POSSIBLE REGULATORY APPROACHES TO REDUCING CO_2 EMISSIONS FROM CARS
070402/2006/452236/MAR/C3

Final Report

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1 INTRODUCTION

This is the Final Report for service contract 070402/2006/452236/MAR/C3 *Possible Regulatory Approaches to Reducing CO_2 Emissions from Cars*.

The analysis underlying this Final Report has proceeded through the development of a series of Technical Notes addressing specific aspects of the analysis, and which are listed in Annex 1. These have also been scrutinised by the Steering Group for this project, who have given feedback and advice that has been reflected in subsequent analysis and later versions of the notes. Key elements of these notes are also summarised in relevant sections below.

The following sections highlight the project team's conclusions as derived from the technical notes. The final versions of the Technical Notes themselves are annexed in full to this report.

2 SETTING OUT THE POLICY OPTIONS

2.1 The 'No Action' Option

The Commission's February 2007 Communication – COM (2007) 19 - indicated that the voluntary agreements already in place were not on track to be met and that a legislative proposal was therefore necessary to achieve the Community target for CO_2 emissions. Hence the 'no action' and voluntary options have already been excluded and a mandatory system must be considered. This analysis therefore focuses on the options for such a regulation.

The Commission also indicated in its Communication that it favoured options to be operated at the Community level rather than the Member State level. However, for the sake of completeness our analysis began by assembling a 'long list' of possible regulatory options as described below.

2.2 Generating the 'Long List' of Regulatory Options

As there were potentially an almost infinite number of different permutations of different components of a possible legal regime, the project team initially considered the separate components of a possible system independently. The broad components addressed in our analysis, and the options for each, were:

- Obligated or responsible entity (trade associations; manufacturers or groups; importers, distributors and dealers; and Member States)
- Target focus (level of obligation – eg at Member State or EU level, and nature of obligation, eg model/variant or group target?)
- Target type (sloped line targets; single targets; and others)
- Instrument/sanction (exclusion of non-compliant models from the market; fines associated with a target; feebates – a system of fines with rebates, to punish the worst performing cars and reward the best; and trading)
- Choice of a utility function (vehicle mass in kg, or pan area (vehicle l x w) in m^2, or a possible future option of footprint (wheelbase x track width))

Clearly these components are not in reality separate, in that some combinations will work particularly well together, while others will be incompatible. It is the way in which the various components fit together that determines whether a particular combination will work or not, and also how well it will work against the range of agreed criteria described under IA point 4.2. The more extensive discussion of the Interim Report is briefly summarised below.

- ***Obligated or Responsible Entity*** This refers to the legal entities to be placed under the primary obligation to take action to reduce car CO_2 emissions, and to be responsible for ensuring that this takes place. Four different entities were considered. It was assumed that trade associations were unlikely to be suitable obligated entities due to their failure to deliver on the previous voluntary agreements and lack of sufficient influence or legal powers over their members. Manufacturers or groups, importers, distributors and dealers and Member States were therefore considered to be more appropriate obligated entities.

- ***Target Focus*** Under this heading, two distinct elements were combined in order to simplify the analysis:
  - Level of obligation or group obligation – individual vehicle or model/variant
  - Nature of group obligation – group targets offer a degree of flexibility relative to vehicle targets and can be imposed at the level of the obligated entity, at the Member State level or even the EU level

- ***Target Type*** The global target was already laid down – a Community average of 130g/km by 2012 – but it was considered likely that this global target will need to be translated into different targets or types of targets to be used at particular points within a proposed system. The types of target considered were sloped line targets; single targets; and others. The first two were deemed the only fair and viable options for regulating cars through targets set at the model/variant level. Sloped line targets, where a target varies according to some measure of a vehicle's 'utility', were deemed desirable as they allow some flexibility to give a larger allowance of CO_2 emissions to vehicles that offer greater utility than others. The choice of a utility function is, however, another issue – discussed below. Single targets would generally discard the notion of a utility function and impose a single limit or target value for all vehicles, thereby greatly reducing the flexibility of the system and increasing the chances of market disruption or distortion, unless other elements of flexibility were introduced such as fines or feebates, trading in credits, or applying the limit at manufacturer/group level rather than individual vehicle level. Group average targets, on the other hand, may be designed to vary from company to company (or country to country, etc) to reflect their differing positions in the market and distinctive possibilities to reduce their emissions, for example through a percentage reduction or some sort of 'contraction and convergence' option.

- ***Instruments and sanctions*** A number of potential sanctions were considered, namely: exclusion of non-compliant models from the market; fines associated with a target; feebates – a system of fines with rebates, to punish the worst performing cars and reward the best; and trading.

- ***Utility Function*** In order to determine an appropriate utility function, the following criteria were used: good/acceptable measure of 'utility'; preference for a continuously-variable function; availability of required data; understandable; minimising perverse effects; and not excluding technical options. Based on this two main options were shortlisted, namely vehicle mass in kg and pan area (vehicle l x w) in m^2. Both options were deemed to show a reasonably close correlation to CO_2 emissions and offer significant room for improvement, although mass may be less appropriate as it reduces the potential of weight reduction as an option for contributing towards meeting the target. A possible future option of footprint (wheelbase x track width) was also identified, although data for this are not readily available at present; pan area was therefore used as a proxy for footprint at this stage.

These separate design components of a legal system were assembled to produce a 'long list' of 78 logically possible options (ie avoiding conflicting design components). Each option was then given a simple qualitative score (++, +, 0, -, --, ---) for each criterion listed under point 4.2 below, to create an overview enabling a first intermediate selection of options to be identified for more detailed assessment. Some options could be eliminated immediately due to their overall low scores, whilst others naturally fell into 'families' of options which enabled options with similar characteristics to be grouped for the purposes of selecting the intermediate and short lists.

