².[42]

Figure 22: The population density in Europe in 2002.



In addition to other factors, the discrepancies evident in Figure 22 may cause different mobility demands among the people in the different countries and also different requirements to satisfy them. Generally speaking, it is expected that countries with higher population densities would also have better provision of public transportation infrastructure as well as greater road congestion. These two factors would likely have a dampening effect on the demand for new cars.

Regarding the evolution of population density in Europe in the period from 1995 to 2002, the picture is very uniform. In each of the 15 countries the population density increased[43]. The growth is only small, but evident.

[42] data from the year 2002. Source: THE WORLDBANK
[43] Values are missing for Luxembourg.

As a demographic measure, population density provides some insight into the spatial distribution of peoples at the European scale but sheds little light on this distribution within national borders. Additional information is given by measures of the proportion of the population living in urban areas.

5.3.3 Urban population

An analysis of the proportion of people living in urban areas shows increasing percentages in all countries except Finland. The overall average increase is, however, very small - roughly 2 %. Portugal is a notable exception, rising from 58 % in 1995 to 67 % in 2002. In Finland there is a converse development. In 1995, 64 % of the Finish residents lived in urban areas, a figure that was reduced to 59 % by 2002.

The type of area people are living in is an important factor influencing their mobility behaviour. Infrastructure supply in any form – public transport, shopping centers, education institutions, cultural events may be easy or even hard to reach, depending on whether people are living in urban or rural areas. These circumstances will affect mobility choices and in turn car-purchasing behaviour.

5.3.4 Distribution of Age classes in Europe

The age distribution of a society is another factor that is likely to affect car purchasing behaviour. To the extent that age is positively correlated with income, increases in age can have effects on both the numbers and types of cars that are purchased.
Figure 23 presents the age structure in Europe in 2003, which has been divided into six classes (0-14, 15-24, 25-49, 50-64, 65-79 and >80).

The fraction of children (0-14 ages) varies between 15 % (in Germany)[44] and 21 % in Ireland. There is a downward tendency in the development of this fraction from 1992 to 2003. Only in Denmark, Luxembourg and The Netherlands was an increase in this segment of the population evident.

The 15-24 age-segment comprises 11 % of the population in Denmark and Luxembourg and16 % in Ireland.[45] The longitudinal section from 1992 to 2003 shows a very uniform pattern all over Europe: a decrease from 1-4 %.

The biggest fraction is represented by persons between 25-49 years of age. They comprise anywhere from 34 % (Finland, Sweden) to 39 % (Luxembourg) of the population. The development of this group is very uneven in Europe. Over the years, a small increasing tendency can be seen in Belgium, Ireland, Austria and Portugal, whereas the quantity sinks in Denmark, France, The Netherlands, Finland and Sweden. In some countries, the percentage of this group remains nearly the same (Germany, Luxembourg).[46]

The fraction of people between 50-64 years of age comprise between 15 % (Ireland) and 20 % (Finland) of the population. Nearly all countries saw increases in this fraction, except Belgium staying steady and Luxembourg with a decline of one percent.[47]

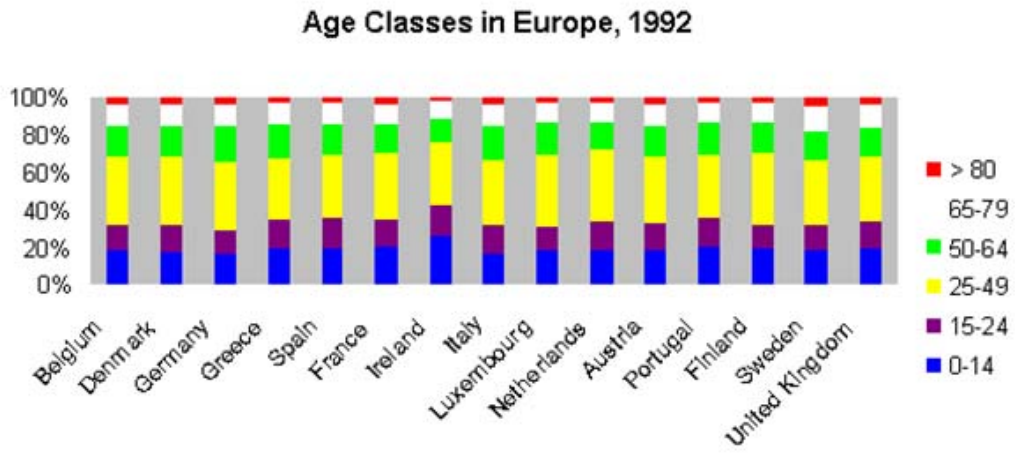
The elder people in Europe form a fraction of the population ranging from 9 % (Ireland) to 13 % (Belgium, Germany, Portugal). In most of the countries, this fraction is growing; Swe-

[44] Maybe the fraction of the Italian Youngsters in 2003 lies below 15 %, in 2001 the value was about 14 %, the values for 2002 and 2003 are missing.
[45] For some countries values are missing: Greece (2001-2003), Spain (2003), Italy (2002-2003) and the United Kingdom (2002-2003).
[46] See above
[47] See above

den is the only country where it has sunk, from 13 % in 1992 to 12 % in 2003. Ireland and The Netherlands have unchanged percentages in this age segment.[48]

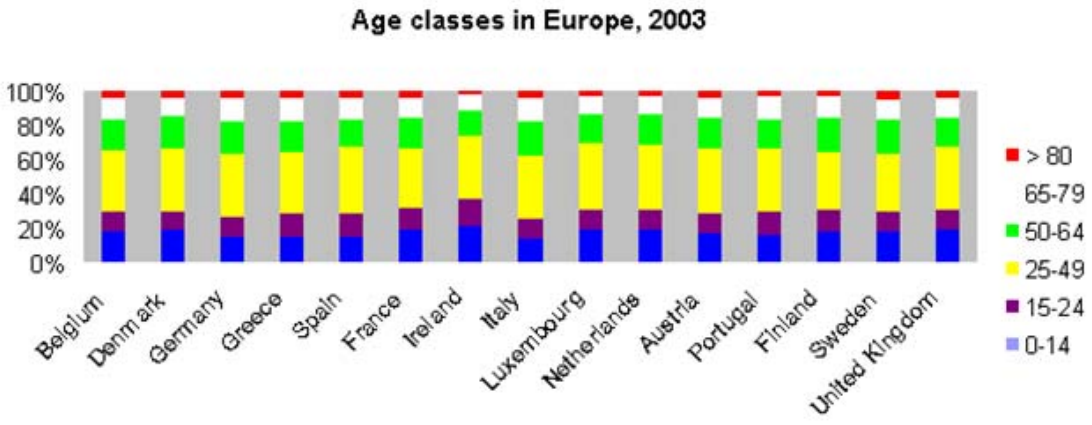
The smallest fraction is comprised of the eldest European persons, aged 80 and above. Their quota lies between 3 % (Ireland, Luxembourg, The Netherlands) and 5 % (Sweden). The size of this fraction is a very stabile. In many countries, the percentage stays the same (Belgium, Denmark, Germany, France, Luxembourg, The Netherlands, Austria). In the remainder of the countries, a light increasing can be observed.[49]

Figure 23: The distribution of the age classes in Europe in the year 1992.



Source: EUROSTAT (2004)

Figure 24: The distribution of the age classes in Europe in the year 2003.[50]



Source: EUROSTAT (2004).

[48] See above
[49] See above
[50] The missing values for the year 2003 are substituted by the values of the years 2000 (Greece), 2001 (Italy and United Kingdom) and 2002 (Spain).

5.4 Other influences

5.4.1 Influence by lifestyle trends

There is a steady growth in the amount of different car types in Europe. The variety in car body forms is growing to a great extent and there is an increasingly smooth transition between the car types. This development has taken place due to the fact that there is a general demand for different car types that better fit the consumer needs. In this context, factors such as functionality or driving pleasure are important criteria that influence the consumer's car purchase decision. Generally, well equipped cars are demanded. In this respect, safety and comfort are two attribute that have a particularly high priority. There is a continuing incentive for automotive producers to improve safety features as evidenced e.g. by the work of EuroNCAP which has been established in 1997.[51] The impact of additional safety features within the observed is time frame is described in chapter 4.10.

As published surveys have demonstrated, consumers in Europe are looking for lifestyle-oriented products and premium brands. This has led to a broadening of the car manufacturers' product range and hence increased competition within ranges. To account for this development, the econometric model includes a price index that measures the average price of competitor cars in the same car segment.

5.4.2 Influence by the country of origin of manufacturers

A final influence to consider is that of the country of origin. All else equal, consumers will tend to purchase cars that they associate with their home country, even when in reality the car may have been manufactured to a large extent elsewhere. In order to control for this national loyalty in car purchasing behaviour, the econometric model includes an indicator variable for foreign automobiles. The variable assumes a value of 1 for those observations in which the nationality of the car manufacturer corresponds to that of the country where the car was sold and a zero otherwise. For example, the variable would take on a value of zero for those observations in which a Fiat is sold in Italy and a value of one for observations of Fiats sold in Denmark.

5.5 Catalogue of non-technical influences for analysis in the econometric model

The foregoing analysis provided a survey of non-technical factors form which those have been identified that potentially had an influence on average CO_2 emissions. The subsequent analysis of Chapter 6 employs econometric modelling to quantify their impact. Thus, the following variables are included in the model:

- Car prices
- Price index of alternative cars
- Size of car
- Indicator for manufacturer's country of origin
- Population density
- Percent of population aged 50 to 64
- Percent urban population

[51] see http://www.euroncap.com/

- Per capita GDP
- Fuel prices (inclusive of taxes)
- Circulation taxes

Because of their immediate relevance for fiscal policy, the final three of these were selected for more detailed analysis by means of statistical simulations, as described in the following chapter. With respect to taxes, the following table summarises the results of the survey.

Table 12: Summary of taxes in Europe with indication for their use in the econometric model

	Circulation tax	**Registration tax**[52]	Remark
Austria	**no**	**no**	Leveling of circulation tax/ inscurance, no relevant changes
Belgium	**no**	**no**	Constant development (consumer's price index)
Denmark	**yes**	**yes**	Change from weight to fuel consumption based circulation tax, high registration tax
Finland	**no**	**no**	No relevant changes
France	**yes**	**no**	Abolishment of circulation tax (12/2000)
Germany	**yes**	**(no tax)**	No relevant changes, but most registrations in Europe
Greece	**no**	**no**	Constant tax rates, no system changes
Ireland	**no**	**no**	Constant moderate increasing, no relevant changes
Italy	**yes**	**no**	Change from engine capacity to engine power based circulation tax
Netherlands	**no**	**no**	Incentives for fuel efficient cars, high registration tax
Portugal	**no**	**no**	High but constant registration tax
Spain	**yes**	**yes**	No relevant changes, but considerable changes of other variables and the registrations' structure
Sweden	**no**	**(no tax)**	No relevant changes
United Kingdom	**yes**	**(no tax)**	Change from engine capacity to CO_2 emission based tax

Six countries – Denmark, Germany, Spain, France, Italy, and the United Kingdom – are singled out for inclusion in the econometric for the analysis of taxes. These countries were selected based on whether significant changes in the tax regime occurred over the period under study and on the weight they are likely to have on overall average CO_2 emissions due to their population counts.

Chapter 6 presents parameter estimates of the influence for each of the selected variables and the interpretation of these influences.

[52] For modelling purposes this variable is included in the new car prices.

6 The Econometric Analysis

6.1 Introduction

This section of the study employs econometric techniques to analyze the roles of technical and non-technical factors in the reduction of average CO_2 emissions between 1996 and 2002. Two modeling approaches are pursued. The analysis of technical factors proceeds on the basis of a linear model that directly relates CO_2 emissions for individual car models to a suite of technical attribute variables. As non-technical influences generally affect CO_2 emissions only indirectly, the analysis of non-technical factors employs a log-log regression that relates the number of car registrations by model type to select socioeconomic variables and automobile attributes. In a second step, associated implications for average CO_2 emissions are derived. Results from both the technical and non-technical analyses serve to gauge the statistical significance and magnitude of the included explanatory variables and to predict hypothetical CO_2 emissions using the model estimates for particular variables of interest. These predictions then serve as the basis for estimating CO_2 emissions under various scenarios pertaining to technological development, per capita GDP, fuel prices, and circulation taxes.

6.2 Methodological Issues

The models are estimated using data on registrations and car attributes for the years 1996 to 2002 that was collected by Polk. This data is augmented by a panel of country-level socioeconomic data spanning the same time interval that was obtained from various sources. Data on per capita GDP and the percent of urban population was obtained from the World Bank's Development Indicators (2004), see chapter 5.3. Energy prices, population densities, and the share of the population in different age brackets was obtained from EUROSTAT, while data on inflation rates was obtained from the OECD. In addition, the ACEA Tax Guides provided the information used to create variables measuring circulation taxes on private cars (see chapter 5.2). All variables that are expressed in currency units were converted into Euros and adjusted for inflation using a GDP deflator obtained from the OECD.

While the models of CO_2 emissions and car registrations are both estimated using Ordinary Least Squares (OLS) regression, there are a few features that distinguish them. The most important of these relates to the functional form of the dependent and independent variables. The parameter estimates for the model of CO_2 emissions are generated from a linear regression model, which can be expressed as:

1) $$y_{it} = \alpha + x_{it}\beta + \varepsilon_{it}$$

where the subscript i refers to the observation, subscript t refers to the time, y is the dependent variable (CO_2 emission), α is a constant, x is a vector of explanatory variables, β is a vector of parameter estimates, and εit is the error term, assumed to have a normal distribution. The parameters ß in the model are interpreted as the unit change in the dependent variable resulting from a one unit increase in an independent variable x, holding all other explanatory variables fixed.

The model of car registrations employs a log-log model, which transforms the dependent and all of the continuous explanatory variables into logarithms. This is a typical specification in

the literature on motorization, and its application here was based on a comparison of the statistical precision and fit of alternative specifications. The log-log model is expressed as:

2) $$\ln(y_{it}) = \alpha + \ln(x_{it})\beta + \varepsilon_{it}$$

With this transformation, the estimated ß's are interpreted as giving the percentage change in the dependent variable from a percentage change in an independent variable holding all other variables fixed. Thus, if Y measures car registrations, X measures per captia GDP, and ß equals 0.7, then a one percent change in GDP is estimated to yield an increase of 0.7 percent in the number of cars registered. The unit of observation is the total number of registrations for a particular model type in a particular year and country.

Unlike the analysis of CO_2 emissions, which estimates separate models for the years 1996 and 2002, the analysis of car registrations estimates a pooled model that combines all the years. Year dummy variables are included in the model to control for the effect of autonomous shifts in the macroeconomic environment while country dummy variables are included to control for fixed national attributes that are not otherwise captured by other variables in the model. Both the models of CO_2 and total registrations incorporate non-linear effects for select variables through the inclusion of squared and interaction terms. The model of CO_2 includes the interaction of the variables measuring engine power (kilowatts) and kerb weight. This allows for statistical tests of whether the effect of engine power on CO_2 is constant across values of kerb weight and, conversely, whether the effect of kerb weight is constant across values of engine power. In the model of car registrations, interaction terms are incorporated to allow for differing effects of explanatory variables according to the car segment.

A final feature distinguishing the two models relates to the generation of predicted values for analyzing CO_2 outcomes under alternative assumptions about changes in the explanatory variables. The predicted values for model (1) are obtained by setting all variables other than the variable for which the simulation is conducted to their mean values and multiplying these means by the corresponding coefficient estimates. The predicted values for model (2) are generated based on the same principle, but incorporate a statistical simulation technique (akin to a Monte Carlo simulation) that facilitates transformation of the logged dependent variable into an absolute value.

6.3 Results: Analysis of technical factors on CO_2

Table 13 presents estimates from four linear regressions of CO_2 emissions on various automobile attributes including registrations of all associations. Columns one and two of the table present parameter estimates for petrol automobiles for the years 1996 and 2002; columns three and four present estimates for diesel automobiles for the same years. All four models explain a relatively high percentage of the variance in the data, with R-square values ranging between 0.82 and 0.90. Moreover, the coefficient estimates are in most cases highly statistically significant and have signs and magnitudes that are generally consistent with intuition. As noted above, the estimates are interpreted as the change in CO_2 emissions from a one unit change in the explanatory variable holding all other variables fixed. Thus, it is seen that a one millimeter increase in the attribute width results in a 0.037 increase in emissions. For the binary indicator variables, the estimates are interpreted as the difference in CO_2 emissions relative to a comparison group that is excluded from the model. For example, the indicator variable for automatic transmission is seen to vary between 11 and 13 in columns one through three, suggesting that automobiles with automatic transmissions emit roughly 12

more grams of CO_2 than automobiles with standard transmission types (the comparison group) holding all other factors fixed. Interestingly, the coefficient estimate of automatic increases substantially for diesel automobiles between 1996 and 2002, indicating a roughly 10 gram increase. Finally, both kerb weight and engine power have positive effects on CO_2 emissions, but the negative coefficient on the interaction of the two variables (kerbwgt*KW) indicates that this effect is diMinishing.

Table 13: OLS regression of technical attributes on CO_2 emissions (selected coefficients)

	Model 1: Petrol 1996	Model 2: Petrol 2002	Model 3: Diesel 1996	Model 4: Diesel 2002
Cylinders	1.49	6.61	6.40	9.40
	(0.000)	(0.000)	(0.000)	(0.000)
Length (mm)	0.0001	-0.0006	0.0109	0.0025
	(0.898)	(0.264)	(0.000)	(0.000)
Width (mm)	0.037	0.012	0.006	-0.012
	(0.000)	(0.000)	(0.411)	(0.000)
Height (mm)	0.06	0.02	0.07	0.06
	(0.000)	(0.000)	(0.000)	(0.000)
Automatic transmission	11.389	12.635	11.827	22.065
	(0.000)	(0.000)	(0.000)	(0.000)
Cubic capacity (cm^3)	0.024	0.014	0.040	0.026
	(0.000)	(0.000)	(0.000)	(0.000)
Kerb weight (kg)	0.039	0.068	0.035	0.083
	(0.000)	(0.000)	(0.000)	(0.000)
Engine power (KW)	0.444	0.596	0.093	0.471
	(0.000)	(0.000)	(0.219)	(0.000)
Kerbwgt*KW	-0.0001	-0.0002	-0.0003	-0.0004
	(0.000)	(0.000)	(0.000)	(0.000)
R-squared	0.85	0.88	0.82	0.90
Number of observations	18359	37949	5583	18633

P-values are in parentheses. <0.10 indicates significance

Beyond estimating the effects of the individual automobile attributes, the results from the model can be used to gauge the extent to which technological changes have contributed to reductions in CO_2 emissions. For this purpose, three variables are selected for more detailed analysis – kerb weight, engine power, and height – all of which have undergone increases of at least three percent between 1996 and 2002. The analysis abstracts from the question of why these increases occurred to focus specifically on their implications for CO_2 emissions. This issue is addressed by using the parameter estimates from the model to generate pre-

dicted values of emissions corresponding to a range of values for each of the three variables in question, holding the other variables at their associated mean values. Predictions are generated for the years 1996 and 2002 for both the petrol and diesel fuel types, and are plotted in Figure 25 through Figure 27 below.

Figure 25: Predicted CO_2 emissions for different values of height

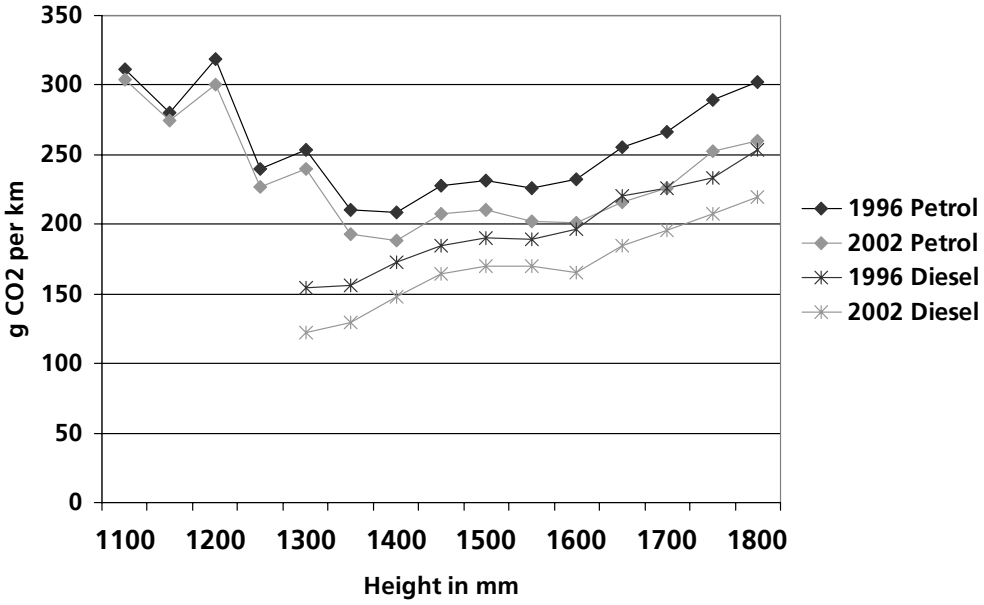


Figure 26: Predicted CO_2 emission for different values of kerb weight

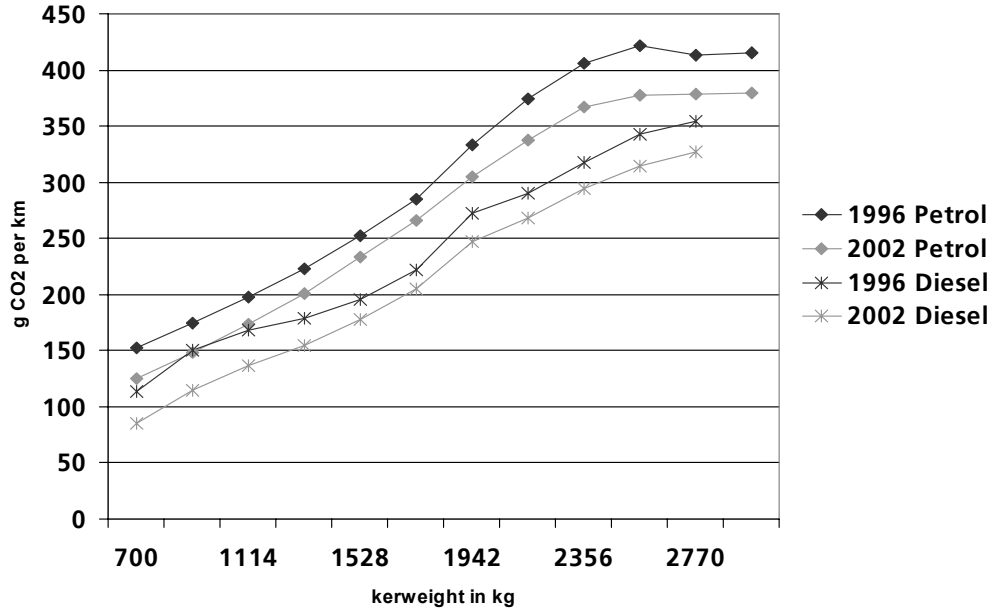
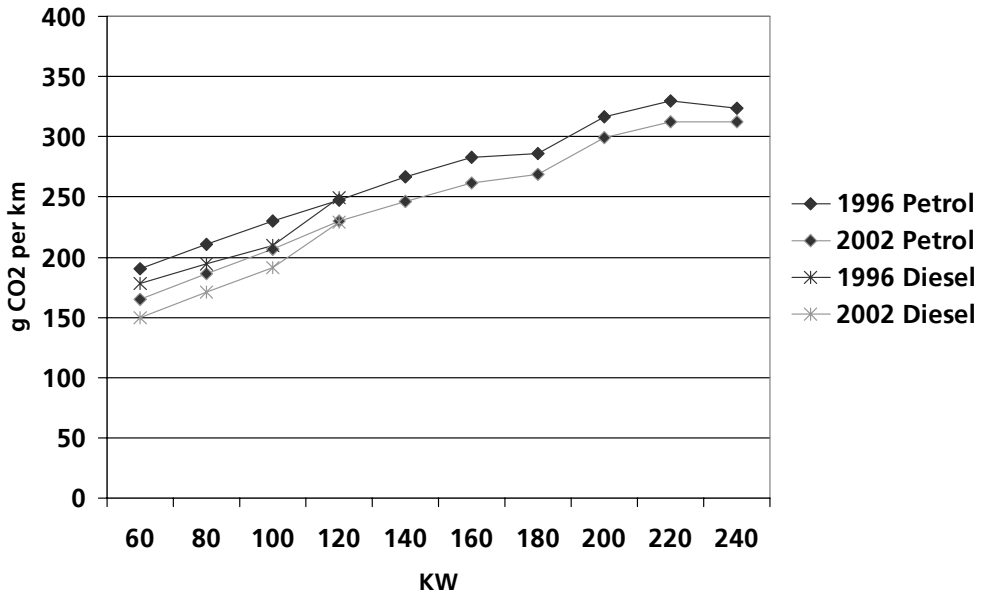


Figure 27: Predicted CO_2 emission for different values of engine power



All of the graphs indicate a reduction in total CO_2 emissions between 1996 and 2002 over the entire range of values. For example, a diesel car having a height of 1300 mm is predicted to emit approximately 155 grams of CO_2 in 1996, holding the other attributes fixed at the mean value corresponding to that height. By 2002, a car having the same height is expected, on average, to emit roughly 125 grams. The initially sporadic values of CO_2 for petrol cars are a likely consequence of the preponderance of sports models over low ranges of height.

The greatest reduction in CO_2 is seen for the attribute kerb weight, which on average corresponds to a CO_2 emission that is 29 grams below the value in 1996 for petrol automobiles and 25 grams lower for diesel automobiles assuming all other variables are fixed at their mean values. These figures translate into percentage reductions of 10 and 12.6 percent, respectively. With respect to the other two attributes, engine power and height, diesel automobiles were characterized by both larger absolute and percentage reductions in CO_2 emissions than petrol automobiles. For example, given a constant engine power, diesel cars underwent a reduction of 21.7 grams (10.2 percent) on average compared with 17 grams (6.7%) for petrol cars over the range of values for engine power (KW). The corresponding figures for height are 27 (14%) and 23 (9.2%) grams.

These reductions, however, will to varying extents be diminished by increases in the attributes themselves over the interval under study. As indicated in Table 14, for example, the average engine power increased by margins greater than the corresponding reductions in CO_2. The opposite pattern is seen for the attributes of kerb weight and height. With reference to the above figures, it also bears noting that the magnitude of the reduction, indicated by the vertical gap between the curves, remains relatively constant for a given attribute. Nevertheless, the general picture to emerge is that of technical change affording reduced CO_2 emissions over all values of the three attributes studied.

Table 14: Comparison of percentage increases in attribute values with percentage decreases in associated CO_2 emissions between 1996 and 2002

		Percent increase in attribute (observed)	Average percent decrease in CO_2 (predicted from model)
Kerb weight	**Petrol**	5.8%	10%
	Diesel	7.5%	12.6%
KW	**Petrol**	9.6%	6.7%
	Diesel	23.6%	10.2%
Height	**Petrol**	3.6%	9.2%
	Diesel	3.0%	14%

Findings from this analysis show substantial improvements in reducing CO_2, especially when considering the actual growth of the observed attributes. However, focusing on these technical indicators would not paint a comprehensive picture of the technological development that influences CO_2 emissions, as a multiple of other determinants and their interactions will play a role. In this regard, it should be noted that these interactions preclude the summation of the values in the table to arrive at a total percentage reduction in emissions. Instead, the figures give an indication of the average CO_2 reduction over values of a particular attribute holding the other attributes fixed. They thus provide a gauge of the extent to which manufacturers achieved greater efficiency in limiting emissions given trends toward increasing weight, height and engine power.

6.4 Results: Analysis of non-technical factors on CO_2

6.4.1 Model Estimation

Turning attention to the role of non-technical factors, the analysis begins with a market level model of the determinants of automobile registrations. Table 15 presents select coefficient estimates from four models of registrations for petrol and diesel cars. The models in columns one and two are estimated on data that pools private and non-private cars while the models in columns three and four are estimated exclusively on private cars (for the share of private cars see Annex 2). The models are additionally distinguished by the inclusion of a variable for circulation taxes in columns three and four. The models that include this variable are estimated on data from six countries that are deemed to be relevant according to findings in chapter 5: Denmark, the U.K. Germany, Spain, France, and Italy. As noted above, the coefficient estimates in all four models are interpreted as elasticities.

The majority of elasticity estimates are statistically significant and of the expected sign. Two price variables are included in the model: the price of the car and a price index representing the average price from competitor cars in the same segment. The price of the car is seen to be negatively related to the number of registrations while the price index for alternative manufactures has a positive effect, which is consistent with expectations of consumer behaviour. In particular, a 1% increase in price results in a percentage decrease in registrations ranging between 0.95 and 1.81%. Price increases in competitor models result in corresponding increases ranging between 0.17 and 0.87 percent. The size of the car (calculated as height times width) elicits a uniformly positive increase in registrations that is elastic (i.e. greater than 1%) for the case of petrol models and inelastic (i.e. less than 1%) for the case of

diesel models. The indicator variable for a foreign car is negative in all models, suggesting evidence for national biases in car purchasing behaviour. Given that the variable is binary, the percentage difference associated with the foreign as opposed to non-foreign designation is calculated using the formula:

3) $$\%\Delta car_registrations = 100[\exp(\beta) - 100]$$

Applying this formula to the foreign car indicator in model 1 yields a value of -51%, suggesting that the expected number of registrations for foreign cars is 51% of that of non-foreign cars. The variable for population density has among the highest elasticity estimates but with apparently opposing effects – positive for petrol and negative for diesel (noting that the estimate in Model 4 is statistically insignificant). The positive coefficients are a somewhat surprising result given that higher densities are generally associated with higher congestion and hence lower utility from private car transportation. One explanation is that the variable is partially picking up the effects of market size. Based on the coefficients from Models 3 and 4, the percentage of the population aged between 50 and 64 appears to have a negative effect for petrol cars and a positive effect for diesel cars. There is some evidence for a contradictory effect for the case of petrol in Model 1, but the estimate is just out of the range of statistical significance at the 10% level. Given the different samples of countries included in Models 1 and 3, the discrepancy may be attributed to different purchasing behaviour among consumers in this age bracket across nationalities. Further exploration of this issue would require a model that allowed for variable parameter estimates by country. The percent of urban population, again a proxy for congestion, has the expected negative sign in Models 1 through 3 and is insignificant in Model 4. Finally, the variables measuring per capita GDP, fuel prices per 100 km, and circulation taxes are all seen to have non-linear effects on car registrations as evidenced by the significance of the squared terms. In particular, the effect of GDP is positive though diminishing while the effects of fuel prices and taxes are negative and diminishing.

Table 15: OLS pooled regression: Elasticity estimates of the determinants of car registrations (selected coefficients)

	Model 1: Petrol EU15[a]	Model 2: Diesel EU15[a]	Model 3: Petrol select countries[b]	Model 4: Diesel select countries[b]
Car Price	-1.10 (0.000)	-1.69 (0.000)	-0.95 (0.000)	-1.81 (0.000)
Price index of alternative cars	0.71 (0.000)	0.17 (0.208)	0.87 (0.000)	0.71 (0.000)
Size of car	1.41 (0.000)	0.374 (0.013)	1.50 (0.000)	0.74 (0.001)
Foreign car indicator	-0.72 (0.000)	-0.79 (0.000)	-0.69 (0.000)	-0.72 (0.000)
Population density	10.68 (0.000)	-5.24 (0.049)	26.95 (0.000)	3.49 (0.289)
Percent aged 50 to 64 years	0.05 (0.105)	0.02 (0.683)	-0.12 (0.003)	0.19 (0.001)
Percent urban population	-1.00 (0.000)	-0.18 (0.004)	-1.92 (0.000)	0.00 (0.997)
Per capita GDP	271.41 (0.000)	172.78 (0.000)	241.01 (0.000)	64.43 (0.233)
Per capita GDP squared	-14.10 (0.000)	-9.27 (0.000)	-12.54 (0.000)	-3.61 (0.199)
Fuel price per 100 km	-15.43 (0.000)	-8.13 (0.000)	-21.53 (0.000)	-3.96 (0.007)
Fuel price per 100 km squared	0.73 (0.000)	0.35 (0.004)	1.06 (0.000)	0.13 (0.128)
Circulation tax			-0.85 (0.000)	-1.52 (0.000)
Circulation tax squared			0.07 (0.000)	0.15 (0.000)
R-squared	0.31	0.24	0.33	0.23
Number of observations	91481	43062	65943	27601

P-values are in parentheses. Country dummies, year dummies, and the interaction of each car segment with the variables per captia GDP, circulation tax, and fuel price are included in the model but not present in the table.

a This model excludes the countries Ireland and Luxembourg due to missing information on car prices.

b Countries included are: Denmark, Germany, Spain, France, Italy, and the United Kingdom.

6.4.2 Statistical Simulation

Returning to the core question of the effects of non-technical influences on average CO_2 emissions, it is of interest to move beyond assessing the statistical significance and magnitude of the coefficient estimates to consider their implications for the proportion of registrations in each segment. In principle, it would be possible to generate predicted values from the model over a range of values for the explanatory variables – as was done using the results from the model of CO_2 – and then take the exponential to transform the dependent variable out of logarithmic form. Given the log-log specification of the model, however, such a procedure will generally result in a biased predictor due to both the distribution of the estimator and the random nature of the disturbance term[53]. To address this difficulty, a technique advanced by King, Tomz, and Wittenberg (2000) was employed that uses statistical simulation to obtain predicted values of the dependent variable over a range of values for the independent variables. One key advantage of the approach is that it uses the parameter estimates from the model to first simulate the dependent variable ln(Y), making it then possible to apply the inverse function exp(ln(Y) in order to produce an estimate of Y, the quantity of interest. Tomz, Wittenberg and King (2003) have developed a software to facilitate implementation of the technique called CLARIFY, which was used in the present analysis[54]. Three independent variables were selected for simulation – per capita GDP, fuel prices, and circulation taxes – on the basis of their immediate relevance for policy and likely importance in determining segment shares.

Because of the computational intensity of the procedure, the first step in its implementation was to aggregate the data by segment and re-estimate a simplified version of the model. The associated loss of information from aggregation for individual automobiles led to the substitution of the explanatory variable gasoline prices per 100 kilometers for simply gasoline prices. As above, two variants of the model were estimated, the first on the entire sample of countries and the second limited to private automobiles and to those countries for which tax changes are relevant. The data was further partitioned into two groups corresponding to the ACEA and JAMA manufacturer's associations. Following model estimation, the simulated predictions were calculated for the year 2002, the results from which are presented in Figures 28-33. Simulations were generated for each combination of manufacturers association, fuel type, and determinant (GDP, fuel price, and circulation tax) with the exception of diesel automobiles falling under JAMA due to the volatile market changes that occurred over the period under study in this subgroup. The plotted lines show the predicted share of registrations by segment for different values of the independent variables per capita GDP, petrol prices, and circulation taxes holding all other conditions in 2002 fixed. For example, from Figure 28 it is seen that given an average per capita GDP of 20700, the Small segment is predicted to account for roughly 37% of all ACEA registrations.

ACEA

The plots of predicted values for ACEA automobiles, shown in Figures 28-30, reveal complex patterns of shifting registration shares with changes in the independent variables. For petrol automobiles, increases in GDP lead to a reduction in the shares of Small and Lower Medium segments and increases in the shares of the Medium and – to a lesser extent – the Upper Medium segments, suggesting shifting preferences for larger cars as income increases. For the case of increasing circulation taxes, the Medium and Lower Medium shares increase with decreasing or roughly stable shares in the remaining segments. The Medium segment also increases given increases in gasoline prices, in this case accompanied by slight increases in

[53] Van Garderen, (2001), p. 120.
[54] available at http://gking.harvard.edu/

the Upper Medium share and decreases in the Small share. The remaining shares remain relatively constant. These trends may be indicative of a greater sensitivity to fuel prices among consumers of the Small segment, who may reduce car purchases, relative to consumers of large automobiles.

Figure 28: Influence of per capita GDP in Euros on the ACEA segment shares of petrol cars in 2002

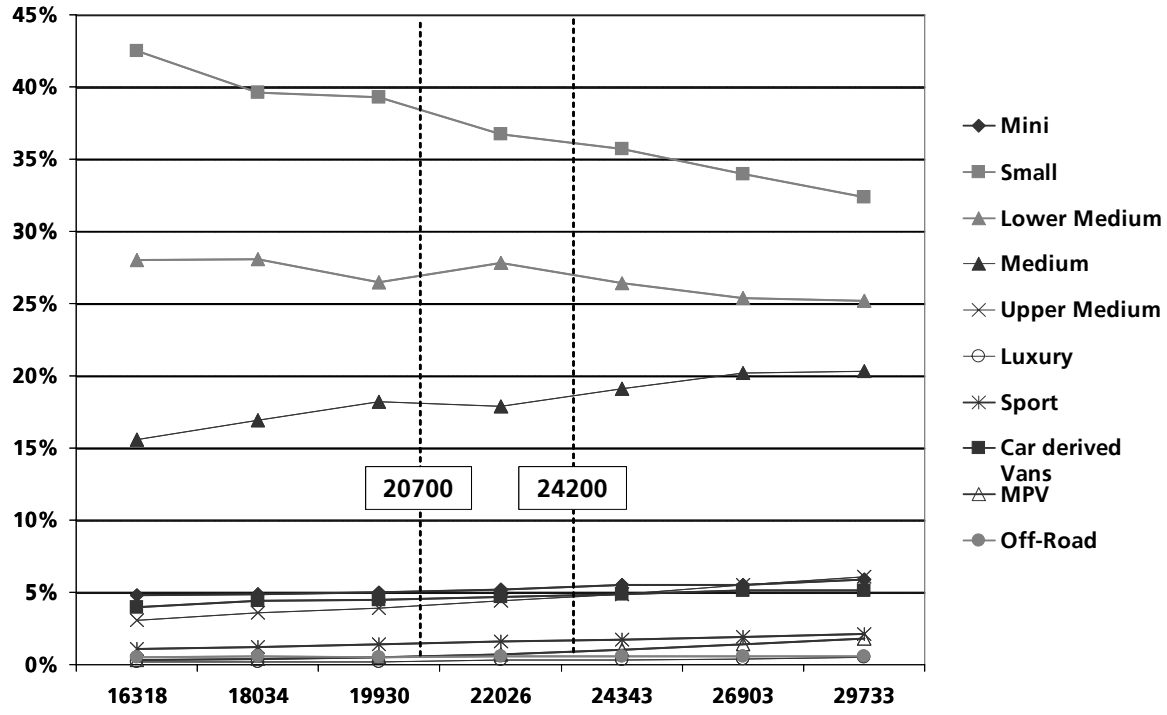


Figure 29: Influence of the fuel price in Euros on the ACEA segment shares of petrol cars in 2002