2.3 Shortening the List of Options

For the full evaluation of the short list of options, assessment criteria for evaluation of the different options for implementing the 130 g/km policy followed the Impact Assessment (IA) Guidelines (SEC(2005)791). However, for the purpose of the assessment of the 78 policy options identified, a shorter list of filtering criteria was applied to allow a more simple, transparent and operational assessment to be applied. The criteria used for the assessment were as follows:

- *Market distortion* (exclusion of models): a strict interpretation of market distortion was applied (ie formal or de facto exclusion of models from the market).
- ***Distortion of EU open market*** (price difference between countries): focus on the possibility of creating differences in vehicle base price for specific models between countries (or over time).
- ***Even distribution of burden over manufacturers:*** compares distribution of compliance costs as well as distributional effects of fines and rebates between manufacturers/groups.
- ***Fairness to early movers***: ability to reward early movers (who have already improved their fuel efficiency) relative to those (laggards) who have not.
- ***Polluter pays principle***: from a societal/moral point of view the system is 'fair' when owners or makers of large or high CO_2 emitting cars pay more towards meeting the 130 g/km target.
- ***Certainty of meeting 130 g/km average***: whatever system is applied, there will be questions about the sanctions and the degree of compliance that results. However, even in the case of full compliance, some systems give much greater inherent certainty that the overall target will be met than others.
- ***Average compliance cost per car***: assessment based on data from TNO 2006.
- ***Average compliance costs for small cars:*** assessment based on data from TNO 2006.
- ***Practicability:*** difficulty or complexity for implementation and operation of the system or of components of it.
- ***Enforceability:*** difficulty of enforcing compliance (including receipt of fines or payment of rebates and the obligation to trade), once the system has been implemented. As such complementary to 'practicability'.
- ***Accommodation of new player/mergers:*** some systems, eg those that imply 'grandfathered' rights, are more difficult to apply to new entrants who have no history upon which to base their allocations.

- ***Comprehensibility of the option:*** other things being equal, it is desirable that options be easy to comprehend.
- ***Other*** (specific issues or problems): these were annotated in the assessment.

For each option the criteria outlined above were applied and assessed according to a scoring rationale developed by the project team and translated into a matrix with the help of simple qualitative scores (++, +, 0, -, --, ---), illustrated in Technical Note 5.

---	impossible option – 'killer' arguments identified
--	unfeasible option - very strong *con* arguments
-	unlikely option - fairly strong *con* arguments
0	neutral with regards to this criterion
+	possibly feasible options - problems identified, *pros* and *cons* balanced
++	feasible option - *pros* strongly outweigh *cons*, no serious or insurmountable *con* arguments

The scores have been then grouped and weighted, and an average weighted result has been derived as a composite of all the criteria. This result was then manipulated to 'amplify' the scoring differences between best and worst options (this was done as all options tend to regress towards the mean when evaluated across a range of options, reflecting the fact that rarely are any options good or bad on all counts). A filter was then applied to select the options above a specific threshold of score that retained a suitable list of options. The matrix clearly showed that there is no single option that does not have negatives and only a few that have no double-negatives. All show a combination of very different scores on different criteria. That is, there is no clear 'winner'. The more promising Intermediate List options were grouped into three 'families' corresponding to 'responsible entity', 'target focus' and 'target type' respectively.

a. Family = Responsible Entity

- In the case of responsible entities, Manufacturer / groups was the strongest branch with most options getting + or ++; and
- The branches Dealer/Importer and Member States only had a couple of options each that bear fruit.

b. Family = Target Focus

- In this option Dealer/Importer national sales average had only two options that in some scoring methods get a +. For the rest this branch was not bearing fruit at all.
- Manufacturer / groups EU sales average got the highest scores, and Mfr / Mfr national sales average combined with Mfr / Mfr groups as Responsible Entity ends in second place overall.
- Depending on the exact amplification method, the family 'Car model/variant' had up to 50% options with a + or ++, but the rest were 0 or below.

c. Family = Target Type

This family categorisation showed a very mixed picture:

- Under the current weighting the Sloped line target option did not get any ++ scores at all. This reflects the fact that it scores poorly on meeting the 130g target, violates the polluter pays principle, is complex and can be impractical in some contexts.

- For overall weighted score sloped line is getting positive scores for less than half of the options while %-reduction scores positive on more than half of the options, including a number of ++ values.
- Uniform limit with trading generally gets high score.

2.4 Selection of Shortlisted 'Families'

Following the above Intermediate Assessment, the Commission proceeded to the selection of a short list of options for more intensive study. From this, three 'families' of shortlisted options have been selected for detailed analysis in the quantitative model (see Technical Note 9):

a. Uniform limit
    - applied per vehicle
    - applied to the sales weighted average in 2012 per manufacturer
    - applied to the sales weighted average in 2012 per manufacturer with trading

b. Utility based limit function
    - applied per vehicle
    - applied to the sales weighted average in 2012 per manufacturer
        - For each model sold by the manufacturer the CO_2 emission limit is calculated based on the vehicle's utility value (see explanation further on). The target per manufacturer is then calculated as a sales-weighted average of the limit values per model.
        - This is identical to defining a sales-weighted average utility for the manufacturer and inserting that average utility value in the utility based limit function.
    - applied to define targets for 2012 based on the sales weighted average in 2006 per manufacturer
    - applied to the sales weighted average in 2012 per manufacturer with trading

c. Percentage reduction
    - applied to the sales weighted average in 2012 per manufacturer
    - applied to the sales weighted average in 2012 per manufacturer with trading

3 QUANTITATIVE ANALYSIS OF COST IMPACTS

3.1 Introduction

Using an updated version of the model developed in [TNO 2006] a wide range of regulatory options for implementing the 130 g/km legislation for passenger cars has been quantitatively assessed with respect to average costs per car for meeting the target and especially the distribution of required CO_2 reduction efforts and associated costs per vehicle over the various manufacturers / manufacturer groups selling cars in Europe and over the six market segments discerned in the model (small, medium and large vehicles running on petrol or diesel). Details of the updates made to the model are described in Technical Note 6 (Note on model update).