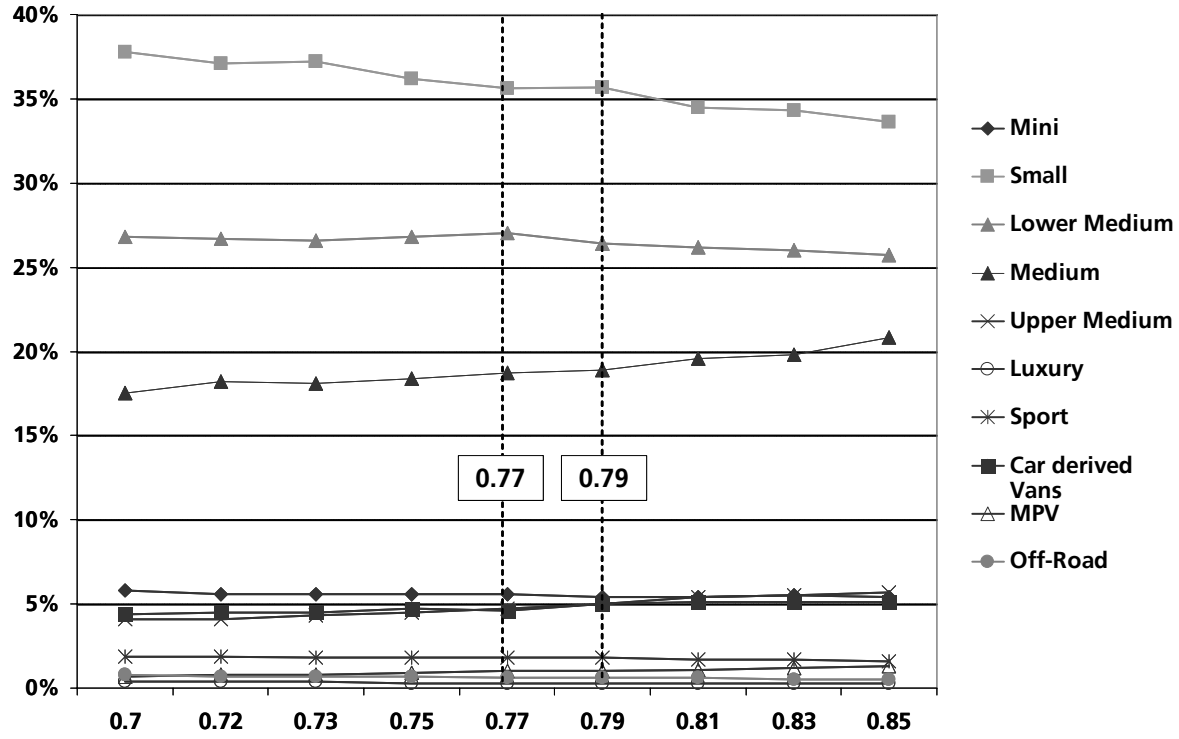
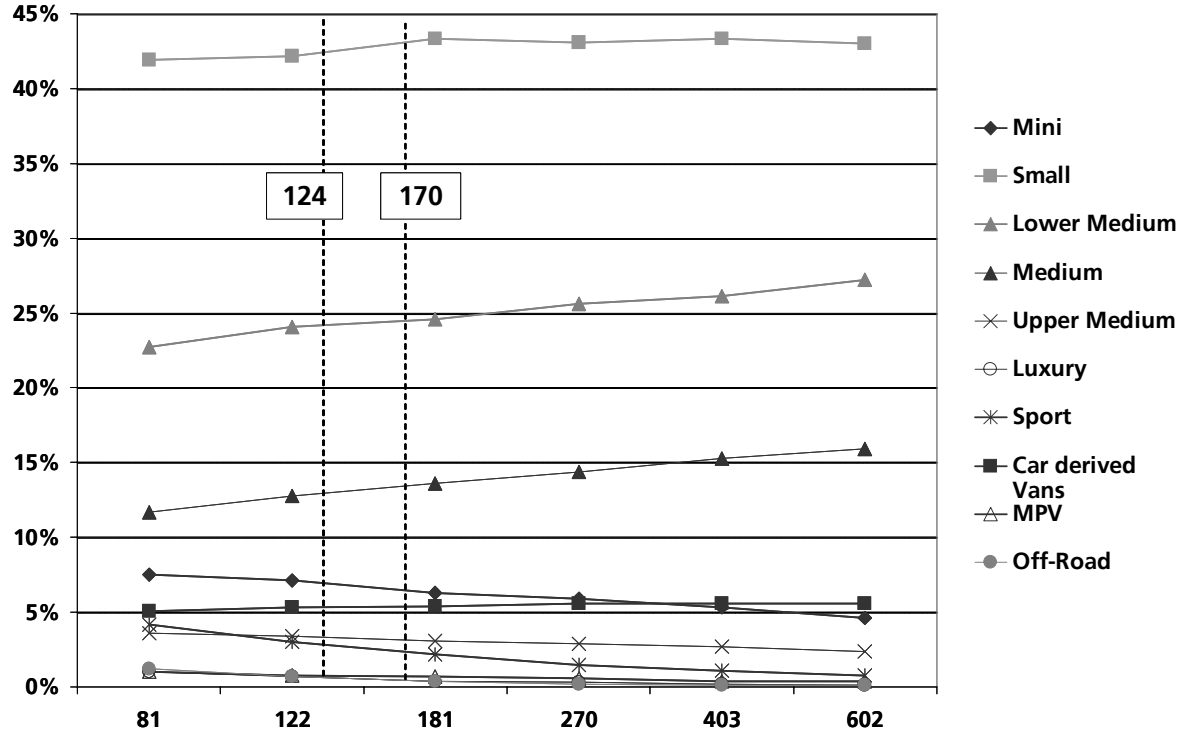


Figure 30: Influence of circulation taxes in Euros on the ACEA segment shares of petrol cars in 2002



With respect to ACEA diesel automobiles, increases in per capita GDP have the strongest effects on the medium and lower medium segments, which decrease and increase shares, respectively. The MPV and Car Derived Van segments also undergo increases. The segment shares remain relatively constant in response to fuel prices, with some evidence of increasing shares for the Lower Medium segment and decreasing shares for the Upper Medium segment. Finally, the most notable effects of circulation taxes are to increase the market shares for the Small and Upper Medium segments and decrease shares for the Medium segment. Segment shares decrease for the Car Derived Vans, MPV and Off-road segments, and increase for the Mini and Lower Medium segments, though the trends are less pronounced.

Figure 31: Influence of per capita GDP in Euros on the ACEA segment shares of diesel cars in 2002

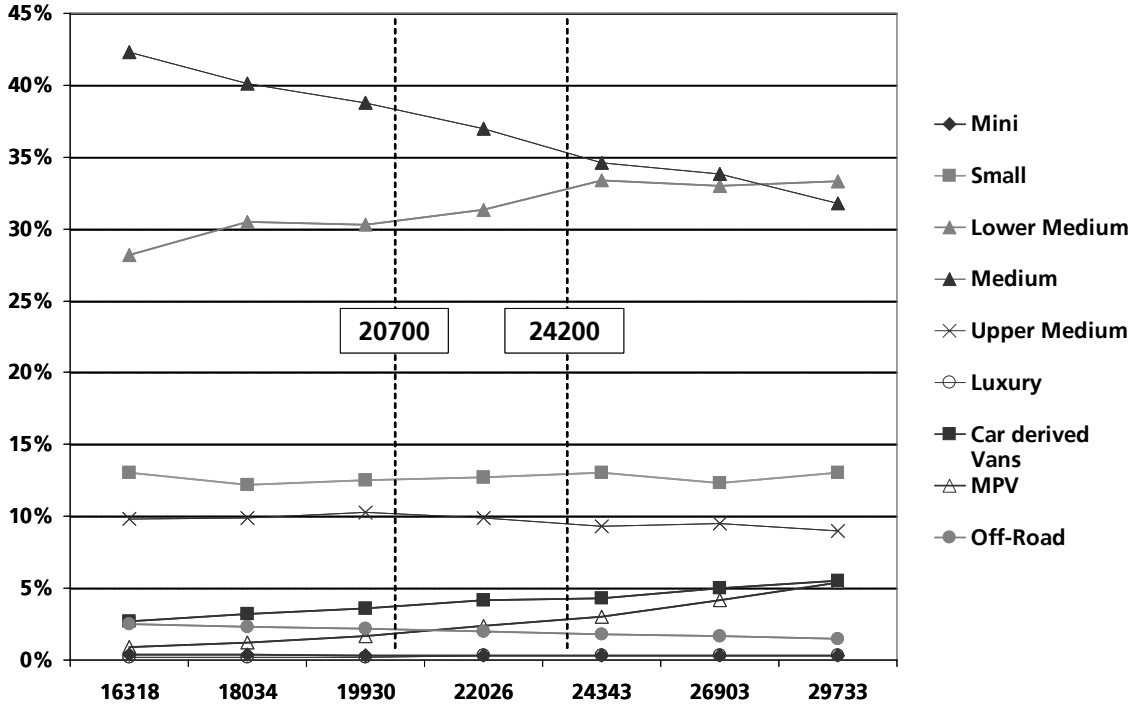


Figure 32: Influence of the fuel price in Euros on the ACEA segment shares of diesel cars in 2002

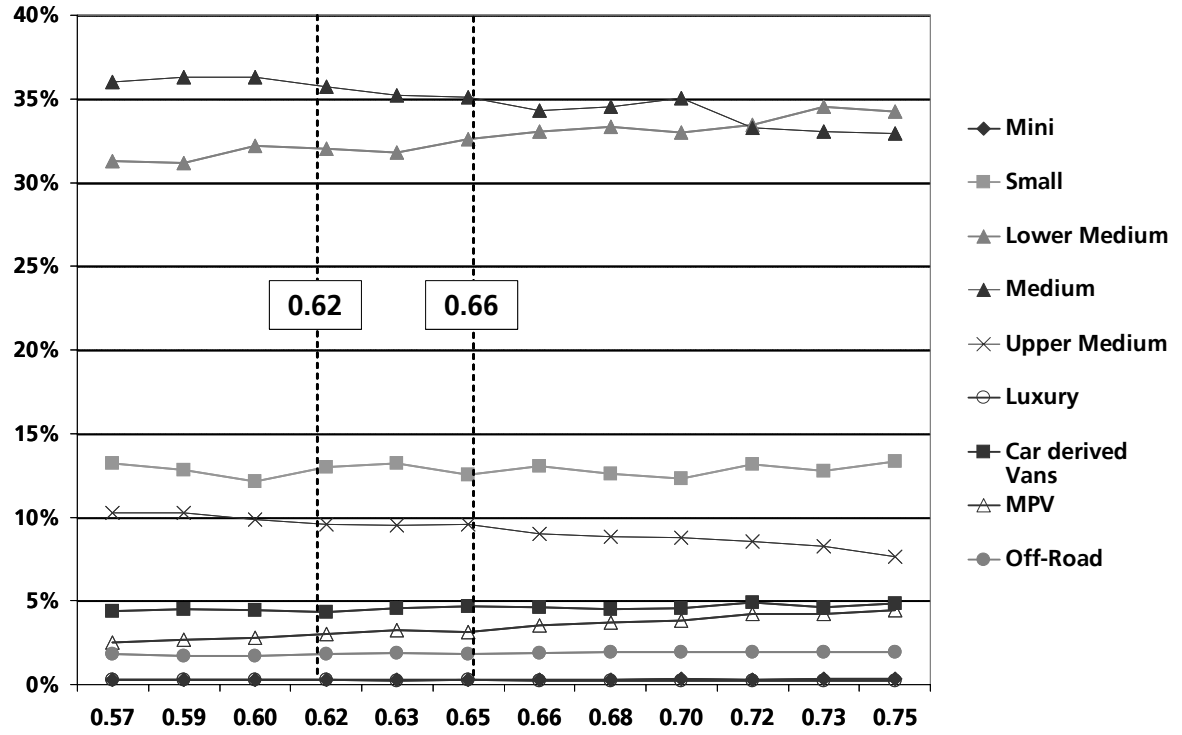
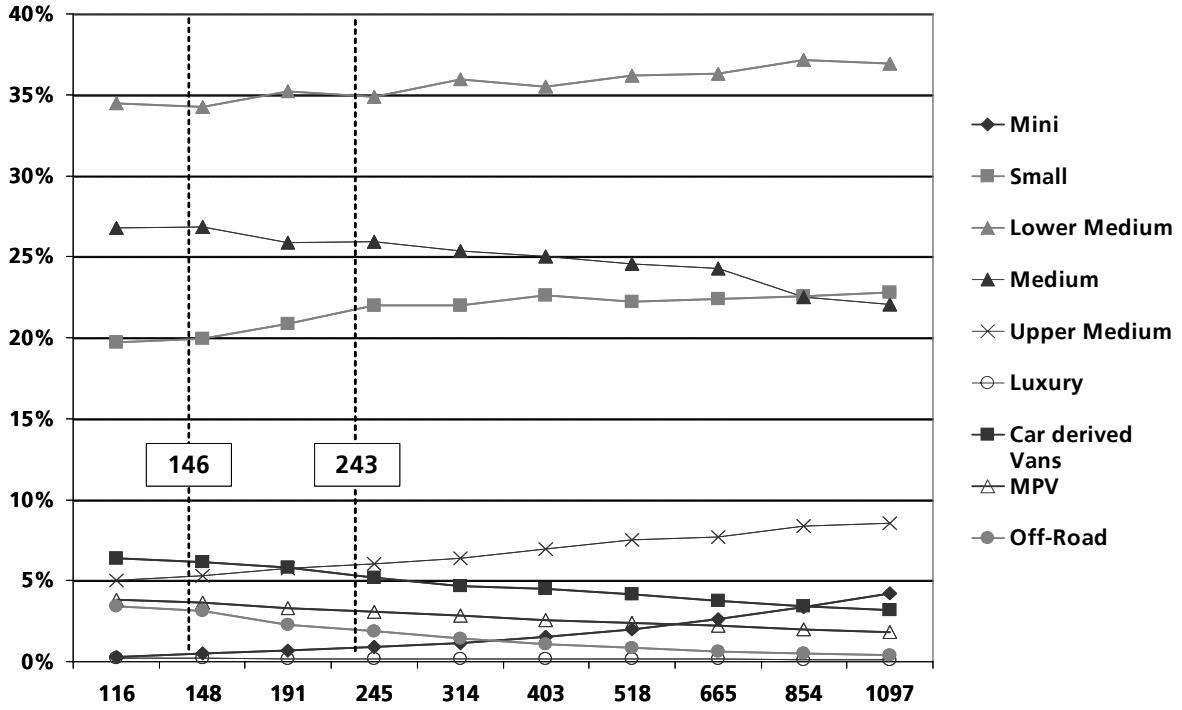


Figure 33: Influence of circulation taxes in Euros on the ACEA segment shares diesel cars in 2002



JAMA

Somewhat different patterns emerge from the analysis of automobiles associated with the JAMA manufactures association, which as noted above focuses on petrol automobiles due to idiosyncratic changes in the diesel market. For the case of GDP, the most evident trend is that of a reduction in the market share of the lower medium segment, with slightly increasing shares in most of the remaining segments. In a pattern similar to that identified for ACEA, the Lower Medium and Small segments decrease slightly in response to increased fuel prices, while the Medium segment undergoes a slight increase. Finally, with respect to taxes, the strongest effects are seen for the Mini and Medium segment shares, both of which increase. Pronounced decreases are seen for the Off-road and Sport segments.

Figure 34: Influence of per capita GDP in Euros on the JAMA segment shares of petrol cars in 2002

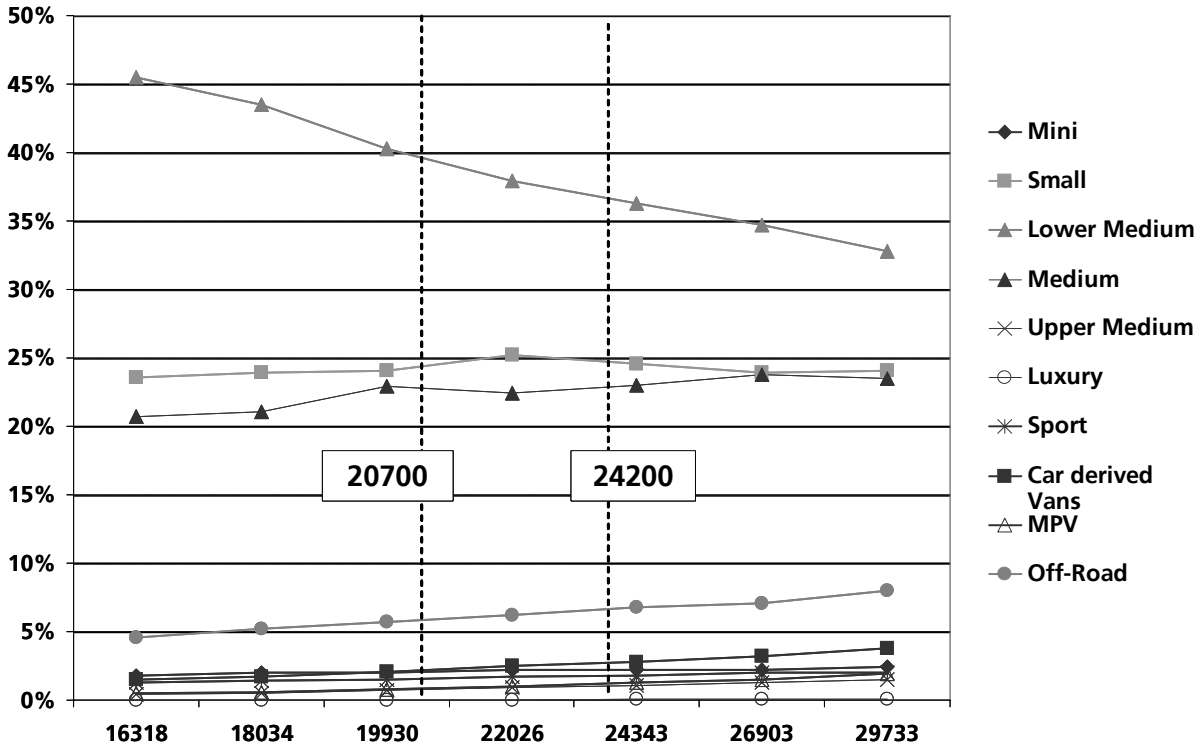


Figure 35: Influence of the fuel price in Euros on the JAMA segment shares of petrol cars in 2002

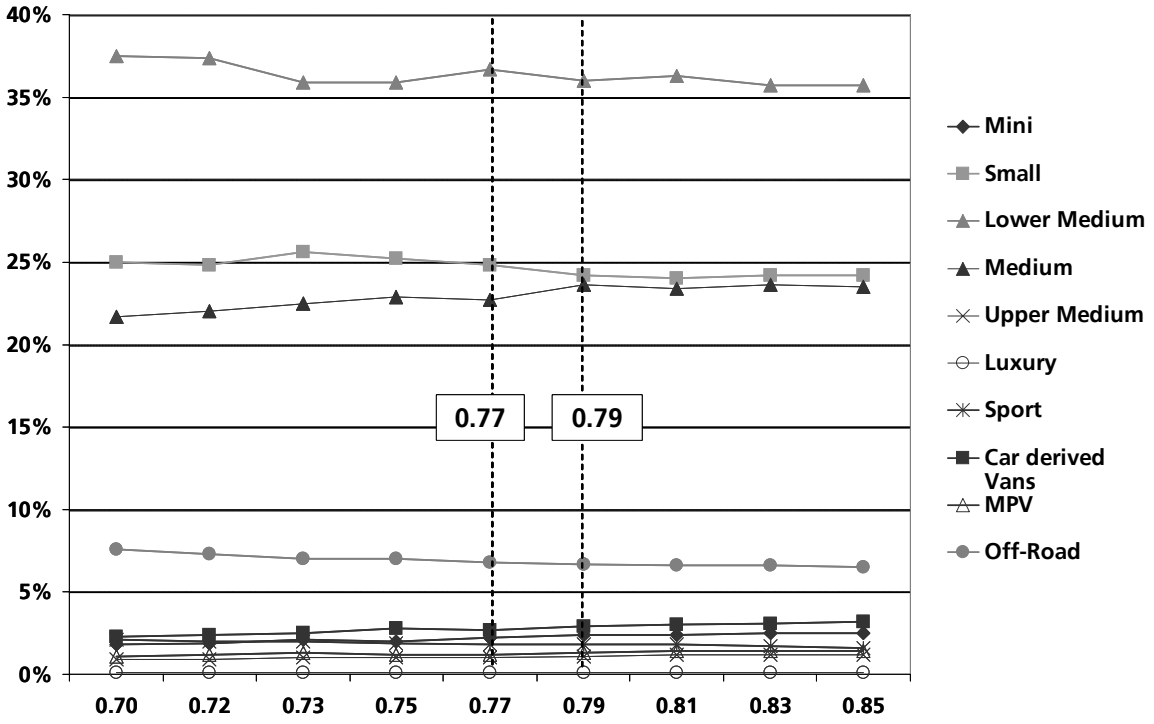
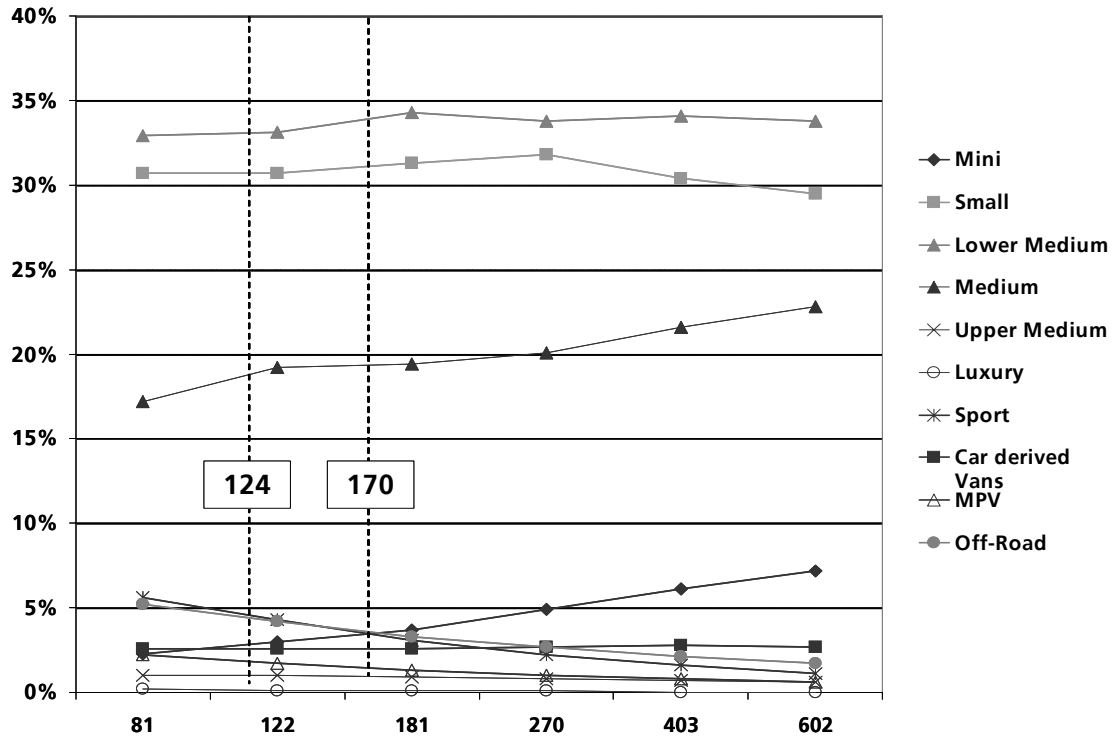


Figure 36: Influence of circulation taxes in Euros on the JAMA segment shares petrol cars in 2002



6.4.3 Implications for average CO_2 emissions

In a final step, the implications of these shifting market shares for overall average CO_2 emissions were investigated by performing a weighted calculation using figures on the average CO_2 emissions by segment from 1996 and 2002. These calculations were carried out over two values corresponding to the average value of the explanatory variable in 1996 and 2002, as indicated by the dashed lines in the graphs. Subsequently, the resulting difference in average CO_2 emissions was calculated and is presented in Table 16 for ACEA and Table 17 for JAMA cars, respectively. This difference applies to the year 2002 given the different hypothetical values for per capita GDP, fuel prices and circulation taxes.

ACEA

With respect to ACEA automobiles, the largest effect is seen to be that of per capita GDP. Given a per capita GDP of 20700 in 2002, the average emission is calculated to be approximately 173.52 grams holding other factors fixed at their mean values. A per capita GDP value of 24200 in 2002, 17% higher, would yield an average emission of approximately 176.02 grams, corresponding to an increase of roughly 2.49 grams. Smaller effects are seen with respect to fuel prices. At petrol fuel price of 0.77 Euros per liter – the inflation adjusted average price in 1996 – average emissions are calculated to be 175.85 grams. Taking the average petrol price from 2002, 0.79 Euros, the average CO_2 emissions would be slightly higher at 176.15 grams, for a difference of roughly 0.29 grams. This slightly positive result is a likely consequence of the predicted decreasing market share of the Small segment discussed above. By contrast, higher diesel fuel prices are calculated to result in a reduced average CO_2 emission, but again the difference is close to zero, corresponding to roughly 0.17 grams. Finally, higher levels of circulation taxes in 2002 are seen to correspond to lower average CO_2 emissions for both petrol and diesel automobiles. Applying the 1996 inflation adjusted average circulation tax of 124 Euros to the year 2002 would result in an estimated average emission of 172.33 grams. Were the average 2002 circulation tax of 170 Euros applied, the calculated average emissions would be 1.39 grams lower at 170.94 grams. Inserting the corresponding circulation taxes for diesel automobiles from the two years results in a difference of 2.17 grams.

Table 16: Predicted changes in average CO_2 emissions (ACEA) for different values of GDP, circulation taxes and fuel prices in 2002

	Explanatory variable	Baseline values		Corresponding De- / Increase in CO_2 grams
Petrol	**Per capita GDP**	20700	24200	+ 2.49
	Fuel price per litre	0.77	0.79	+ 0.29
	Circulation Tax	124	170	- 1.39
Diesel	**Per capita GDP**	20700	24200	- 1.00
	Fuel price per litre	0.62	0.67	- 0.17
	Circulation Tax	146	243	- 2.17

JAMA

Table 17 presents results from the same exercise for JAMA petrol automobiles. While the direction of the differences is the same as for ACEA, the magnitudes differ, particularly for the case of per capita GDP. This determinant is calculated to result in a positive difference of

1.04 grams over the two GDP values analyzed, roughly 1.45 grams lower than the value calculated for ACEA. Smaller differences emerge with respect to fuel prices and circulation taxes. Values of 0.35 and -1.45 grams are calculated for the effects of fuel prices and circulation taxes, respectively, in both cases 0.06 grams higher than the corresponding figures for ACEA.

Table 17: Predicted changes in average CO_2 emissions (JAMA) for different values of GDP, circulation taxes and fuel prices in 2002

	Explanatory variable	Baseline values		Corresponding De- / Increase in CO_2 grams
Petrol	Per capita GDP	20700	24200	+ 1.04
	Fuel price per litre	0.77	0.79	+ 0.35
	Circulation Tax	124	170	- 1.45

Two caveats with respect to the above results bear noting. The first is that the model simulations are based on the assumption that all explanatory variables stay fixed expect the variable for which the simulation is conducted. As such, the model does not incorporate the effects of broader adjustments in the economy from shifts in macroeconomic conditions. With respect to the analysis of taxes, for example, it is conceivable that consumers reduce expenditures on other goods to enable them to purchase an automobile for which taxes have increased, a behavioral adjustment that is not captured by the model. The upshot is that the model estimates represents an upper bound effect of the impact of the tax. The second caveat is that because the model was run by pooling data from different countries, differences in macroeconomic and fiscal conditions across countries subjected the analysis to various sources of uncertainty, such that the 95% confidence intervals for many of the curves overlap. While such overlap precludes the identification of statistically significant differences, the figures in the table can nevertheless be interpreted as indicative of general tendencies that would emerge given the different values for the variables analyzed. For the case of per capita GDP, these tendencies suggest an effect that is positive and somewhere below 2.5 grams for petrol cars and negative and somewhere above -1.04 grams for diesel cars. For the case of fuel prices, the effect hovers slightly above and below zero, and for the case of circulation taxes the effect is negative and of a magnitude roughly equal to that of GDP. Hence, given their magnitude and the mixture of negative and positive effects, there is insufficient evidence to conclude that the observed reductions in ACEA's and JAMA's specific CO_2 fleet average was significantly influenced by the non-technical factors analyzed here.

6.5 Conclusion

This chapter has analyzed the effects of technical and non-technical factors on CO_2 emissions. The analysis of technical attributes identified several statistically significant determinants of CO_2 emissions including height, kerb weight and engine power. While increases in all of the factors are identified to have a positive effect on CO_2 emissions, this effect was attenuated between the years 1996 and 2002. Particularly strong reductions were observed for kerb weight. A car having the same kerb weight in 2002 as in 1996 has an expected emissions value that is reduced by 29 grams. In gauging the magnitude of the identified reductions, the simultaneous increases in the attributes analyzed must also be considered.

The analysis of non-technical factors began with a market level model of automobile registrations that pooled observations from the ACEA and JAMA manufacturer associations. Statisti-

cally significant elasticity effects were identified for all the variables analyzed, which included car attributes and socioeconomic variables. In a second step, separate models were estimated for registrations from the ACEA and JAMA manufacturing associations after aggregating the observations by segment. Using the model parameters, statistical simulations were run to predict the market shares of the different segments over different values of per capita GDP, fuel prices, and circulation taxes. These shares were then combined with data on CO_2 emissions by segment in 2002 to calculate the implications for average CO_2 emissions in 2002 over different values of the analyzed determinants. With respect to ACEA automobiles, the largest impacts were found for GDP on petrol automobiles, a determinant which was found to increase CO_2 by 2.49 grams over the values analyzed. The average CO_2 emission of the JAMA fleet was also increased by GDP, but by only one gram. The remaining differences in CO_2 emissions were considerably smaller, as were discrepancies between the ACEA and JAMA values. This, in addition to the fact that some influences were positive and others negatives, led to the conclusion that the non-technical influences analyzed played an insubstantial role on net in the overall average CO_2 emission reductions in the ACEA and JAMA fleets.

7 Summary and Conclusions

The purpose of this study is to provide the European Commission with information about the causes for the CO_2 reduction of newly registered passenger cars achieved between 1995 and 2003. According to the commitments of the automobile manufacturers' associations and the Commission, CO_2 reductions must be achieved by technical measures taken by the manufacturers and market changes linked to these developments. Therefore, DLR's investigation intended to identify whether the reductions achieved were due to technical measures or due to other measures such as changes in consumer behaviour that are unrelated to any technical measures adopted by the manufacturers.

The procedure and methods applied were mainly divided into three parts, a descriptive one and two econometric analyses, using technical attributes in the one case and non-technical influences in the other case. An extended review of possible non-technical influences, in particular of vehicle taxes in the European Member States, was a preparatory work package. As data of the Monitoring Report do not provide sufficient information about consumers' behaviour, a data set of new registrations on model and version level, provided by POLK, was mainly used for the analysis. Cars have been grouped into segments and power sub-groups. As the study concentrated on issues being relevant for the European average, a description of sophisticated hybrid cars or incentives for alternative fuelled vehicles is not included. In the following the main findings of the study are presented.

Technical influences on the average CO_2 emission

Remarkable changes in the use of technologies for the reduction of the fuel consumption for new passenger cars have been observed within the period under investigation. The most significant are advanced combustion technologies for diesel engines. Further improvements have been applied to already available technologies (e.g. by friction reduction or electric power steering). The identified improvement in diesel technology is larger than in petrol technology. While the identified improvements in the individual segments for **ACEA** have caused reductions of up to 17.6 % for petrol vehicles, diesel reductions have been stronger, reaching a maximum value of 20.6 %. Individual segments of **JAMA** reached even higher reduction rates as the upper values were 19.9 % for petrol and 35.5 % for diesel[55].

A quantification of the influence of individual technologies would only be possible with single efficiencies and by applying a detailed Tank-to-Wheel analysis. Therefore the study focuses on identifying non-technical influences, which are described below.

Alternatively, an econometric analysis of technical factors on CO_2 emissions revealed significant technical improvements with respect to the attributes kerb weight, engine power, and height. Specifically, for a given range of values for these attributes CO_2 emissions were reduced by 7 to 14 % between the years 1996 and 2002. The largest decreases were observed for the attribute height for diesel cars, which on average had emissions that were 27 g/km lower in 2002 over all possible values for the variable. However, conclusions with regard to the contribution of technological developments to the overall CO_2 reductions can not be drawn with the limited number of technical indicators available.

[55] This calculation excludes segments that do not have a representative number of registrations.

Non-technical influences on the average CO_2 emission

As non-technical influences affecting possibly the behaviour of purchasers, politically motivated measures such as taxes, socio-economic trends, e.g. people's income and other factors like the offered model range were analysed. A number of them are integrated in the econometric model (see Table 15). The most relevant influences were deemed to be per capita GDP, fuel prices and the annual circulation taxes. For these variables, estimations were carried out that show their effect on the average European CO_2 emissions over the range of values observed in the data. The effect of changes in the market structure was evaluated by the descriptive analysis.

Influences with respect to the model range

For **ACEA's** car fleet some changes have been observed between 1996 and 2002[56]. Most significant is the growth of Car Derived Vans (e.g. Opel Zafira, Renault Scenic), which represented only 3.4 % of all new registrations in 1996 but nearly 10 % in 2002. Further considerable growth appeared for the Mini segment (4.5 to 7.1 %) and, on a lower level, for Off-Road cars (0.9 to 1.7 %).

On the other hand, a decreasing trend is seen for the share of Medium cars as well as for Upper Medium cars. Trends of the major segments Small and Lower Medium mirror each other to some extent, but the combined total of the two underwent a decrease of its market share (approximately 58 to 54 %). Luxury, Sport and MPV show slight decreases.

Moreover, a trend towards higher powered cars, in particular among diesel cars, and towards an increase in the number of versions has been observed. Reductions in the specific CO_2 emissions appeared for all segments with the tendency of above average reductions for petrol segments which gained market shares. Furthermore, for the most important segment - Small cars - high specific CO_2 reduction rates were recorded.

Overall, this resulted in a compensatory effect: the identified average CO_2 reduction rates for segments with a growth in their registration share (Mini, Off-Road and Car Derived Van) compensated the somewhat higher absolute CO_2 emissions of the Off Road and MPV segments and the somewhat under average reduction in specific CO_2 emissions in the middle class segments.

The most significant effect results from the overall increase in the diesel share since, as mentioned above, diesel performed better than petrol. In practice, this shift helped to achieve the observed more than average reduction in specific CO_2 emissions of those segments which gained market shares.

If the segment structure had not changed between 1996 and 2002, but the specific emissions per segment had developed according to the actual observed values, the total specific emissions of ACEA's fleet would have been 2.2 g/km higher than the monitored value. However, if in addition the increase of the diesel share is taken into account, this tendency would be overcompensated as the total emissions of ACEA's fleet would then be reduced by 4.5 g CO_2/km, resulting in an average emissions value that is 2.3 g/km lower than monitored. Hence, while the structural composition of the segments had a slightly increasing effect on average CO_2 emissions, the share of diesel cars had a stronger and opposing effect.

This means that the total average CO_2 emissions would have been 2.3 g lower than monitored if specific CO_2 reductions and the diesel share had been developed like they did but the segment structure remained constant.

[56] Due to high inconsistencies data for 1995 could not be used. Detailed registrations data for 2003 were not available in due time.

The main reason for this effect is the increase in average power of diesel car in all segments. It was found out that consumers change their behaviour in clear consistency to the trend that was supported by the offered model range of the manufacturers, e.g. consumers adapted to the development towards higher engine power which was necessary in order to achieve comparable driveability of diesel and gasoline vehicles.

The development of the structure of **JAMA's** car fleet shows some differences to the ACEA fleet. Especially the much higher share of Off-Road cars and the losses in the Lower Medium segment are significant. Considering their share of registrations, diesel cars were less important for JAMA than for ACEA.

With regard to the engine power, remarkable increases for the sub-groups with stronger engines are recorded for petrol as well as for diesel. However, these findings reflect also a gap in the model range of 1996. Reductions in CO_2 emissions show above average reductions for Small and Off-Road (petrol).

As with ACEA, holding the shares of segment and power groups fixed, does not affect the average petrol emission of JAMA significantly. Diesel emissions, however, unlike to ACEA, jump up from 180.5 to 193.7 g/km. Here, the absence of relatively low emitting diesel segments like Small and Car Derived Vans is reflected. Due to the low proportion of diesel cars, the overall average emission for JAMA changed only slightly by 0.7 g to 174.7 g/km.

Due to the contrary emission levels of JAMA (diesel higher than petrol) in comparison to ACEA (diesel lower than petrol) the average value would increase further by 2.6 g to 177.3 g/km if the increasing diesel share is taken into account. Therefore, the total average CO_2 emissions would have been 3.3 g higher than the original value if specific CO_2 reductions and the diesel share had developed as they did but the segment structure remained constant.

As in the case of ACEA, considerable changes in consumer behaviour for JAMA automobiles could not be identified. Those changes that are observed corresponded primarily to the structure of the model range. Hence, observed changes in CO_2 are rather influenced by the model policies of manufacturers.

Influences with respect to car labelling

The effectiveness of the car labelling Directive 1999/94/EC is currently being assessed as part of the implementation of Article 9 of this Directive. Although no final assessment is available at this point of time, all information indicates that the car labelling Directive had, up to now, only negligible effects on consumer's car choice and did therefore not contribute to the observed reduction in specific CO_2 emissions.

Influences by EU regulations

A number of regulations were introduced in the relevant time frame from 1998 to 2003 comprising environment and safety aspects especially. Based on information available for public, no evidence for influencing direct CO_2 emissions of the relevant directives e.g. by affecting the powertrain efficiency, curb weight or aerodynamic resistance, could be found.

Influence by improved safety performance

Regarding the impact on CO_2 emissions caused by the requirements of a good EuroNCAP rating, what is beyond legal requirements, the influence of additional weight was analysed.

Negative impacts with respect to aerodynamics due to changes of the front design for better pedestrian safety appeared to be very low and quantified information could not be obtained.

The additional equipment due to safety reasons was calculated by 15 to 20 kg. Based on various sources, a CO_2 emission increase in the range of 0.8 to 2.4 g/km can be attributed this extra weight.

Influences with respect to the GDP per capita, fuel prices and circulation taxes

The analysis of the influence of non-technical factors on CO_2 emissions proceeded in two stages. The first stage employed an econometric model that related the number of car registrations to select socioeconomic variables and automobile attributes. Following model estimation, the second stage of the analysis derived associated implications for average CO_2 emissions under alternative scenarios pertaining to changes in selected determinants of interest. Several attributes were included as explanatory variables in the models and, after a pre-assessment of results, the parameters per capita GDP, fuel prices and circulation taxes were selected for more detailed scenario analysis to understand the extent to which changes in these variables could affect average CO_2 emissions. This scenario analysis proceeded in two steps.

- Using the estimated parameters from the econometric model, step one employed a statistical simulation technique to generate predicted shares of automobiles by segment for both petrol and diesel categories. These shares were calculated over a range of values for the variables per capita GDP, fuel prices and circulation taxes. To isolate effects, each simulation was run for the year 2002 by varying one of the three variables while holding the other two fixed at their mean values.
- In step 2, the implications of the shifting market shares revealed by the simulations for overall average emissions were investigated. This involved performing a weighted calculation using figures on the average CO_2 emissions by segment in 2002 and baseline values corresponding to the average value of the explanatory variable from 1996 and 2002. Subsequently, the resulting difference in average CO_2 emissions was calculated, presented in the table below. This figure applies to the difference in CO_2 emissions that would be observed in the year 2002 given the different hypothetical values for per capita GDP, fuel prices and circulation taxes.

ACEA

The largest effects are observed for per capita GDP on petrol automobiles (a 17 % increase in GDP corresponds to an increase of roughly 2.49 grams in CO_2 in 2002). A negative and smaller effect of 1 gram is observed for the case of diesel automobiles and GDP. The small, albeit unexpected, result of the positive effect of petrol fuel prices on CO_2 could possibly be explained by a greater sensitivity to fuel prices among consumers of small automobiles, for whom purchases decline, relative to consumers of large automobiles. This change in the market structure could result in higher average CO_2 emissions. The results for taxes are, as expected, both negative. Specifically, the analysis predicts that given an average tax level of 170 Euros for petrol automobiles in 2002, CO_2 emissions would be approximately 1.39 grams lower than if the average tax level were 124 Euros. The corresponding figure for diesel automobiles given differences in the average values of diesel circulation taxes is -2.17 grams.

Table 18: Predicted changes in average CO_2 emissions (ACEA) for different values of GDP, circulation taxes and fuel prices in 2002

	Explanatory variable	Baseline values		Corresponding De- / Increase in CO_2 grams
Petrol	Per capita GDP	20700	24200	+ 2.49
	Fuel price per litre	0.77	0.79	+ 0.29
	Circulation Tax	124	170	- 1.39
Diesel	Per capita GDP	20700	24200	- 1.00
	Fuel price per litre	0.62	0.67	- 0.17
	Circulation Tax	146	243	- 2.17

JAMA

While the direction of the differences is the same as for ACEA, the magnitudes differ, particularly for the case of per capita GDP. This determinant is calculated to result in a positive difference of 1.04 grams over the two GDP values analyzed, roughly 1.45 grams lower than the value calculated for ACEA. Smaller differences emerge with respect to fuel prices and circulation taxes. Values of 0.35 and -1.45 grams are calculated for the effects of fuel prices and circulation taxes, respectively, in both cases 0.06 grams higher than the corresponding figures for ACEA.

Table 19: Predicted changes in average CO_2 emissions (JAMA) for different values of GDP, circulation taxes and fuel prices in 2002

	Explanatory variable	Baseline values		Corresponding De- / Increase in CO_2 grams
Petrol	Per capita GDP	20700	24200	+ 1.04
	Fuel price per litre	0.77	0.79	+ 0.35
	Circulation Tax	124	170	- 1.45

It bears noting that the model simulations are based on the assumption that all explanatory variables stay fixed except the variable for which the simulation is conducted. As such, the simulations and corresponding CO_2 change represent an upper bound effect of the impact of the variables. An additional implication is that each figure in the table should be interpreted in isolation; they should not be added. Finally, as the model was run by pooling data from different countries, differences in macroeconomic and fiscal conditions across countries subjected the analysis to various sources of uncertainty. Nevertheless, the figures in the table can be interpreted as indicative of general tendencies that would emerge given the different values for the variables analyzed.

In summary, the analysis calculates differences in hypothetical CO_2 values that would result in that year given different values for per capita GDP, fuel prices and circulation taxes. Overall, the investigation finds some evidence of the influence of non-technical factors on average CO_2 emissions. Given the magnitude and mixture of negative and positive effects of these influences, however, no evidence could be found that the observed total reductions of ACEA's and JAMA's CO_2 fleet average was significantly influenced by other factors than technological developments.