A complete overview of all assessment results is presented in Technical Note 9 (on quantitative results). In this chapter we present as an example the results for one specific scenario and focus on overall conclusions that can be drawn from the assessments presented in Technical Note 9.

3.1.1 Families of options

The following **three families** of basic regulatory options have been modelled, on the basis described above:

- <u>uniform limit</u>
  - applied per vehicle
  - applied to the sales weighted average in 2012 per manufacturer
  - applied to the sales weighted average in 2012 per manufacturer with trading
    - **Note**: in the results presented below the uniform limit is indicated as the 0% slope variant of the options with a utility based limit function.
- <u>utility based limit function</u>
  - applied per vehicle
  - applied to the sales weighted average in 2012 per manufacturer
    - For each model sold by the manufacturer the CO_2 emission limit is calculated based on the vehicle's utility value (see explanation further on). The target per manufacturer is then calculated as a sales-weighted average of the limit values per model.
    - This is identical to defining a sales-weighted average utility for the manufacturer and inserting that average utility value in the utility based limit function.
  - applied to the sales weighted average in 2012 per manufacturer with trading
- <u>percentage reduction</u>
  - applied to the sales weighted average in 2012 per manufacturer
  - applied to the sales weighted average in 2012 per manufacturer with trading

In this chapter detailed results will only be presented for utility based limit functions applied to the sales weighted average in 2012 per manufacturer. Similar results for the other regulatory options can be found in Technical Note 9 (on quantitative results). Generic differences between the regulatory options are however summarised in the conclusions to this chapter.

Application of a certain measure to the sales weighted average CO_2 emissions per manufacturer implies that manufacturers are allowed to perform internal averaging, i.e. the excess emission of one vehicle that emits more that the value allowed by the limit can be compensated by other vehicles that perform less than allowed if the limit were applied at the vehicle level. The model calculates the distribution of reductions per segment that yields the lowest overall costs for meeting the sales averaged target. This solution is characterised by equal marginal costs in all segments. Within each segment also internal averaging is included implicitly as all vehicles in the segment undergo CO_2 reduction up to the same level of marginal costs.

3.1.2 Baseline scenarios

The costs for reaching various possible targets in 2012 are calculated relative to a 2012 baseline without the new CO_2 policy for passenger cars, and are expressed as the retail price increase per vehicle associated with applying technical reduction measures between 2006 and 2012 to comply with the assessed option in which the 130 g/km target for 2012 is applied. As a baseline scenario for the 2006-2012 period two options are modelled:

- **b0**: manufacturers do not apply additional CO_2 reduction measures between 2006 and 2012 so that for each manufacturer in each segment the average CO2 emission rises proportional to the autonomous mass increase that is assumed to occur between 2006 and 2012;
- **b1**: manufacturers apply CO_2 reduction measures between 2006 and 2012 to compensate the impact of autonomous mass increase (or other trends) on CO_2 and so maintain the average CO_2 emission in each segment at the 2006 level. The costs of these measures are subtracted from the costs for reaching the 2012 target.

For results presented relative to **baseline b1**, in which, the costs of CO_2 reduction measures applied by manufacturers between 2006 and 2012 to maintain the average CO_2 emission in each segment at the 2006 level are subtracted from the costs for reaching the 2012 targets. Further explanations on the baselines can be found in Technical Note 6 (Note on model update).

3.1.3 Scenarios for autonomous mass increase (AMI)

Four different scenarios have been assessed for the autonomous mass increase that is assumed to occur between 2006 and 2012.

- Scenario **a** assumes an average autonomous mass increase of 0.82% p.a.. This value is derived from scenario **a** in Table 3.27 of [TNO 2006] and has also been used as central estimate in the IA.
- Scenario **b** uses an autonomous mass increase of 1.5% p.a., which was the baseline in the calculations for [TNO 2006].
- Scenario **c** assesses the costs for meeting the target under the assumption that the there is no autonomous mass increase between 2006 and 2012 (AMI = 0.0% p.a.).
- Finally scenario **d** explores the impacts of a more extreme assumption for the autonomous mass increase of 2.5% p.a..

3.1.4 Nomenclature of combined scenarios (AMI and baseline)

Results presented in this chapter and in Technical Note 9 (on quantitative results) for the 8 different possible combinations of baseline scenario and assumption on autonomous mass increase (AMI) are labelled as follows:

- **a / b0**: AMI = 0.82%, baseline: CO_2 increases with AMI
- **a / b1**: AMI = 0.82%, baseline: CO_2 per car maintained at 2006 level
- **b / b0**: AMI = 1.5%, baseline: CO_2 increases with AMI
- **b / b1**: AMI = 1.5%, baseline: CO_2 per car maintained at 2006 level
- **c / b0**: AMI = 0.0%, baseline: CO_2 increases with AMI
- **c / b1**: AMI = 0.0%, baseline: CO_2 per car maintained at 2006 level
  - CO_2 emissions remain the same between 2006 and 2012 if AMI = 0.0% p.a.. The results for scenario **c** therefore do not depend on the baseline scenario (**b0** or **b1**).
- **d / b0**: AMI = 2.5%, baseline: CO_2 increases with AMI
- **d / b1**: AMI = 2.5%, baseline: CO_2 per car maintained at 2006 level

In this chapter only the results for scenarios **a / b1** (AMI = 0.82% p.a.) and **c / b1** **(AMI = 0.0% p.a.)** are shown. Similar results for all other scenarios can be found in Technical Note 9 (on quantitative results). It should be stressed however that while differing assumptions and combinations here make a significant difference to the overall average cost of the measure, they have little or no impact on either the distributional impact of the measures or on other aspects of instrument design such as the slope of a utility-based limit function.

3.1.5 Baseline data for 2006

For 2006 the model contains data on vehicle sales, CO_2 emissions, mass and pan area per segment per manufacturer (group) that have been calculated based on data supplied by AAA. The two bubble graphs in Figure 1 and Figure 2 compare manufacturers with respect to average mass, average pan area, average CO_2 emissions and sales. More detailed analysis of these data is presented in Technical Note 7 (Note on bubble graphs).