REFERNCES

ALLGEMEINER DEUTSCHER AUTOMOBIL-CLUB [ADAC] (2004): Evaluation of Member State reports according to Article 9 – Actual Status, 7/23/2004

ALLGEMEINER DEUTSCHER AUTOMOBIL-CLUB [ADAC], (2003): ADAC-Special: Auto-Test, Der aktuelle Neuwagen-Katalog: Kaufberatung, Magazin, Ratgeber, [Several Volumes].

BMVIT (2002): Austrian Federal Ministry of TranSport, Innovation and Technology: Verkehr in Zahlen, Edition 2002, Vienna, [Oktober 2002].

BOSCH (2003): 25 years of the Bosch ABS antiblock braking system – from novelty to norm, Press Release, July 2003, Stuttgart.

CONSULTING ENGINEERS AND PLANNERS [COWI], (2001): Fiscal Measures to Reduce CO_2 Emissions from New Passenger Cars – Main Report for the European Commission, Directorate General for Environment.

CONSULTING ENGINEERS AND PLANNERS [COWI], (2003): Fiscal Measures to Reduce CO_2 Emissions from Private Passenger Cars Env.C.1/SER/2002/0029r – Final Report for the European Commission, Directorate General for Environment: Country Calculations; Down to Target; Diesel Sensitivity.

DRIVER AND VEHICLE LICENSING AGENCY [DVLA], UK: Vehicles Information page, http://www.dvla.gov.uk/vehicles/taxation.htm [January 2004].

EC-GREECE (2003), THE EUROPEAN COMMISSION (2003): Inventory of Taxes in the EU. Greece.

EUROPEAN AUTOMOBILE MANUFACTURERS ASSOCIATION [ACEA], (2003): ACEA Economic Report – Overview on Taxation and other Measures 1103. Summary of Tax, Environment, TranSport and Emission Policy Measures in 2002/2003 by Country.

EUROPEAN AUTOMOBILE MANUFACTURERS ASSOCIATION [ACEA], (2003): ACEA Tax Guide 2003.

EUROPEAN AUTOMOBILE MANUFACTURERS ASSOCIATION [ACEA], THE COMMISSION SERVICES, (2003): Monitoring of ACEA´s Commitment on CO_2 Emission Reduction from Passenger Cars (1995-1999), Final Version of the Joint Report.

EUROPEAN COMMISSION, (1999): Commission Recommendation of 5 February 1999 on the Reduction of CO_2 Emissions from Passenger Cars (notified under Document Number C (1999) 107): 1999/125/EC, 13.2.1999, Official Journal of the European Communities L 40/49.

EUROPEAN COMMISSION, (2000): Commission Recommendation of 5 February 1999 on the Reduction of CO_2 Emissions from Passenger Cars (JAMA) (notified under Document Number C (2000) 803): 2000/304/EC, 20.4.2000, Official Journal of the European Communities L 100/57.

EUROPEAN COMMISSION, (2000): Commission Recommendation of 5 February 1999 on the Reduction of CO_2 Emissions from Passenger Cars (KAMA) (notified under Document Number C (2000) 801): 2000/303/EC, 20.4.2000, Official Journal of the European Communities L 100/55.

EUROPEAN COMMISSION, (2000): Communication from the Commission to the Council and the European Parliament: Implementing the Community Strategy to Reduce CO_2 Emissions from Cars – First Annual Report on the Effectiveness of the Strategy, COM (2000) 615 FINAL; COM (2001) 643 FINAL; COM (2002) 693 FINAL; COM (2004) 78 FINAL.

EUROPEAN COMMISSION, (2000): Decision No 1753/2000/EC of the European Parliament and of the Council establishing a Scheme to Monitor the Average Specific Emissions of CO_2 from New Passenger Cars, 10.8.2000, Official Journal of the European Communities L 202/1.

EUROPEAN COMMISSION, (2000): DIRECTIVE 1999/94/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 13 December 1999 relating to the Availability of Consumer Information on Fuel Economy and CO_2 Emissions in respect of the Marketing of New Passenger Cars, 18.1.2000, Official Journal of the European Communities L 12/16.

EUROPEAN COMMISSION, (2002): Communication from the Commission to the Council and the European Parliament: Taxation of Passenger Cars in the European Union – options for action at national and Community levels, COM (02) 431 FINAL.

EUROPEAN COMMISSION, (2002): Proposal for a Council Directive amending Directive 92/81/EEC with regard to the Possibility of applying a Reduced Rate of Excise Duty on Certain Mineral Oils containing Biofuels and on Biofuels, COM (01) 547 final, in: Official Journal of the European Communities, C149/7, 21.06.2002.

EUROPEAN COMMISSION, DIRECTORATE GENERAL FOR ENERGY AND TRANSPORT (ED.): Oil Bulletin, http://www.europa.eu.int/comm/energy/en/oil/bulletin_en.html [December 2003].

EUROPEAN COMMISSION, DIRECTORATE GENERAL TAXATION AND CUSTOMS UNION, (2002): Study on Vehicle Taxation in the Member States of the European Union – TAXUD/00/310 – Final Report.

EUROPEAN COMMISSION, DIRECTORATE GENERAL XXI, CUSTOMS AND INDIRECT TAXATION, INDIRECT TAXATION, (1997): Vehicle Taxation in the European Union 1997, Backgroundpaper, Réf XXI/306/98-EN.

EUROPEAN PARLIAMENT, COMMITTEE ON ECONOMIC AND MONETARY AFFAIRS, (2003): Report on the Commission Communication on Taxation of Passenger Cars in the European Union, COM (02) 431 – (2002/2260(INI)).

EUROSTAT (2004): http://europa.eu.int/comm/eurostat/ [June 2004]

FEDERAL MINISTRY OF FINANCE, GERMANY [BMF]: Ecological Taxreform: Development of the taxes for petrol and diesel in the Federal Republic of Germany, http://www.bundesfinanzministerium.de/Steuern/Grundlagen-.734.9190/Artikel/index.htm [January 2004].

FEDERAL STATISTICAL OFFICE, GERMANY, (2003): Statistical Yearbook for the Federal Republic of Germany 2002, Wiesbaden.

FRIEDIRCH H.E., ET AL, VOLKSWAGEN AG, (2001): Strategies and Trends in Lightweight Construction – Design and Material in Competition, in: The Association of Engineers, VDI Germany – Reports 1653: Vehicle Concepts for the 2nd Century of Automotive Technology, Dresden, p. 449 – 470. [German Language]

GERMAN AEROSPACE CENTER, INSTITUTE OF TRANSPORT RESEARCH [DLR-IVF], (ED. 2002): New Cars' Fuel Consumption 2010 – Activation of reduction potential and the contribution to climate protection.

GERMAN ASSOCIATION OF THE AUTOMOTIVE INDUSTRY [VDA], (2004): Fuel Consumption – Market Weighted-Fuel Consumption since 1978, http://www.vda.de/en/aktuell/kraftstoffverbrauch/index.html [February 2004].

GERMAN FEDERAL MINISTRY OF FINANCE (2003): http://www.bundesfinanzministerium.de/Anlage19672/KfZ-Steuer-fuer-PKW.pdf [June 2004].

GERMAN FEDERAL MINISTRY OF FINANCE (2004): http://www.bundesfinanzministerium.de/Steuern-und-Zoelle/Lexikon-Steuern-A-Z-.701.1368/Kraftfahrzeugsteuer.htm [June 2004].

GOVERNMENT OF BELGIUM (2004): Taxe compensatoire des accises, Official website: http://www.belgium.be/eportal/application?languageRedirected=yes&docId=3703&pageid=contentPage&languageParameter=fr [June 2004].

GOVERNMENT OF BELGIUM (2004): Taxe de circulation complémentaire, Official website: http://www.belgium.be/eportal/application?origin=navigationBanner.jsp&event=bea.portal.framework.internal.refresh&pageid=indexPage&navId=1565 [June 2004].

GOVERNMENT OF BELGIUM (2004): Taxe de mise en circulation, Official website: http://www.belgium.be/eportal/application?origin=navigationBanner.jsp&event=bea.portal.framework.internal.refresh&pageid=indexPage&navId=1563 [June 2004].

HEIL, B. ET AL., DAIMLERCHRYSLER AG, (2001): Selected Concepts for Sustained Fuel Consumption Reduction of Gasoline Engines – Approaches to Problems and Steps towards their Solutions, in DaimlerChrysler (Ed.): Offprint for the 22nd International Engine Symposium in Vienna, April 2001, p. 3 - 43. [German Language]

HELP (2004): Official website of the Austrian Government for providing help in handling with the authorities, http://www.help.gv.at/Content.Node/6/Seite.060118.html [June 2004].

INLAND REVENUE, UK: Company Cars, http://www.inlandrevenue.gov.uk/cars/company_cars.htm [December 2003].

JOSEFOWITZ, W. ET AL, VOLKSWAGEN AG, (2002): Aktivitäten bei Hybrid Antriebssystemen in Vergangenheit, Gegenwart und Zukunft und deren Beschreibung von Schlüsselkomponenten und deren Einfluss auf den Kraftstoffverbrauch, in: The Association of Engineers, VDI Germany, Fortschritt - Berichte Reihe 12, No. 484, Braunschweig, p. 40 – 56.

KING, G. ET AL (2000): Making the Most of Statistical Analyses: Improving Interpretion and Presentation, in: American Journal of Political Science 44, no. 2 [April 2000], 347-61.

KUHFELD, H. ET AL (2002): Große Unterschiede in der Abgabenbelastung von Personenkraftwagen in Europa, in: German Institute for Economic Research [DIW], Wochenbericht Nr. 47/2002, p. 811-819.

KUNERT, U. ET AL (2003): Die Abgaben auf Kraftfahrzeuge in Europa, German Institute for Economic Research [DIW], Sonderheft 174.

MARKETING SYSTEMS GMBH (2001): EUROCAR – Mittelfristbericht III 2001, Essen.

NoVA (2004): Official brochure to the NoVA of the Austrian government, http://www.wkw.at/docextern/abtfinpol/extranet/wkoat/WeitereSteuern/NoVAwko.pdf

R. L. Polk Marketing Systems GmbH (2003): Registration of New Passenger Cars, Essen.

SAVE PROGRAMME (2003): CLASE (Cluster ECLAB) Tenth Progress Report [September 2003].

Schade, B. et al (2002): Strategien, Maßnahmen und ökonomische Bewertung einer dauerhaft umweltgerechten Verkehrsentwicklung. Bewertung der dauerhaft umweltgerechten Verkehrsentwicklung mit dem systemdynamischen Modell ESCOT (Economic assessment of Sustainability policies Of TranSport). F + E Vorhaben im Auftrag des Umweltbundesamtes FKZ 298 96 108, Berlin.

Study on vehicle taxation in the member states of the European union – Final Report January 2002 TIS.PT

Swedish Environmental Protection Agency (2000): EU Fuel and Vehicle Tax Policy Report 5084, Stockholm.

The Society of Motor Manufacturers and Traders Ltd [SMMT], UK: CO_2 Emissions Data: Introduction, http://www.smmt.co.uk/co2/co2intro.cfm [January 2004].

The World Bank (2002): Urban Air pollution – Can Vehicle Scrappage Programs be Successful?, http://lnweb18.worldbank.org/sar/sa.nsf/Attachments/Briefing8/$File/Briefing_Note_No_8.pdf [July 2004]

Tomz, M. et al (2003): CLARIFY: Software for Interpreting and Presenting Statistical Results. Version 2.1. Stanford University, University of Wisconsin, and Harvard University.

Van Garderen, K. J. (2001): Optimal prediction in loglinear models, Journal of Econometries 104/2001, p. 119-140.

Annex 1 Proposal for a method to identify and assess the reasons contributing to the CO_2 reduction of M1 vehicles achieved between 1995 and 2003

(submitted to the Commission on 7 July 2003)

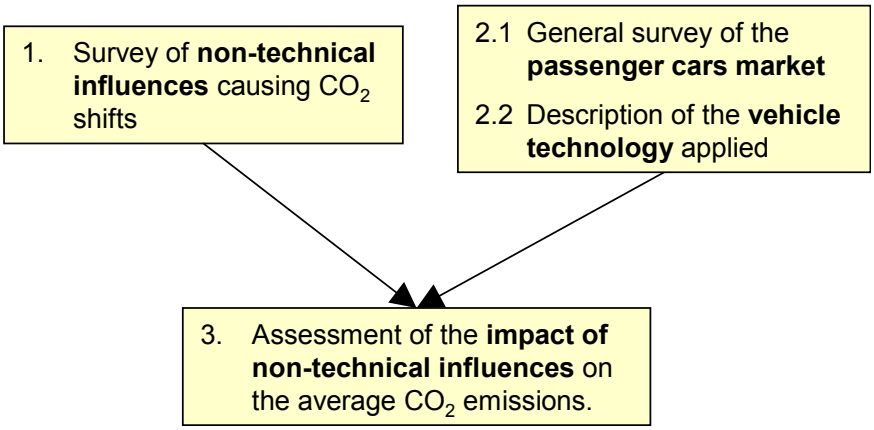
According to the commitment between the car manufacturers' associations and the European Commission the committed target of 140 g CO_2/km has to be achieved by technical measures taken by the manufacturers and market changes linked to these developments.

This paper proposes a method for identifying and assessing reasons, which have contributed to the CO_2 reductions achieved in the period 1995-2003. A differentiation of technical measures and other measures such as changes in consumer behaviour due to fiscal incentives will serve as a basis for reports according to article 10 of Decision 1753/2000/EC.

For the study on the given subject a distinction into three parts appears to be appropriate:

1. An analysis of all non-technical influences which may have had an impact on consumers' behaviour and thereby causing CO_2 shifts. A Europe-wide survey has to provide information on whether there have been such influences at all and in which Member States they emerge. This part will lead up to an in-depth analysis of identified influences for specific Member States;
2. A general survey of the European new passenger car market including changes in the allocation of the car sizes, functionalities and the vehicle performance. Moreover, the technologies applied in current vehicles are described with respect to the power train as well as the car as a whole;
3. An assessment of the non-technical measures on the car market in terms of causing CO_2 shifts by using the findings of part 1 and 2 of the study and by carrying out further investigations; application of individual methods of quantifying the effects on the average CO_2 emissions.

Figure 1: Overview of the proposed procedure



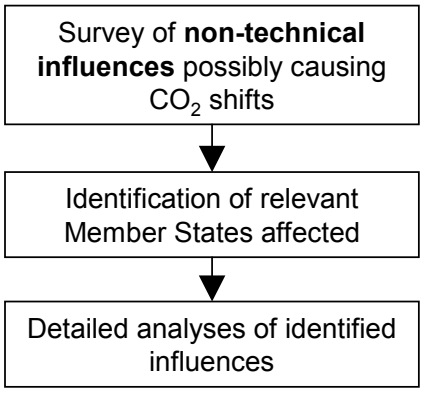
1. Survey of non-technical influences

At first, it is intended to prepare an overview of influences, which can affect consumers' behaviour in general. The overview will contain politically motivated measures, socio-economic trends and other possible influences on the new passenger car market.

Based on this general overview, the Member States will be analysed in the second step in order to identify which Member States have been subject of non-technical influences during the investigation period from 1995 to 2003.

The influences identified in Member States will than undergo detailed analyses of their composition, base, amount etc.

Figure 2: Survey of non-technical influences



A general differentiation has to be made between private and company cars because a number of influences will affect these two groups differently.

In general the differentiation of influences can be done as follows[57]:

Politically motivated

- Fiscal measures influencing
  - car purchase (e.g. registration tax),
  - car ownership costs (e.g. circulation tax),
  - car running costs (e.g. fuel tax including diesel-petrol differentiation).
- Introduction of Labelling
- Scrapping incentives

Caused by socio-economic trends

- Economic influences: higher or lower income level of people could lead to changing behaviours, e.g. increasing motorization or the ownership of a second or a third car
- Demographical influences: more senior car purchasers
- Social influences: more (young) female car purchasers

[57] Note: This list represents only a theoretical overview. It has to be proved whether the listed aspects actually have an influence on purchasers in terms of causing CO_2 shifts.

Other influences

- Active influence on the market by extraordinary promotion for certain cars (e.g. phase-out models or sale for manufacturers´ employees)
- Stimulation of customers´ interest by extending or changing the model range
- Inevitable requirements from other fields affecting fuel consumption (e.g. safety components)

2. General survey of the passenger car market and the technologies applied

As a second main part of the study the survey of the passenger car market in Europe as well as the description of the applied vehicle technology will provide a comprehensive overview of the situation by 1995 and the state of the art for 2003. For this purpose the survey will include analyses of the data as provided by the monitoring system. Information obtained from other research studies, the manufacturers' annual reports and other publications will give further input. Supplementary illustrations of exemplary models or types should give practical examples and visualise the development as it is realised by the consumers.

From this survey indications of non-technical influences should also be derived. At the best, data used so far could be a sufficient basis for quantifications of these influences, however mostly additional data requirements will be figured out from this part of the study to elaborate part 3, the assessment of the impact on the average CO_2 emissions.

2.1 General survey of the passenger car market

The general survey of the European M1 vehicle market will start with the supply side. The range of vehicle concepts that are offered by the manufacturers and their main characteristics in respect of car size, performance etc. will be presented here. Information about changes between 1995 and 2003 will be based on general data for:

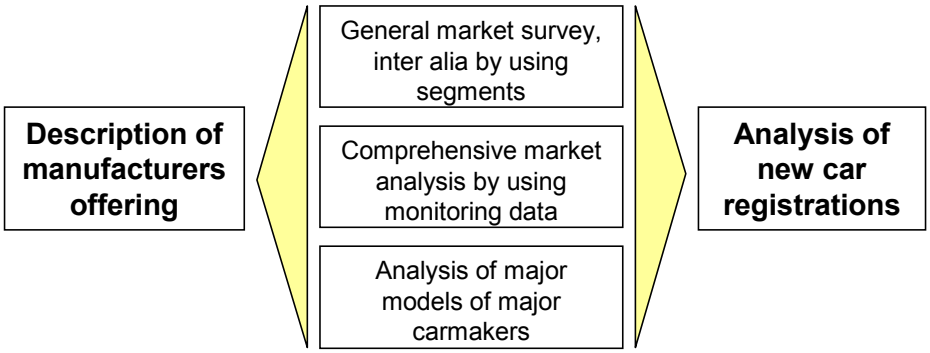
- Vehicle size and functionality
- Vehicle performance and propulsion system (petrol/diesel share)
- Major safety and comfort equipment
- Marked position, e.g. in terms of low-budget or so called "premium class"
- Other relevant characteristics

Findings with respect to the supply side will then be reflected with available figures of new registrations, i.e. purchasers' behaviour will be described in parallel. A segmentation as applied by common data sources is sufficiently useful for this task.

As a second component of the market survey the monitoring data will be used, although an in-depth market analysis will not be possible with these data. However they have the advantage that all registrations in Europe are covered and statistical assessments e.g. with regard to motorisation and engine power will be possible. The entire development in Europe and trends of the Member States will be shown and several relations, e.g. fuel consumption per engine power or mass, will be analysed.

The market development will be demonstrated by means of a detailed investigation of some market leading models. This will show how the range of technological options, model versions, and prices has developed on the markets between 1995 and 2003. By analysing e.g. Peugeot 206 and a few other very popular models a comparatively large scope of the car market is represented.

Figure 3: Survey of the M1 vehicle market



2.2 Description of technologies applied

In this section the state of technology of M1 vehicles by 2003 will be described and a comparison with the state of 1995 will be given. Major developments of this period, which affect the fuel consumption of a cars will be included and differentiated as follows:

- Petrol engine
- Diesel engine
- Components and transmission
- Entire vehicle (weight, aerodynamics etc.)

The whole range of cars and technologies should be considered in this survey. Very popular cars as well as very sophisticated models with a low number of registrations have to be described in order to give an overview of technologies applied in series productions. However, in the further process of the study the technologies have to be evaluated with respect to their share of the car production or registrations respectively.

Improvements of technologies within the investigation period can either be compensated by other developments or can actually be shown with technical data. Therefore, the monitoring data will be checked for reflecting any of the described technical developments.

Additional to the description and analysis above, more detailed analyses of some exemplary models are proposed. By using e.g. a lean powered compact car or a medium powered estate car the changes of technologies become very illustrative. Several typical models will be selected for this purpose. Technical changes can directly be attributed to technical figures in this way and it might be possible to get some indications of distinguishing technical and consumer related influences.

3. Assessment of the impact of non-technical influences on the average CO_2 emissions

Based on the surveys of part 1 and 2 of the study the impact of non-technical influences on the average CO_2 emissions will be assed. The aim is to assess their relevance by providing a quantification of the influences or at least an order of magnitude if possible. This will be achieved by joining and interpreting the results achieved so far as well as results from other studies.

The different kinds of non-technological influences on the average CO_2 emissions are expected to vary significantly in the way they impact consumer behaviour. They could either occur as direct influence on the car purchase or as indirect influence on the living conditions of consumers. Within the relatively short time horizon of this study, it is expected that only direct influences will have a significant impact and will be considered further.

- Further distinctions can be seen between the subjects of influences:
- Direct influence on consumers, either on the whole range or only on certain groups
- Influence on business customers
- Influences aiming at a special group of cars
- Actions being intended to influence the carmakers themselves (mainly by the government)

In consequence of the different ways of influences a fixed and universally applicable method for quantifying seems not to be advisable. However, as a starting point the identified non-technical influences and the findings from the market and technology survey have to be analysed further. For those Member States where relevant non-technical influences are assumed, the significance of their impacts will be determined. At best, it will be possible to test this significance by statistical analyses of the market data available.

The next step will be the definition of additional data required for quantification. In general three opportunities appear to be suitable to assess the non-technical influences:

- Calculating the effect directly by using the available data of the Member State affected
- Quantifying the influence by comparisons between Member States
- Assessing the influence by carrying out sensitivity analyses.

Furthermore, appropriate research studies on similar subjects will be evaluated and could possibly represent an important support for establishing the individual quantification method. Results from other investigations can also be used for deriving the magnitude of influence itself.

Annex 2 Share of private cars applied in the econometric analysis

Table 20: Share of private cars

		1996	2002
Denmark	Mini	64%	63%
	Small	66%	69%
	Lower Medium	52%	58%
	Medium	37%	39%
	Upper Medium	21%	22%
	Luxury	16%	15%
	Sport	37%	39%
	Car derived Van	50%	58%
	MPV	21%	22%
	Off-Road	21%	22%
France*	Mini	75%	75%
	Small	75%	75%
	Lower Medium	75%	75%
	Medium	75%	75%
	Upper Medium	75%	75%
	Luxury	75%	75%
	Sport	75%	75%
	Car derived Van	75%	75%
	MPV	75%	75%
	Off-Road	75%	75%
Germany	Mini	73%	53%
	Small	77%	64%
	Lower Medium	68%	59%
	Medium	59%	46%
	Upper Medium	44%	35%
	Luxury	27%	20%
	Sport	59%	46%
	Car derived Van	67%	59%
	MPV	44%	35%
	Off-Road	44%	35%

		1996	2002
Italy	Mini	96%	97%
	Small	92%	93%
	Lower Medium	85%	83%
	Medium	73%	78%
	Upper Medium	71%	82%
	Luxury	39%	37%
	Sport	73%	78%
	Car derived Van	84%	84%
	MPV	71%	82%
	Off-Road	71%	82%
Spain	Mini	68%	68%
	Small	79%	79%
	Lower Medium	87%	87%
	Medium	90%	90%
	Upper Medium	93%	93%
	Luxury	96%	96%
	Sport	90%	90%
	Car derived Van	87%	86%
	MPV	93%	93%
United Kin-dom	Mini	73%	72%
	Small	66%	63%
	Lower Medium	44%	42%
	Medium	34%	34%
	Upper Medium	46%	46%
	Luxury	48%	56%
	Sport	34%	34%
	Car derived Van	44%	
	MPV	46%	46%
	Off-Road	46%	46%

Source: R. L. Polk Marketing Systems GmbH, 2004; assumptions by DLR

* For the case of France, for which no data on private shares was available, the default assumption of 75% applied in COWI's (2001) Main Report was adapted.

Annex 3 Analysis of the Monitoring data

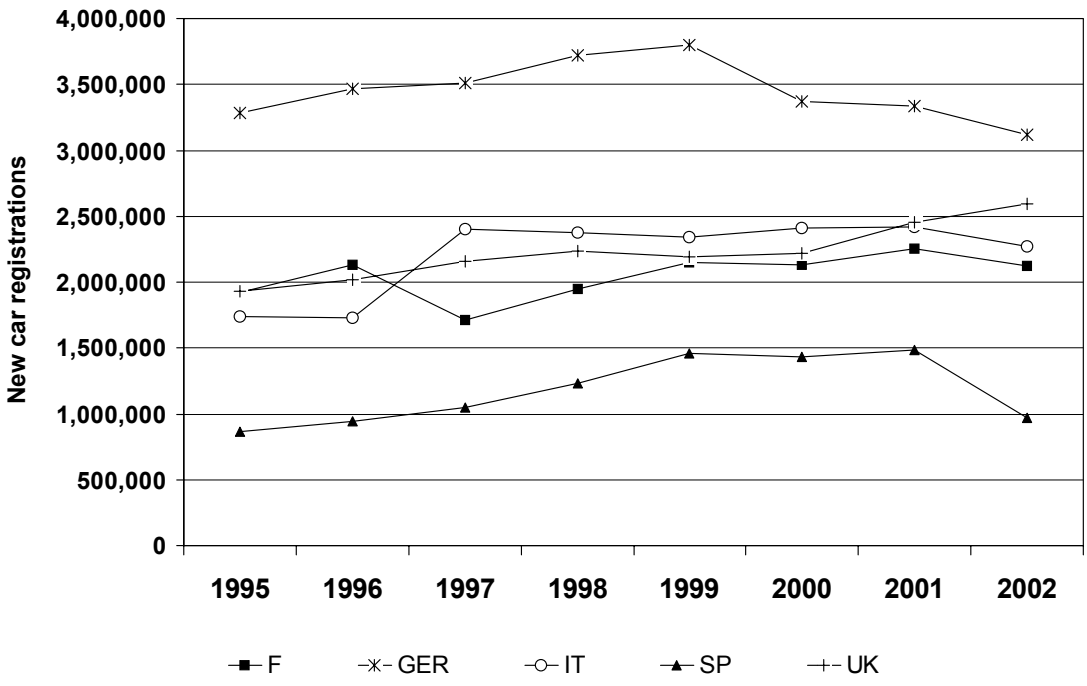
Annex 3.1 New car registrations

When reviewing the data of the development of the number of new vehicle registrations in the EU15 (including ACEA, JAMA and KAMA) in the period from 1995 to 2002, an overall increase of registrations can be stated for most countries until almost 1999, followed by a slight decrease in the last two or three years. For the five Member States ranking as the largest markets in the EU – France, Germany, Italy, Spain and the UK – overall registrations rose between 10 % in France and 35 % in the UK (see Figure 37). In Spain, until 2001 registration numbers increased by 70 % compared to 1995. Concerning the decrease in 2002, possible data insufficiencies have to be checked. Germany and Denmark are the only Member States recording lower registration numbers in 2002 compared to 1995.

The growth of registrations was not steady and uniform in all countries. In Italy a forty percent increase occurred in 1997, after that year registrations were stable. In Germany, after rising numbers until 1999, registrations after that year fell below the level of 1995. In France, after a considerable low in 1997, registrations increased since then. For the development of new cars' registrations in Spain and the UK significant peaks and lows can not be stated.

Especially the breaks in France and Italy in 1997 are interesting for further analyses on the reasons that potentially caused these developments. E.g. scrapping incentives have to be considered as temporary impacts, but this has to be proven in the further steps.

Figure 37: Newly registered passenger cars in large Member States (F, GER, IT, SP, UK)



Source: Communications from the Commission, Monitoring reports of the car manufacturer associations' commitments.

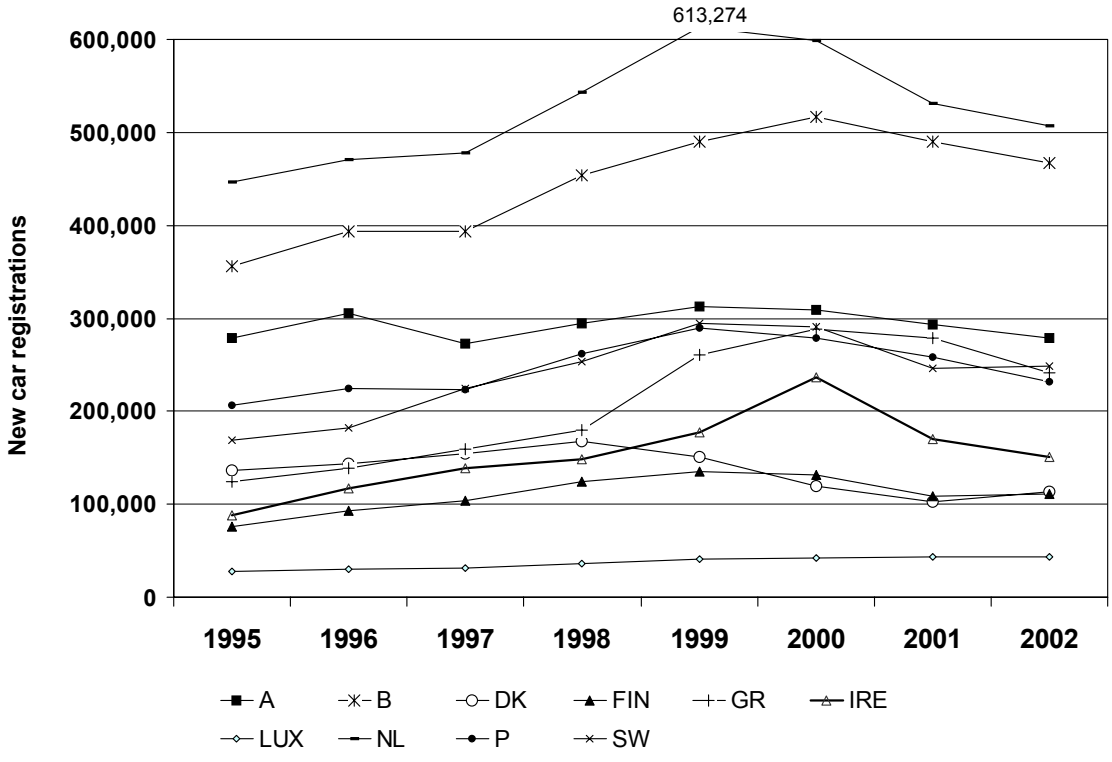
Having a closer look at the Member States with a lower number of new registrations (see Figure 38), one can state high increases in Greece and Ireland (about 70 % to 90 % more registrations in 2002 compared to 1995) with a maximum by 2000 and a considerable decrease afterwards. Finland and Sweden had a similar development when compared to Greece and Ireland, but the increase was less strong.

In the Netherlands, Belgium, Portugal and Austria new car registrations stagnated or decreased two times, at first 1996/97 and secondly 1999. Comparing 2002 and 1995 for these countries, only the registrations in Austria did not increase.

For Denmark decreasing numbers of registrations are recorded since 1998, thus at least two years earlier than in the most other Member States. Furthermore, the decrease rate in Denmark is much higher than by average.

Therefore, the need for an analysis of influences is obvious for Denmark and also for Greece and Ireland because of their relatively high temporary maximums. More interesting than the change of total registrations is the structure of the new registrations, e.g. the share of small and large or lowly and highly powered cars. Thereby, the motorisation rate could play an important role. If there is no change in the structure of the new car fleet, an influence on the average CO_2 emissions is unlikely.

Figure 38: Newly registered passenger vehicles in smaller Member States (A, B, DK, FIN, GR, IRE, LUX, NL, P and SW)



Source: Communications from the Commission, Monitoring reports of the car manufacturer associations' commitments.

Petrol and diesel share

The diesel technology has experienced much progress during the last ten years. Diesel cars became much more dynamic than before, and their fuel consumption decreased simultaneously. This is certainly one reason for the fast increase of the diesel share. But fuel taxes and circulation taxes also have an influence on the profitability of driving a diesel car. Since changes in the tax systems occurred in the investigation period, especially with regard to the tax level difference of diesel and petrol, a closer look to the diesel registration is necessary. The determination of a possible shift to diesel as result of other reasons than the technical progress would have to be analysed further.

When reviewing the development in registrations for petrol and diesel vehicles, the various shares of diesel registrations in the European Union in the base year 1995 must be stated. As shown in Table 21 several countries (like France, Austria and Belgium) had already high diesel shares of more than 40 % by 1995. On the contrary, in some countries the diesel share was below 10 %, e.g. in Denmark or Sweden.

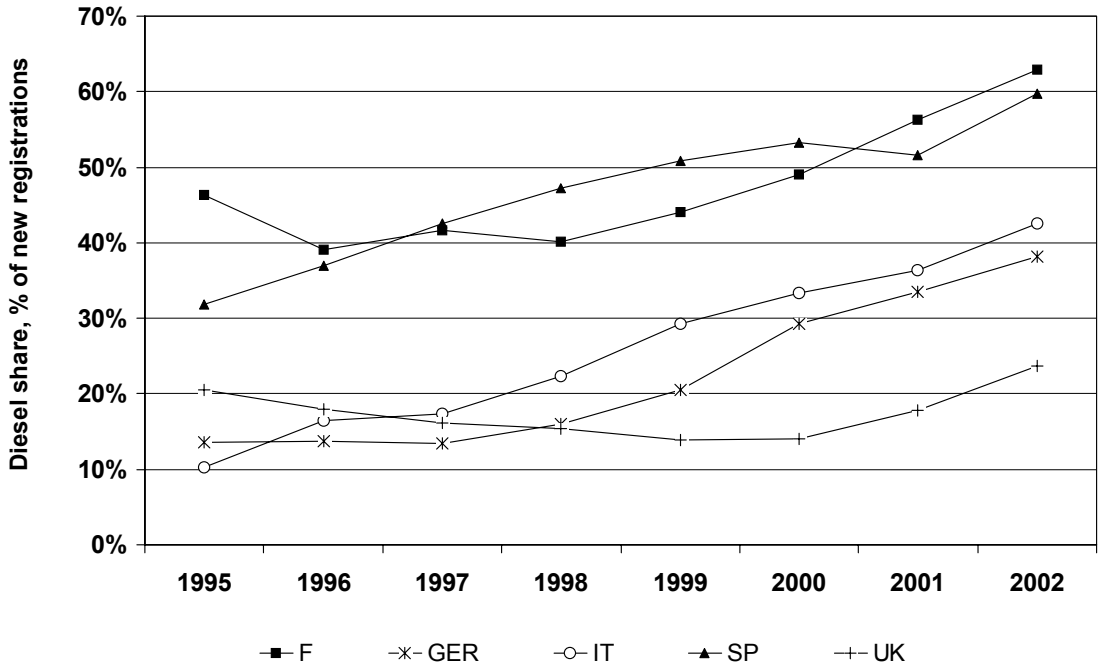
Table 21: Diesel share in the Member States

Diesel share [%]	1995	1996	1997	1998	1999	2000	2001	2002
A	41.4	48.0	51.7	53.5	57.1	61.8	65.6	69.6
B	46.5	45.4	49.4	51.2	53.8	56.0	62.2	64.3
DK	2.9	2.6	3.0	4.9	9.8	15.4	20.2	19.3
F	46.3	39.1	41.7	40.2	44.0	49.0	56.2	62.9
FIN	n/a	n/a	n/a	n/a	n/a	n/a	15.7	13.7
GER	13.6	13.8	13.5	16.0	20.5	29.2	33.5	38.2
GR	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
IRE	15.3	12.9	11.1	12.5	11.4	11.6	14.5	18.1
IT	10.3	16.4	17.3	22.4	29.2	33.4	36.3	42.6
LUX	27.7	30.4	33.4	38.6	41.7	50.4	57.9	62.2
NL	13.8	15.1	16.9	20.3	22.7	22.6	22.8	21.5
P	10.6	13.1	16.8	20.2	22.1	27.4	28.8	36.3
SP	31.8	37.0	42.5	47.2	50.8	53.3	51.6	59.8
SW	2.7	5.1	7.4	10.7	7.1	6.3	5.5	6.7
UK	20.5	18.0	16.2	15.4	13.9	14.1	17.8	23.7

Source: Communications from the Commission, Monitoring reports of the car manufacturer associations' commitments.

Independent from the initial diesel share by 1995, a rise in total registrations of diesel cars can be stated for all five large Member States (see Figure 39). In each case the increase is greater than the decrease for the petrol registrations. For example, the amount of registrations in Italy rose more than four fold and doubled in Germany and Spain. In France and the UK, 40 % more diesel vehicles were registered annually in 2002 compared to 1995.

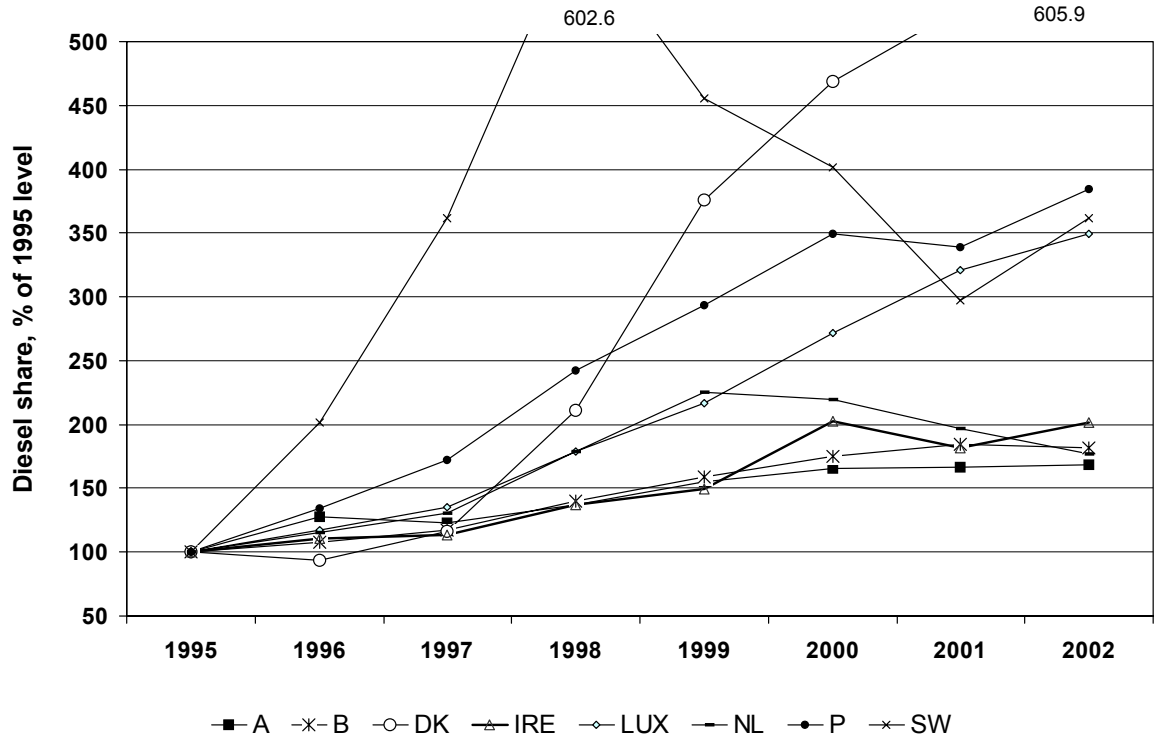
Figure 39: Development of the diesel share in large Member States (F, GER, IT, SP, UK)



Source: Communications from the Commission, Monitoring reports of the car manufacturer associations' commitments.

Notable developments of diesel registrations can be observed for some of the smaller Member States (see Figure 40). For Austria, Ireland and Belgium a steady increase can be identified. Diesel registrations in these countries nearly doubled in 2002 compared to 1995. For the Netherlands, a similar development can be stated, with the exception of 1999 when registrations show a maximum and decreased in the ongoing years but stayed on a higher level in 2002 compared to 1995. For Portugal and Luxembourg, a strong increase can be stated. Registrations increased more than 250 % in 2002 compared to 1995. In Denmark, the development is even more noteworthy: registrations rose continuously, and from 1998 on, with a very high growth rate. In 2002, diesel registrations were more than six times higher compared to 1995. For Sweden, a similar vibrant development can be stated until 1998, when the registrations rates were more than six times higher than 1995. Yet after 1998, the registration figures decreased to the value of three times higher registrations in 2001. Yet, in 2002, another increase occurs.

Figure 40: Development of diesel registrations in smaller Member States (A, B, DK, IRE, LUX, NL, P and SW)



Source: Communications from the Commission, Monitoring of the car manufacturer associations' commitments.