Note: The data supplied by AAA are based on the empty weight of the vehicle, and this value is used throughout this analysis wherever ‘vehicle mass’ is referred to. This value differs from that used in the associated Monitoring Mechanism and the revised Type Approval Directive 2007/46/EC, where an additional 75kg is added to reflect the weight of the driver.

Figure 1 **Average CO_2 emissions per manufacturer as function of average mass: size of bubbles indicates total sales (petrol + diesel vehicles)**

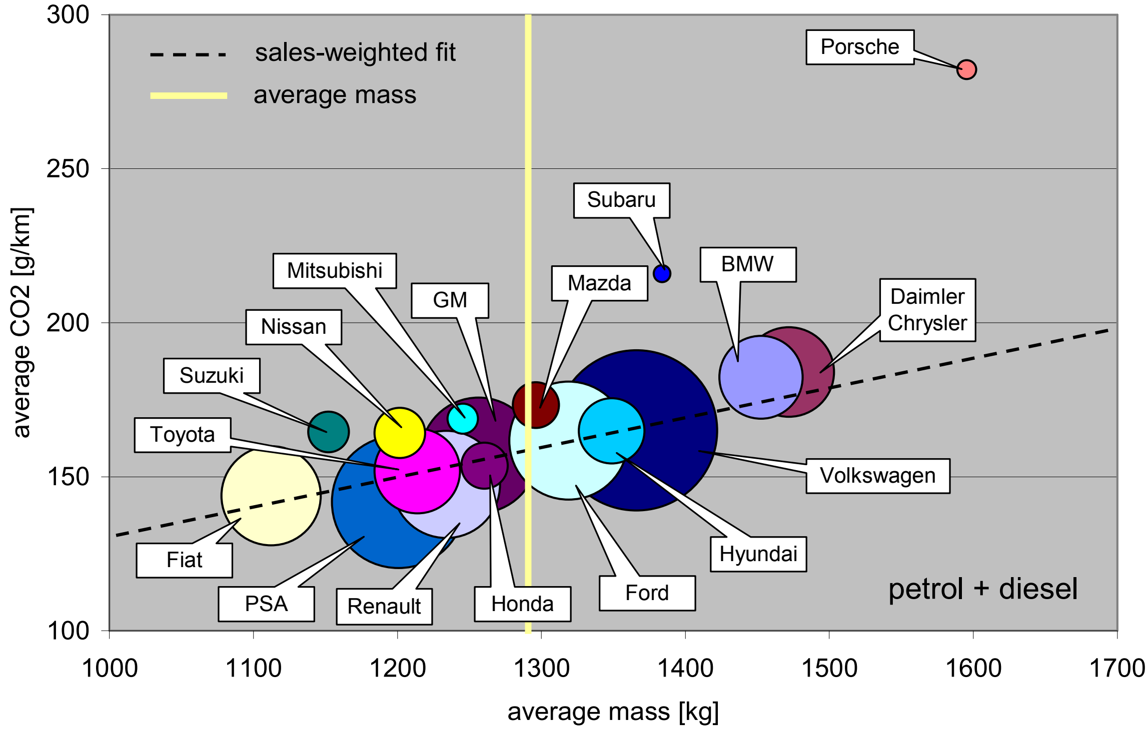
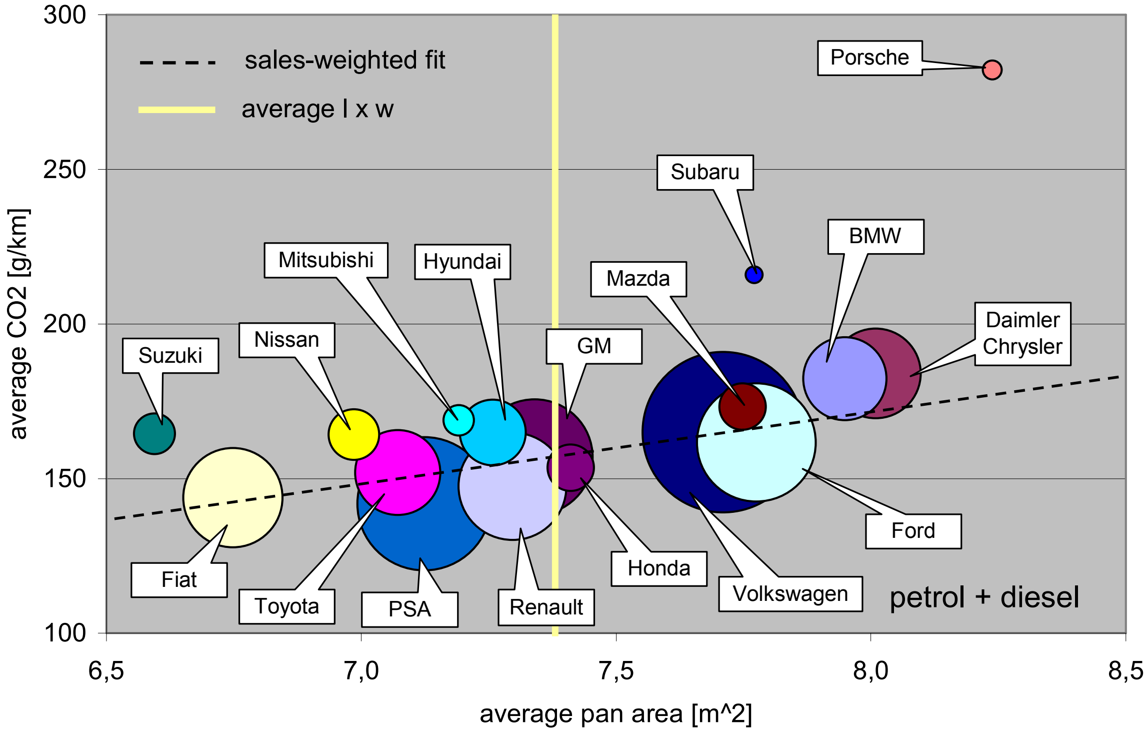