Summary of registration analysis

As a result of the analysis of total registrations as well as of the petrol-diesel share, some specific developments in several Member States could be identified. The most significant developments are summarised below:

- Italy: a 40 % increase of registrations in 1997; continuous and steep increase of diesel registrations, more than four times more diesel in 2002 compared to 1995.
- France: a 20 % decrease of total registrations in 1997.
- Germany: Registrations drop by 13 % in 2000; generally, less cars were registered by 2002 compared to 1995.
- Spain: highest overall growth rate in registrations of the large Member States and strong increase of the diesel share .
- UK: unusual increase of registrations in 2002 (whereas in most countries numbers went down in that year).
- The Netherlands, Belgium, Portugal and Austria: Drop of registrations in 1997, another drop in 1999/2000.
- Greece and Ireland: Highest growth rates until 2000, considerable decrease since then.
- Finland and Sweden: Similar development to Greece and Ireland, but the increase was not as strong as for these Member States. Sweden: Diesel registrations rose more than five times between 1995 and 1998 and decreased afterwards

- Denmark: Decreasing registrations after 1998, 20 % less registrations 2002 compared to 1995. Strongest diesel increase of all countries when comparing 1995 to 2002, five times more diesel registrations in 2002.
- Austria: Continuous decrease of petrol registrations since 1995, registrations in 2002 only 55 % of those in 1995.
- UK: Unusual increase of petrol registrations (higher values 2002 than 1995), decrease of diesel until 2000.

In the further research work, these developments and possible influences are assessed jointly in order to provide the potential impact on the average CO_2 emissions. For this analysis, also the updated data of reporting year 2003 will be incorporated.

Annex 3.2 Physical car characteristics

The elaboration of the physical car characteristics is a major task in order to get indications for changes in the structure of new registration. Changing consumer behaviour to low powered cars or to heavier cars can possibly be identified and correlations to the total new registrations can be made. In the first step, only ACEA figures are used. A calculation of the possible difference when leaving out JAMA and KAMA is given below for the example of mass (see Table 22) and engine power (see Table 23). Differences are shown for the two Member States with the highest ACEA share in the EU15 and the lowest share, France and Ireland.

For mass, average ACEA values and those for all three associations are nearly identical by 1995. In 2001 a marginal difference of less than 1 % occurred.

Table 22: Differences of mass figures when leaving out JAMA and KAMA

average mass	1995	2001
France		
ACEA	1039.00 kg	1170.00 kg
ACEA + JAMA + KAMA	1043.60 kg	1178.83 kg
Difference [kg]	**4.60 kg**	**8.83 kg**
Difference [%]	0.44 %	0.75 %
Ireland		
ACEA	1057.00 kg	1150.00 kg
ACEA + JAMA + KAMA	1055.51 kg	1158.07 kg
Difference [kg]	**-1.49 kg**	**8.07 kg**
Difference [%]	-0.14 %	0.70 %

Source: Communications from the Commission, Monitoring of the car manufacturer associations' commitments.

When having a further look at engine power, for France with the lowest share of JAMA and KAMA, the difference is below 1 % for 1995 as well as for 2002 when excluding JAMA and KAMA. For Ireland, which shows the highest rate of JAMA and KAMA cars, the inaccuracy is higher as it ranges from almost minus 2.5 % to almost plus 5.6 %. Depending on the given subject this can be a difference not to be neglected. However, in general the ACEA data are taken as a sufficient base to enter in the analysis of the physical car characteristics.

Table 23: Differences of engine power figures when leaving out JAMA and KAMA

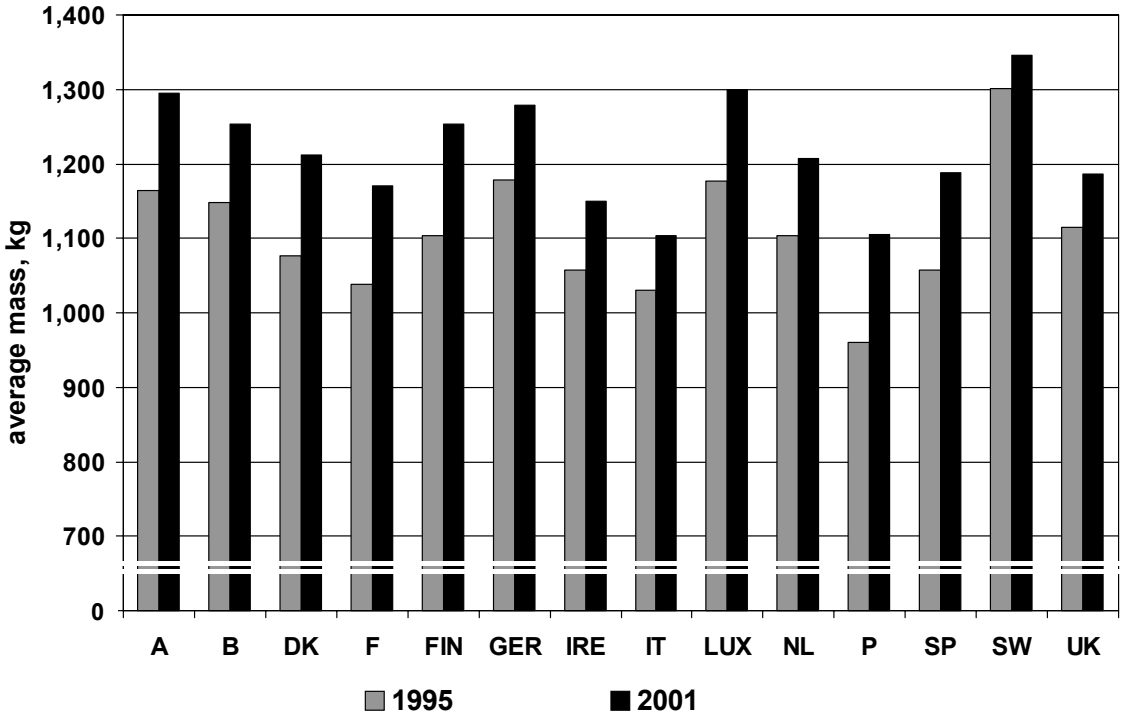
average engine power	1995	2002
France		
ACEA	55.00 KW	73.00 KW
ACEA + JAMA + KAMA	55.49 KW	73.38 KW
Difference [KW]	**0.49 KW**	**0.38 KW**
Difference [%]	0.89 %	0.52 %
Ireland		
ACEA	55.00 KW	77.00 KW
ACEA + JAMA + KAMA	58.06 KW	75.10 KW
Difference [KW]	**3.06 KW**	**-1.90 KW**
Difference [%]	5.57 %	- 2.47 %

Source: Communications from the Commission, Monitoring of the car manufacturer associations' commitments.

Mass of new registrations

The average mass of all newly registered vehicles in the EU15 was around 1,100 kg by 1995 and increased by nearly 100 kg until 2002. Only from 1999 to 2000 a short period of constant weights is recorded. In most years, Sweden, Germany and Luxembourg show the highest weights while Italy and Portugal recorded the lowest values (see Figure 41). Petrol cars generally weighted less than diesel cars as the average was 1,068 kg compared to 1,204 kg by 1995 and 1,204 kg compared to 1,318 kg by 2001.

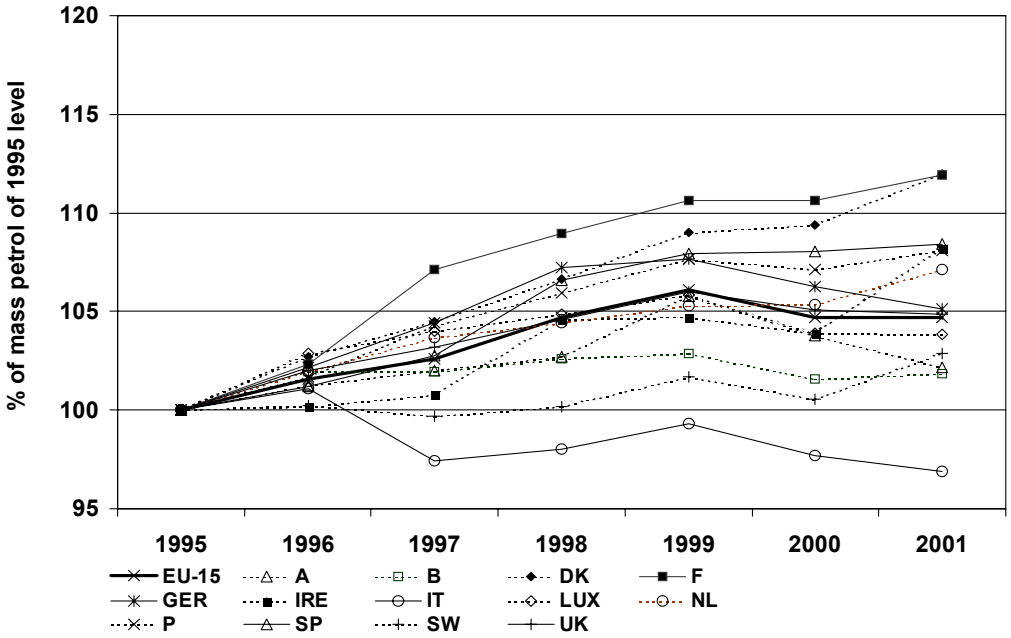
Figure 41: Average mass of ACEA's new car registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

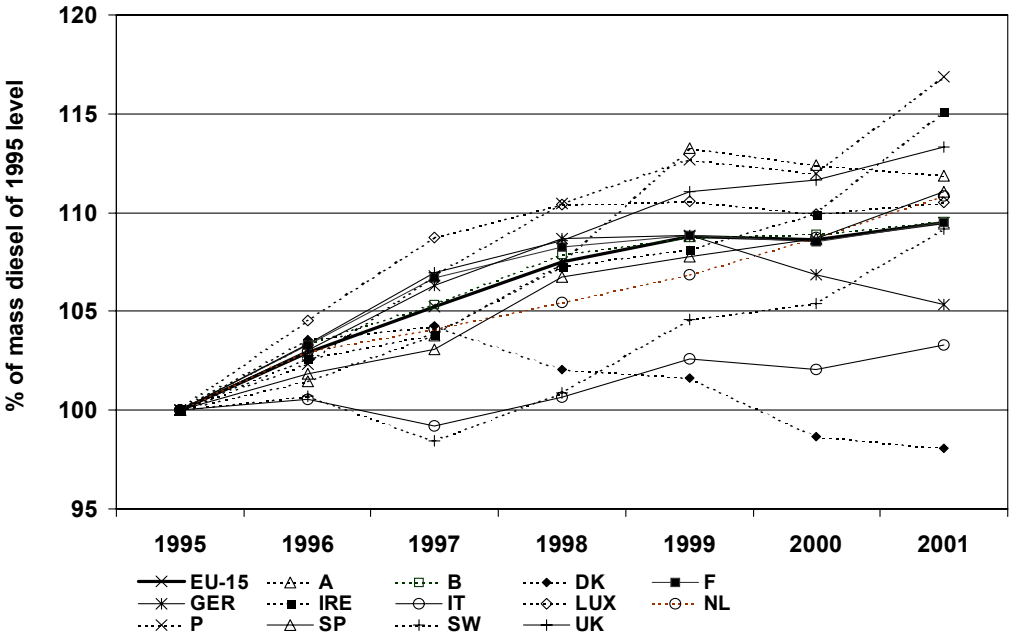
For petrol cars the mass increase was lower than for diesel cars (5 % compared to 10 %, see Figure 42 and Figure 43). The highest increase occurred in Portugal with about 15 % in contrast to Sweden with the lowest increase of about 3.5 % between 1995 and 2001. Exceptional developments for the whole period are recorded for petrol cars in Italy and diesel cars is Denmark, where values in 2001 are below those of 1995.

Figure 42: Development of the average mass of ACEA's new car petrol registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

Figure 43: Development of the average mass of ACEA's new car diesel registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

The most significant developments regarding the average vehicle mass are summed up here:

- Germany and Austria are the only Member States showing a mass decrease in 2000 and 2001, whereas the petrol and diesel development is similar. In the year before, an extraordinary increase occurred in Austria. At least for Germany, this development is similar to the development of the total registrations.
- Italy: An extraordinary decrease can be stated in the year 1997; afterwards the average mass per vehicle was increasing again. For petrol and diesel, the development is similar.
- In Denmark the development for petrol and diesel is not similar. The average mass of the diesel registrations is decreasing after 1997 and drops below the value of 1995 in 2000 and 2001.
- The mass increase in Ireland by 2001 is exceptionally high.

Though the average weight of newly registered M1 vehicles increased in all Member States in the analysis period, the CO_2 emissions were decreasing in all Member States. The decrease of the CO_2 emissions was very stable for all Member States. In some Member States, developments seem to be interrelated. For example, in the case of Denmark, the strong drop in diesel CO_2 emissions seems to correspond with the decreasing weight figures and the diesel registrations numbers, which were increasing sixfold during the analysis period.

For Italy a parallel development appears for 1996/1997, when the strong CO_2 decrease rate (4.5 %) corresponds with the decrease in average weight and overall registrations were increasing by about 35 % simultaneously. Therefore, more vehicles with a lower weight have been registered during that year. This indicates that there might be non-technical reasons for this temporary development.

Engine power of new registrations

The average engine power increased from 1995 in all Member States by nearly 24 % to an average of 78 KW by 2002. In Sweden, Luxembourg and Germany the highest powered cars are registered in that time period, on the contrary, cars with the lowest engine power are always recorded for Portugal (see Table 24).

Table 24: Average engine power of ACEA'S new car registrations

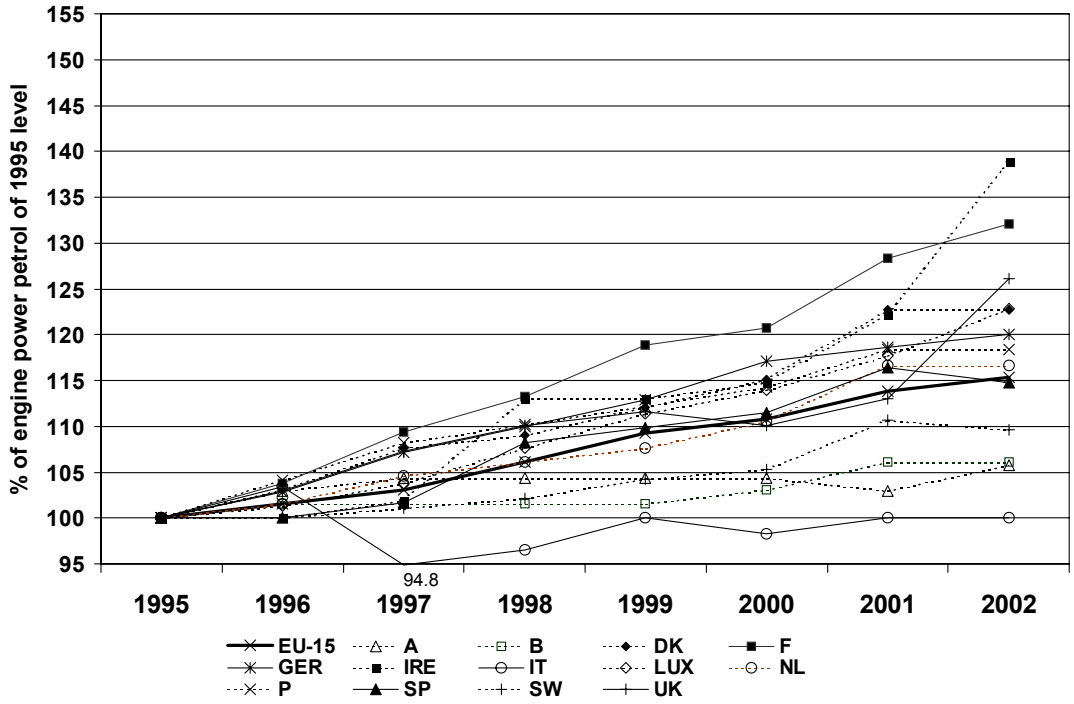
Engine power [KW]	1995	1996	1997	1998	1999	2000	2001	2002
EU 15 average	**63**	**65**	**67**	**69**	**71**	**72**	**75**	**78**
A	64	66	68	70	72	74	75	77
B	63	65	65	66	67	68	73	74
DK	66	68	71	73	74	75	80	79
F	55	57	61	62	65	67	71	73
FIN	63	n/a	n/a	n/a	n/a	n/a	84	84
GER	70	72	75	77	79	82	84	86
GR	n/a	n/a	n/a	n/a	n/a	n/a	n/a	69
IRE	55	55	56	62	62	63	68	77
IT	59	61	57	59	62	63	65	68
LUX	75	76	79	81	83	84	87	90
NL	65	66	68	69	70	73	77	78
P	49	52	55	57	58	61	64	66
SP	58	59	61	63	65	66	70	73
SW	94	93	94	94	96	98	103	103
UK	67	69	72	74	76	76	78	88

Source: Communications from the Commission, Monitoring of ACEA's Commitment.

The power of diesel engines increased approximately twice as much as that of petrol engines during the investigation period (30 % compared to 15 %). When reviewing the increase rates of single Member States (see Figure 44 and Figure 45), the following developments appear to be significant:

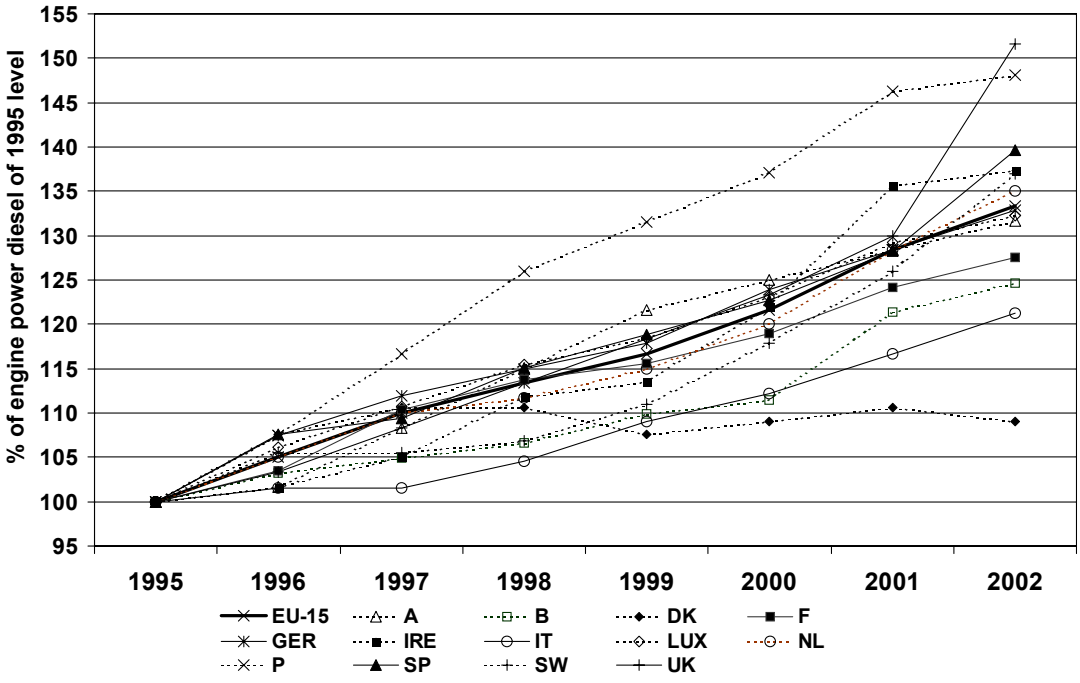
- Italy: In 1997 the average engine power decreased remarkably compared to 1996. In the main, petrol vehicles were causing that decrease. After 1997 the total increase occurred because of increasing diesel values.
- In the UK, diesel cars experienced a power increase well above average by 2002.
- France recorded a continuously high engine power increase especially for petrol cars.
- In Portugal a constantly high power increase appeared for diesel cars.
- Ireland: An unusual increase in 1998 and 2002 occurred, mainly because of increasing petrol values.
- Denmark: For the average engine power of diesel cars an unusual development can be stated. Values increased in 2002 just by 9 % compared to 1995, which is the lowest increase of all Member States. Total and petrol values are within the average range though.

Figure 44: Development of the average engine power of ACEA's new petrol car registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

Figure 45: Development of the average engine power of ACEA's new diesel car registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

The particular developments which resulted from the analyses above have to be compared with the development of CO_2 emissions of the Member States in order to derive conclusions.

At the first glance, a clear conjunction appears for Ireland, where the exceptional increase of engine power by 1998 ran in parallel to the CO_2 emissions, which increased in that year. However, there was another strong increase in engine power in 2002, but CO_2 emissions fell.

In the UK a strong engine power increase occurs in 2002, but the CO_2 emissions decreased. When comparing developments of the whole investigation period a correlation can not be stated as well, because the increase in engine power is constant as well as the decrease in CO_2 emissions. However, total registrations of diesel cars rose in the UK by 2002, unlike in most other Member States. Therefore, the high increase in engine power 2002 seems to correlate with the high increase in registrations.