Figure 2 **Average CO_2 emissions per manufacturer as function of average pan area (l x w): size of bubbles indicates total sales (petrol + diesel vehicles)**



3.1.6 Utility-based limit functions

Linear utility-based limit functions are expressed as: CO_2 limit = a U + b, with U the utility parameter. The slope a and y-axis intercept b can be varied provided that the following relation is fulfilled: 130 g/km = a $\langle U \rangle_{2012}$ + b, with $\langle U \rangle_{2012}$ the average utility value of all new vehicles sold in Europe in 2012. For mass as utility parameter the value $\langle U \rangle_{2012}$ depends on the amount of autonomous mass increase that is assumed to occur between 2006 and 2012. Consequently the utility-based limit functions will be different for the different scenarios with respect to autonomous mass increase. In Technical Note 8 (Note on definition of limit functions) the overall procedure for defining utility-based limit functions for 2012 is explained as well as the labelling methodology by which the slope of the limit function is related to a base slope that is derived from the sales weighted least squares fit through the 2006 data on CO_2 emissions of individual vehicle models versus mass or pan area. In this labelling the slope a a limit function is defined as a percentage of the slope of the "100%" base limit function.

In the calculations presented in this chapter for the case of scenario a / b1 (AMI = 0.82% p.a., CO_2 emissions maintained at 2006 level in baseline) and c / b1 (AMI = 0.82% p.a., CO_2 emissions maintained at 2006 level in baseline) a range of slope values has been used as indicated in Table 1, Table 2, Table 3 and Table 4.

Table 1 Utility based limit functions for scenario a (AMI = 0.82% p.a.).

utility-based limit function (a U + b)	mass			l x w		
		a	b		a	b
least squares fit 2006		0,0934	38,7		22,70	-9,2
slope 120%	*120%*	0,0882	10,5	*120%*	22,17	-34,9
slope 100%	*100%*	0,0735	30,4	*100%*	18,48	-7,4
slope 80%	*80%*	0,0588	50,3	*80%*	14,78	20,0
slope 60%	*60%*	0,0441	70,3	*60%*	11,09	47,5
slope 40%	*40%*	0,0294	90,2	*40%*	7,39	75,0
slope 20%	*20%*	0,0147	110,1	*20%*	3,70	102,5
slope 0%	*0%*	0,0000	130,0	*0%*	0,00	130,0

Table 2 Utility based limit functions for scenario c (AMI = 0.0% p.a.).

utility-based limit function (a U + b)	mass			l x w		
		a	b		a	b
least squares fit 2006		0,0934	38,7		22,70	-9,2
slope 120%	*120%*	0,0914	11,9	*120%*	22,17	-34,9
slope 100%	*100%*	0,0762	31,6	*100%*	18,48	-7,4
slope 80%	*80%*	0,0610	51,2	*80%*	14,78	20,0
slope 60%	*60%*	0,0457	70,9	*60%*	11,09	47,5
slope 40%	*40%*	0,0305	90,6	*40%*	7,39	75,0
slope 20%	*20%*	0,0152	110,3	*20%*	3,70	102,5
slope 0%	*0%*	0,0000	130,0	*0%*	0,00	130,0

Besides these straightforward slope variations (Table 1 and Table 2) also the following specific slope values have been investigated for the case of utility-based limit functions applied per manufacturer without trading (see Table 3 and Table 4):

- a "cost optimised slope" for which the average costs per vehicle are minimised (in the per manufacturer - utility variant without trading);
- a "weighted equalised distribution" and an "unweighted equalised distribution" variant in which the slope is optimised for an even distribution of the burden over all manufacturers.

More detailed explanation on these specific slope definitions is given in Technical Note 8 (Note on definition of limit functions).

Table 3 Utility based limit functions for scenario a (AMI = 0.82% p.a.): specific cases.

utility-based limit function (a U + b)	mass			l x w		
		a	b		a	b
cost optimised slope	*123%*	0,0902	7,7	*123%*	22,68	-38,7
weighted equalised distribution	*77%*	0,0569	52,9	*68%*	12,55	36,7
unweighted equalised distribution	*48%*	0,0353	82,2	*28%*	5,23	91,1

Table 4 Utility based limit functions for scenario c (AMI = 0.0% p.a.): specific cases.

utility-based limit function (a U + b)	mass			l x w		
		a	b		a	b
cost optimised slope	*123%*	0,0936	9,1	*123%*	22,63	-38,4
weighted equalised distribution	*80%*	0,0606	51,7	*67%*	12,37	38,0
unweighted equalised distribution	*39%*	0,0295	91,8	*18%*	3,26	105,8

3.1.7 Presentation of results

Results presented in this chapter and in Technical Note 9 (on quantitative results) are expressed as absolute or relative increases of the retail price per vehicle (price including tax) for the average new vehicle, for a given manufacturer or for a given market segment. This retail price increase is the difference between the estimated retail price of a vehicle in 2012 in the situation in which the 130 g/km legislation is applied compared to the retail price in the 2012 baseline situation, without application of the 130 g/km legislation. The baseline situation is developed on the basis of new vehicle sales data for 2006 and includes assumptions on autonomous mass increase between 2006 and 2012 and on market changes, specifically overall sales, sales distributions and the share of petrol and diesel vehicles in the new vehicle sales (see Technical Note 6 (Note on model update)).

Relative retail price increase is determined by dividing the absolute retail price increase by the average new vehicle retail price (per manufacturer or segment) for 2006.

3.1.8 Caveats

- Results for individual manufacturers presented in this chapter and in Technical Note 9 (on quantitative results) should not be interpreted as predictions of the costs in 2012 for that manufacturer but should rather be seen as an estimate of the costs for a manufacturer with characteristics (in terms of sales distributions and CO_2 emissions per vehicle per segment) similar to that manufacturer.
- All results per segment are calculated under the assumption that manufacturers apply direct and full cost pass through of the costs for CO_2 reduction measures to the retail price of the vehicles in which these measures are applied. In reality manufacturers obviously have the freedom to distribute the overall costs for meeting the 2012 target in a different way over the model spectrum that is offered, or to absorb all or part of the cost rather than passing it through to the purchaser.

3.2 Results for scenario a (AMI = 0.82% p.a.) / baseline b1 and c (AMI = 0.0% p.a.) / baseline b1

Note: the regulatory option '% reduction applied per manufacturer' is presented for comparative purposes against each of the two utility function options mass and pan area, but is identical in each case.

3.2.1 Limit function based on mass or % reduction applied per manufacturer for AMI = 0.82% p.a.

The absolute retail price increase per manufacturer resulting from applying a mass-based CO_2 limit functions with different slope values or a percentage reduction at the level of manufacturers for the case of AMI = 0.82% p.a. is depicted in Figure 3. Dividing absolute retail price increase by the average base retail price per manufacturer yield the relative retail price increase as depicted in Figure 4 and Figure 5 (for specific slope values given in Table 3).

The distribution of relative retail price increases over market segments is presented in Figure 6. Alternative representations of the distributional impacts are presented in Figure 7 and Figure 8 for the slope values 40% and 80%.

Figure 3 Absolute retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated).

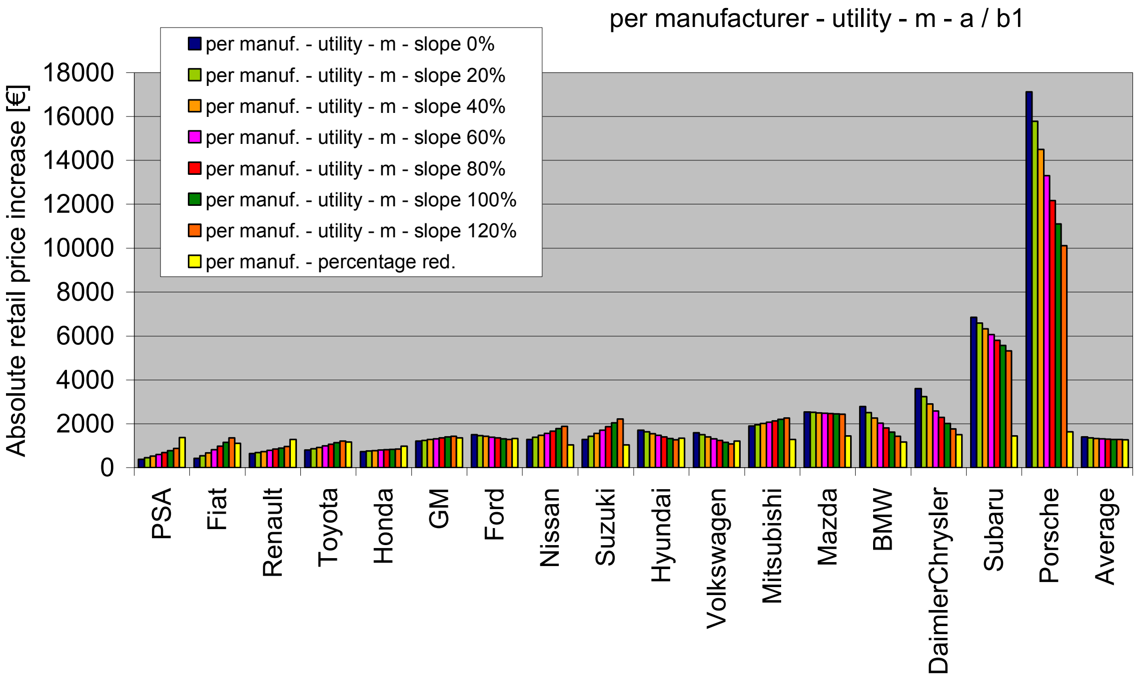


Figure 4 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated).