Engine capacity of new registrations

The average engine capacity in EU15 increased about 5 % in the years 1995 to 2002 reaching 1,744 cm^3 in 2002. Only engine capacities of Sweden were constant, all other countries shoe increasing figures. Besides Sweden, especially the development of Ireland and Portugal is remarkable as cars' engine capacities in those countries grew much more than on average (see Table 25).

Table 25: Average engine capacity of ACEA's new car registrations

Engine capacity [cm^3]	1995	1996	1997	1998	1999	2000	2001	2002
EU 15 average	**1654**	**1661**	**1656**	**1669**	**1699**	**1717**	**1735**	**1744**
A	1779	1807	1825	1818	1847	1853	1847	1859
B	1770	1763	1761	1765	1769	1774	1798	1785
DK	1637	1648	1670	1666	1698	1730	1757	1722
F	1631	1597	1647	1640	1676	1702	1742	1753
FIN	1779	n/a	n/a	n/a	n/a	n/a	1826	1778
GER	1755	1767	1773	1765	1783	1834	1836	1873
GR	n/a	n/a	n/a	n/a	n/a	n/a	n/a	1452
IRE	1505	1469	1458	1510	1475	1471	1547	1578
IT	1450	1487	1419	1452	1520	1543	1569	1588
LUX	1866	1879	1888	1900	1918	1928	1946	1990
NL	1686	1687	1701	1698	1703	1714	1737	1716
P	1321	1340	1367	1386	1419	1449	1492	1518
SP	1619	1641	1671	1715	1739	1759	1760	1739
SW	2088	2042	2008	1966	1972	1955	2000	1993
UK	1683	1696	1714	1717	1719	1706	1716	1738

Source: Communications from the Commission, Monitoring of ACEA's Commitment.

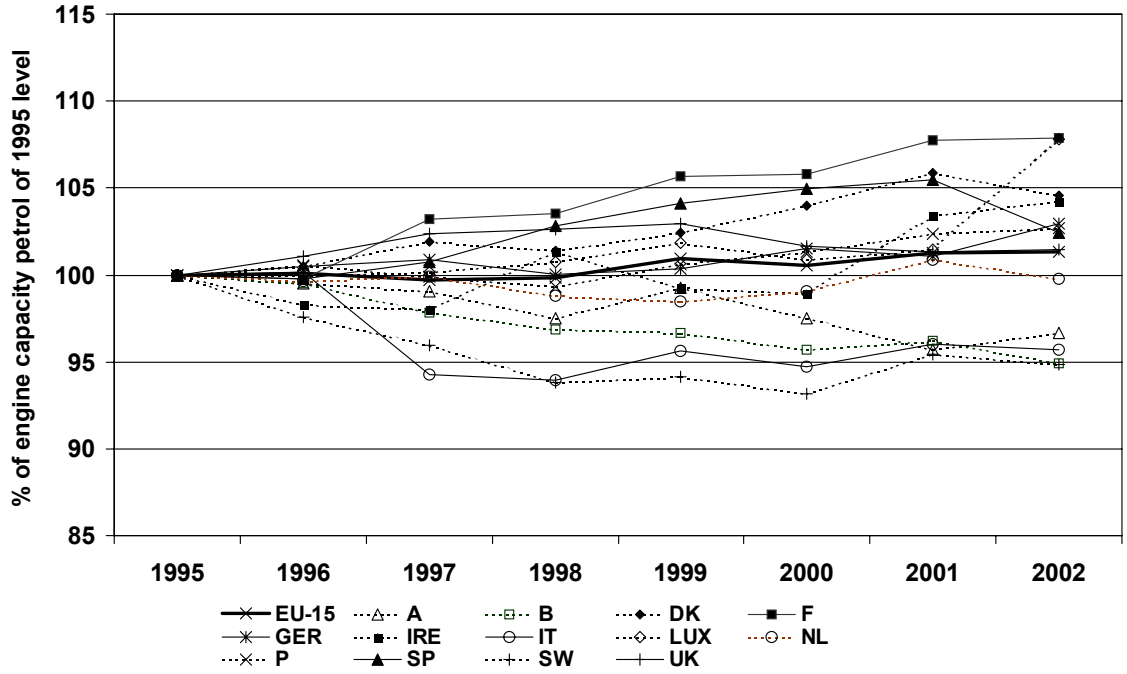
When analysing the capacities of petrol and diesel engines, ranges of engine capacities appear to be interesting. The range of petrol engine capacities in the different countries is very large, from approximately 1,300 cm^3 to almost 2,000 cm^3, whereas recently the range became a little smaller. The range concerning diesel engines is much smaller in general with approximately 1,850 to 2,200 cm^3 over the whole investigation period. Only the diesel cars in Portugal or Greece have significantly smaller capacities.

For the engine capacities from 1995 to 2002 in the different Member States (see Figure 46 and Figure 47) the following unusual developments are identified:

- For Portugal the highest increase (about 15 %) from 1995 to 2002 is identified, exclusively caused by much larger diesel engines.

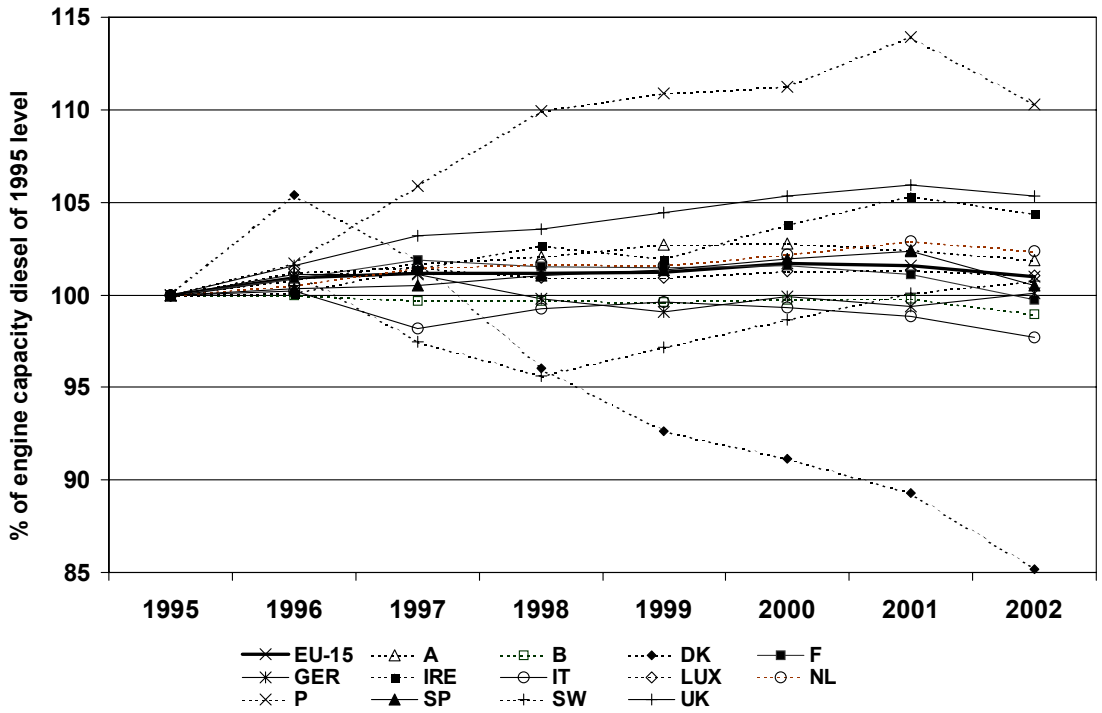
- Denmark: A very unusual development of diesel engine capacities can be stated, which dropped continuously to level of 85 % in 2002 compared to 1995.
- Sweden: Engine capacity decreased in 2002 compared to 1995 about 5 % because of the petrol engines' development. Moreover: Unusual low point of diesel engines' capacity development around 1998.
- In Ireland a nonlinear development is recorded, showing decreasing periods from 1995 to 1997 as well as in 1999.
- In Italy petrol engines became about 5 % smaller by 1997 and were constant since then.

Figure 46: Development of the average engine capacity of ACEA's new car petrol registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

Figure 47: Development of the average engine capacity of ACEA's new car diesel registrations



Source: Communications from the Commission, Monitoring of ACEA's Commitment.

The analysis of the development of the average engine capacity of European cars does not provide a general correlation to the average engine power or the average mass of the cars. The capacities increased to a much lower extend than the other physical characteristics. Therefore, clear indications concerning market changes are not obvious.

Annex 4 Analysis of the registration data by segment from R. L. Polk Marketing Systems

The registration data by segment of the company R. L. Polk Marketing Systems were used for a preliminary analysis when the disaggregated registrations data, used in chapters 4 and 6, had not been available. The data for the preliminary analysis were made available by the Commission and cover the years 1995 to 2001. A major advantage of these data compared with the monitoring data is that they include a segmentation by vehicle size and vehicle types. Therefore, changes in consumer behaviour could be identified in more detail. Data are available for Member States but they are not differentiated by automobile manufacturers associations.

Before analysing the data they were checked with regard to the total number of new registrations and compared with the Commissions' monitoring data. When reviewing some example years (1995, 1998 and 2001) for France, Italy and the United Kingdom, the R. L. Polk Marketing Systems data show only slightly more or less registrations than the monitoring data (between -0.5 % and +0.9 %). For Germany and Spain the differences are higher (-1.9 % to -1.6 % and -3.9 % and -3.4 %, respectively). For Member States with a lower number of registrations, deviations are slight. They vary for Austria, Denmark and Finland between -0.9 % and +0.9 %. In Belgium, the Netherlands, Portugal and Sweden, the differences vary around 3 %. An exception is Greece, showing differences from +9 % to nearly 17 %.

For the Member States of the European Union in total, R. L. Polk Marketing Systems recorded 0.4 % more registrations than the Commission for 1995, 2.3 % less by 1998 and 0.6 % less in 2001. Therefore, these data appear to be reasonable for using them here.

Annex 4.1 Segment analysis

The passenger car classification of R. L. Polk Marketing Systems consists of nine segments and is based on car models, which means that one specific model is always attributed to the same segment, independent of engine power or price of the various versions. It must be pointed out that small vans (such as Renault Scenic or Opel Zafira) are attributed to the same segment as their technical base and not to the segment MPV (Multi Purpose Vehicle)[58]. Regarding the official segmentation of the German car registration agency (KBA) as well as former studies of DLR, the segmentation is regarded plausible and coherent. The following Table 26 shows the 9 segments and gives examples for the models included:

Table 26: Segments of the R.L. Polk Marketing Systems data

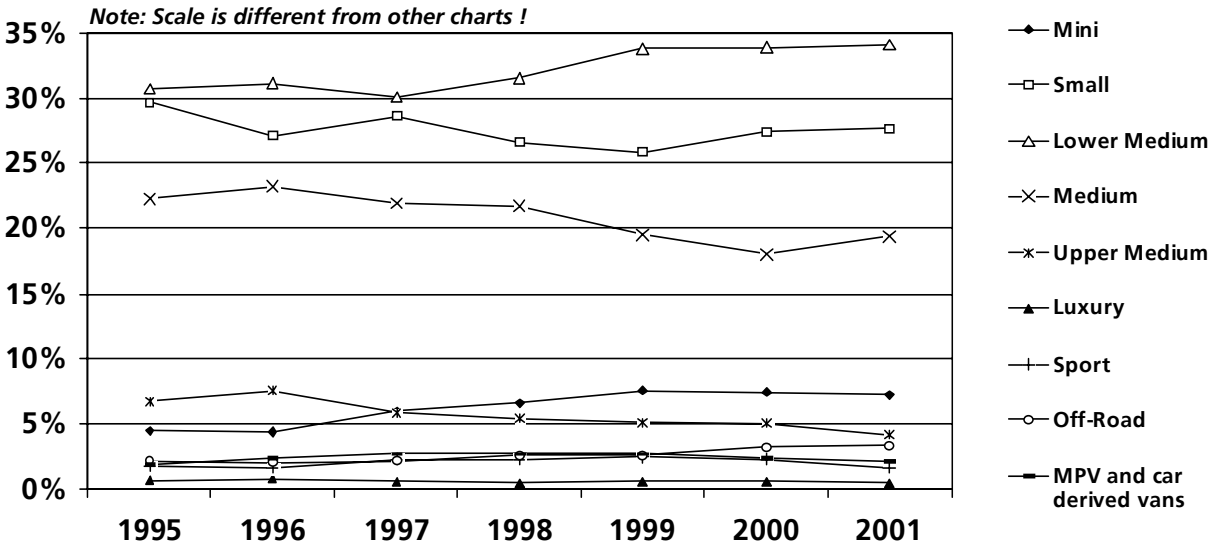
Segment	Example		Segment	Example
Mini	Fiat Seicento, VW Lupo		Luxury	Mercedes S-Class, BMW 7 series
Small	Peugeot 206, Ford Fiesta		Sport	Audi TT, Fiat Coupe
Lower Medium	Opel Astra, Renault Scenic		Off-Road	Mitsubishi Pajero, BMW X5
Medium	VW Passat, Mercedes C-Class, Volvo S 60		Multi Purpose Vehicles (MPV) and car derived vans	Ford Galaxy, Peugeot 807
Upper Medium	Citroen XM, Toyota Camry			

The analysis of the development of the single segments shows that there has been a trend towards smaller segments in the EU15 between 1995 and 2001: The shares of Lower Me-

[58] This represents an important difference to the segmentation used in chapters 4 and 6.

dium (+4 %) and Mini (+3 %) have increased. On the other hand, the shares of Medium and Upper Medium have decreased by about 3% each. A significant shift to Off-road and MPV cannot be recorded within this period.

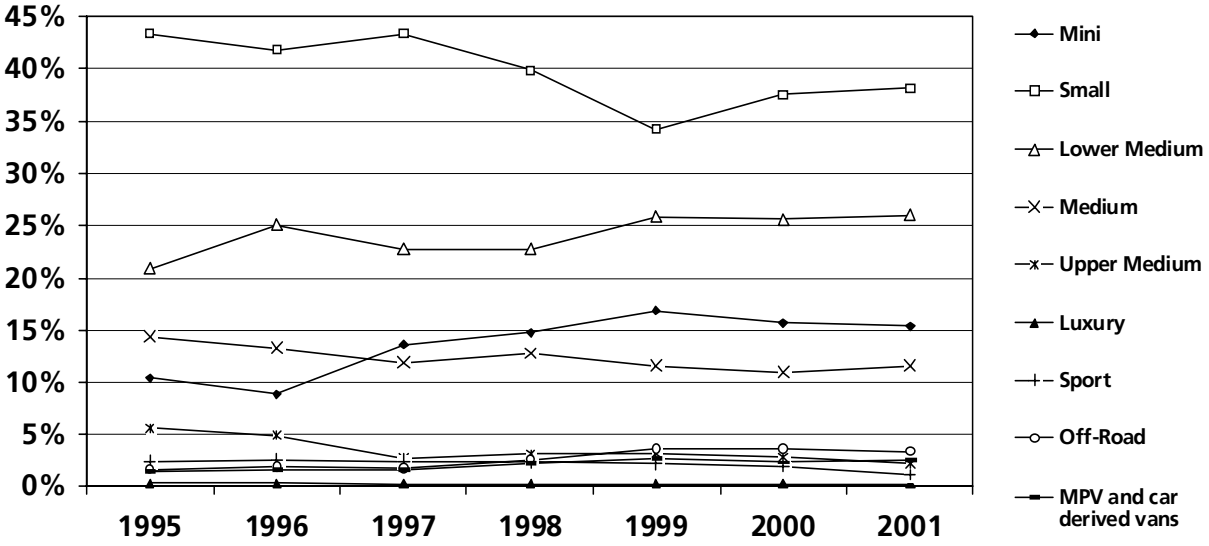
Figure 48: Registrations by segment in the EU 15



Source: R.L. Polk Marketing Systems, (2003)

When one reviews the five countries with the highest numbers in new passenger car registrations, the following characteristics can be stated (see annex 3 for charts of all Member States): In Germany, the shares of the Mini and Lower Medium segments are relatively high. In addition, the share in the Luxury-segment is highest in the EU15. In Italy, the smaller segments are still dominant. Mini, Small and Lower Medium share nearly 80% of total new registrations (2001) while registrations of Medium and Upper Medium vehicles decreased during the investigation period. The remarkable development from 1996 to 1997, analysed with the monitoring data, can also be identified her. At that time the shares of Mini and Small segment cars increased significantly while the other segments decreased.

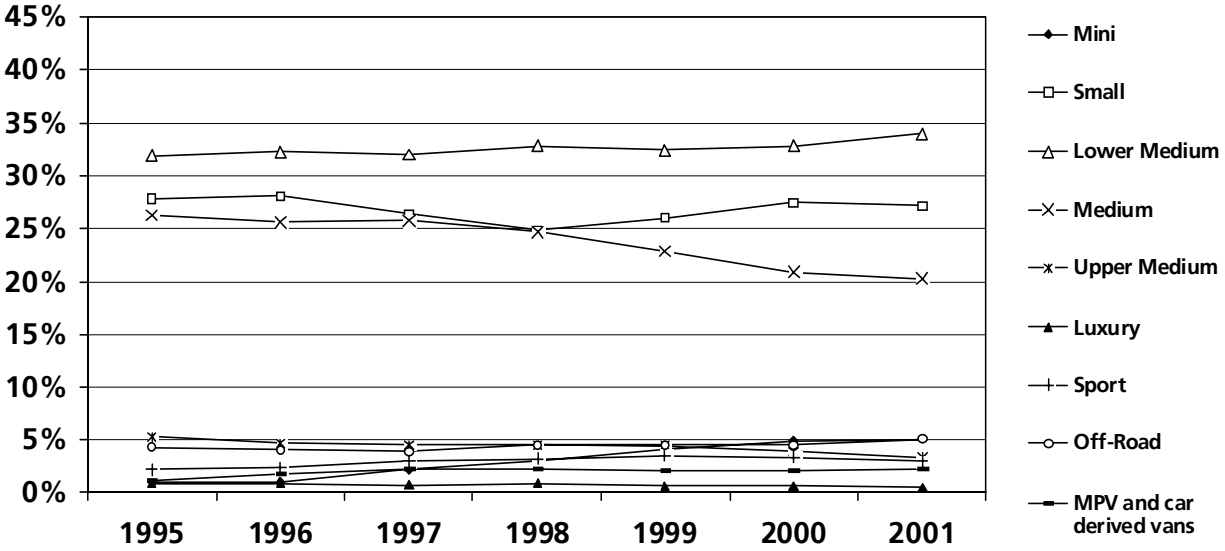
Figure 49: Registrations by segment in Italy



Source: R.L. Polk Marketing Systems, (2003)

For France it can be observed that, in contrast to other Member States, no increase occurred in the Mini segment and the share of MPVs is constantly high (approx. 5 %). In Spain, the greatest concentration is recorded in the Lower Medium segment, which has more than 45 % of all registrations. A significant characteristic of registrations in the United Kingdom is the relatively even distribution of segments: Three segments (Lower Medium, Small and Medium) range between 20 and 35 %, all other segments are below 5 %.

Figure 50: Registrations by segment in United Kingdom



Source: R.L. Polk Marketing Systems, (2003)

Having a further look at the Member States with fewer registrations, a number of characteristics are identified. Austria shows a very high portion of Off-Road and MPV, but Belgium has

the highest share of MPV of all Member States. Lower Medium and Medium balance each other out in Finland at a very high level (both segments together add up to nearly 75% of new registrations). In the Netherlands, the strong decrease of the share of Medium cars and the strong increase in the Mini segment is the most pronounced trend, with the greatest shift in 1998 and 1999. In Sweden, registrations in the segment Upper Medium strongly decreased, while there was a strong increase in the segment Small.

Portuguese registrations of Small segment vehicles decreased strongly while there were increases for Lower Medium and Medium. This finding corresponds well with the analysis' result of the monitoring data, which accounts for strong increasing mass and engine power figures, especially for diesel cars. For Denmark, monitoring and segmentation data show some corresponding developments as well, however to a smaller extend. There, increasing shares of the lower segment cars seem to be connected with the relatively light and low powered diesel registrations recorded in the monitoring data.

Annex 4.2 Conclusion of the Polk Marketing Systems data segment analysis

As a result of the segmentation analysis, it has to be mentioned that some very characteristic compositions of segment shares can be identified, e.g. the great concentration of the Lower Medium segment in Spain or the predominance of the small segments in Italy. Some analogies to the monitoring data analysis could be found out as well (e.g. see development in Italy from 1996 to 1997). These findings indicate that the changes of physical characteristics recorded by the monitoring system – and, therefore, of the CO_2 emissions – can not only be associated to technical changes within certain models or segments, but also to changes of the segment shares, i.e. of the consumer behaviour mainly.