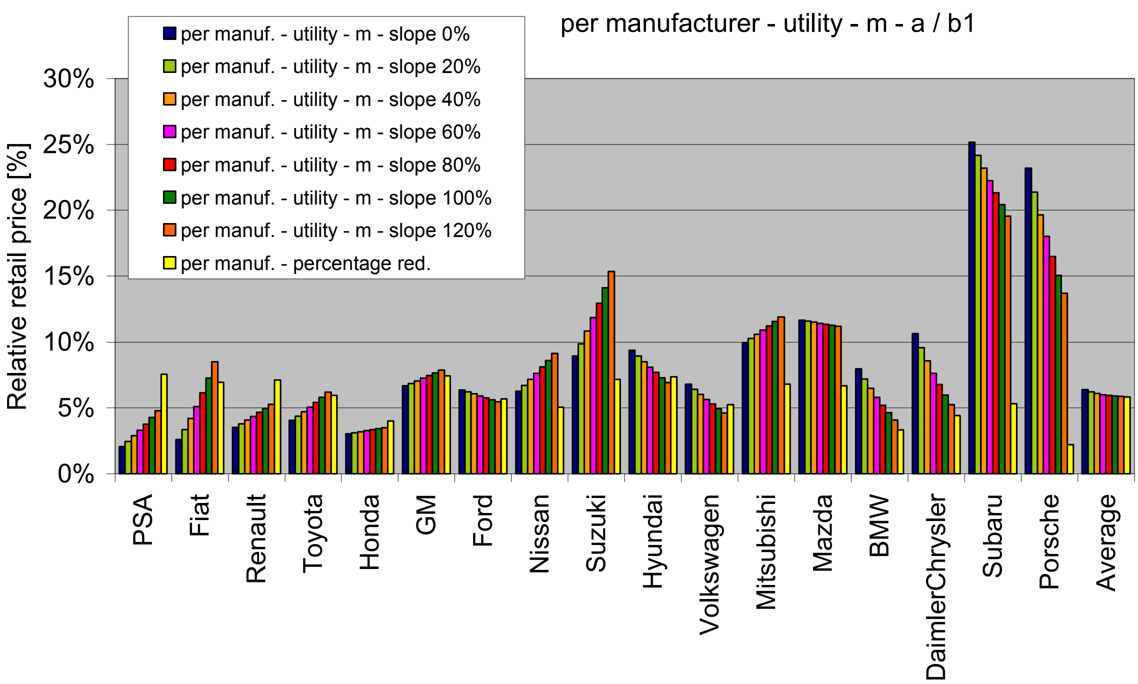
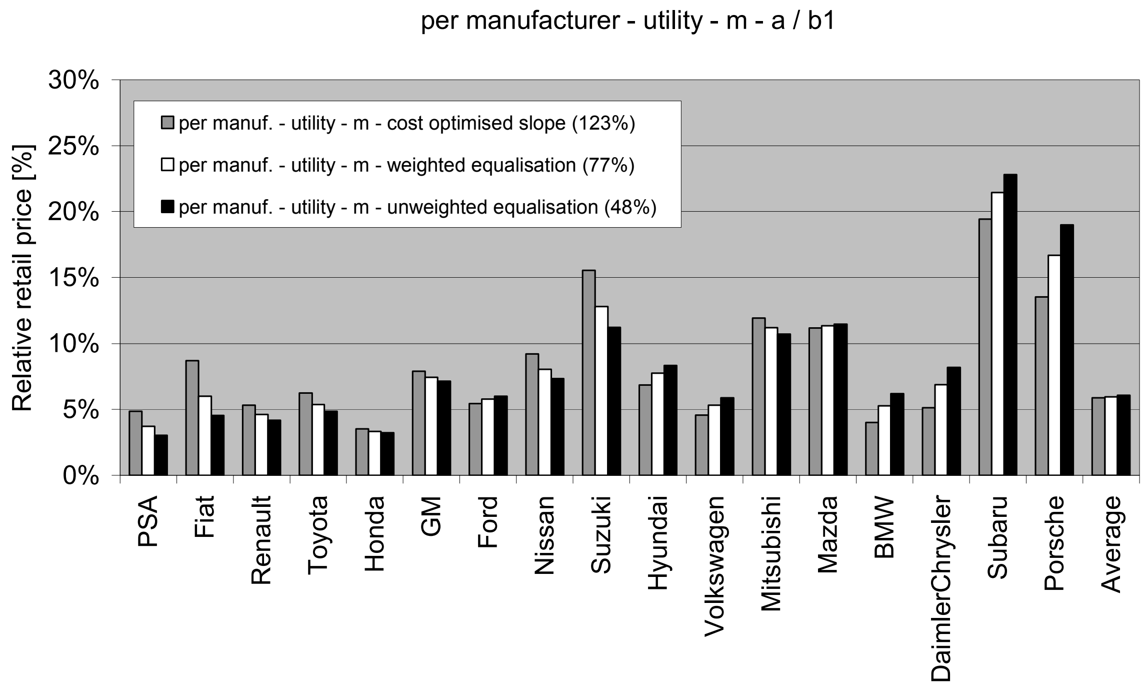


Figure 5 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), for specific slope variants.



Note: Porsche and Subaru have been excluded from both equalisation approaches and therefore retail price increases are relatively high for these manufacturers.

Figure 6 Relative retail price increase per segment for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated).

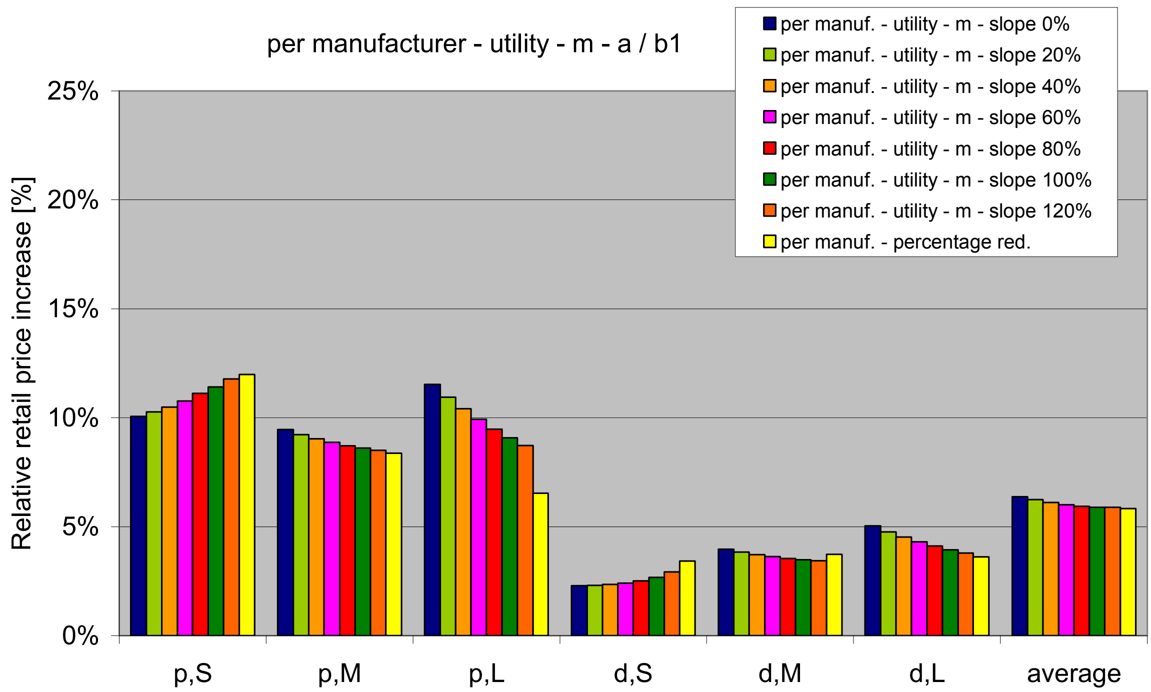


Figure 7 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), slope = 40%.

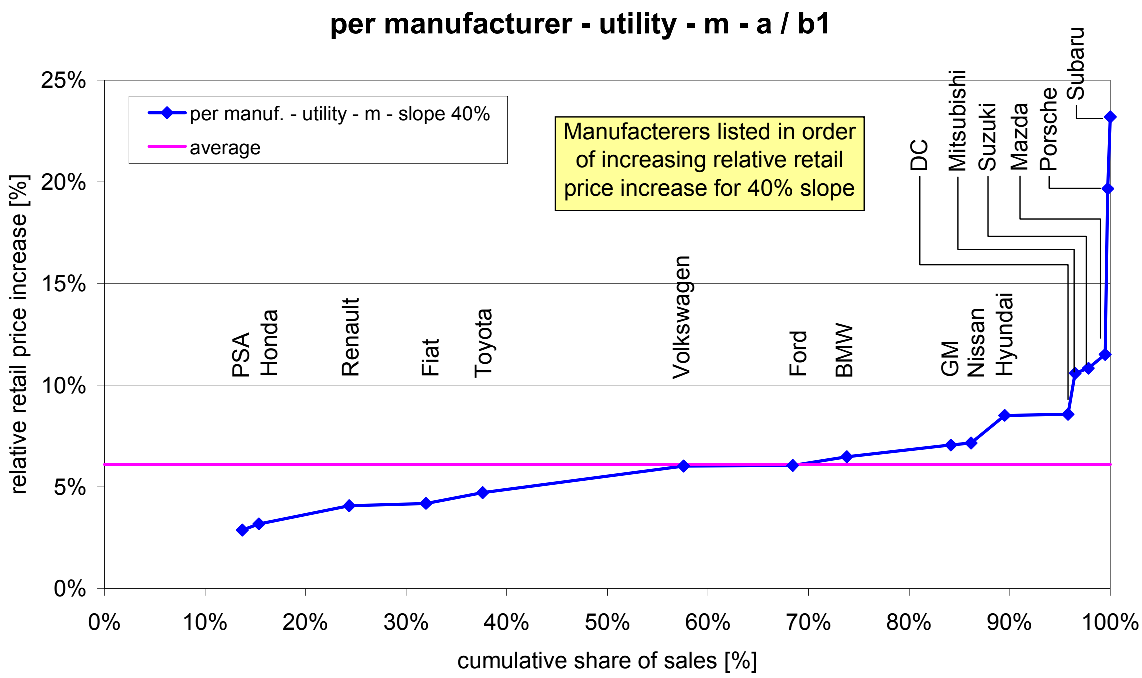
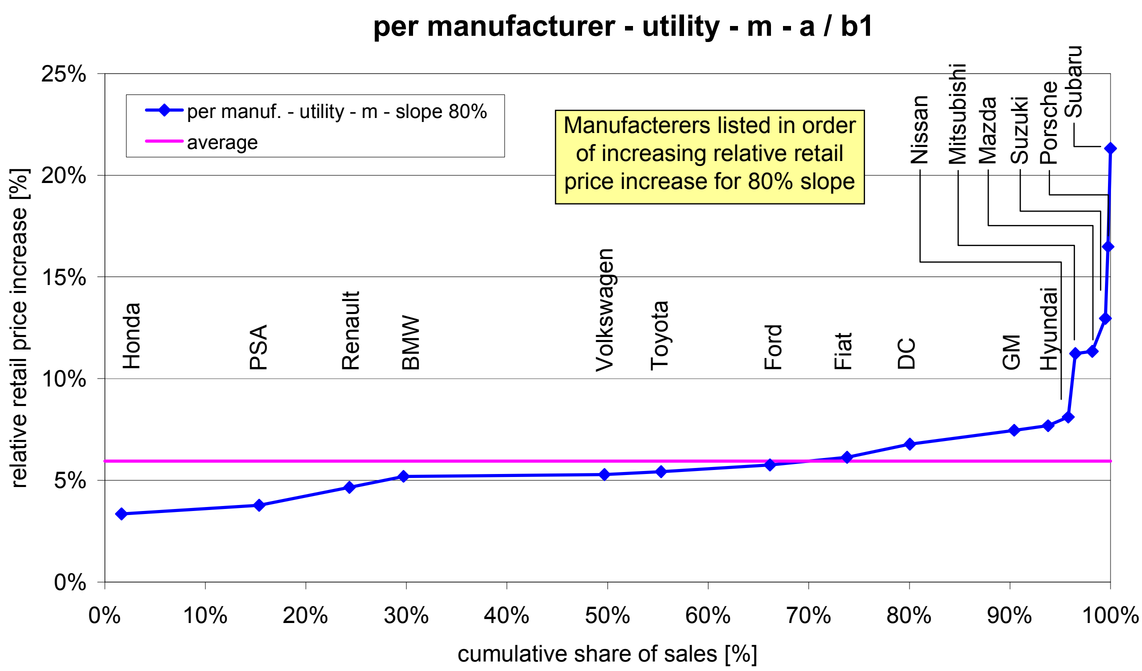


Figure 8 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), slope = 80%.



3.2.2 Limit function based on mass or % reduction applied per manufacturer for AMI = 0.0% p.a.

In the absence of autonomous mass increase (AMI = 0.0% p.a.) the CO_2 emissions of vehicles do not change between 2006 and 2012. As a consequence no costs need to be made for maintaining emissions at the 2006 level in baseline **b1**. For this reason the results for scenario **c** are the same for the baselines **b0** and **b1**.

The absolute retail price increase per manufacturer resulting from applying a mass-based CO_2 limit functions with different slope values or a percentage reduction at the level of manufacturers for the case of AMI = 0.0% p.a. is depicted in Figure 3. Dividing absolute retail price increase by the average base retail price per manufacturer yield the relative retail price increase as depicted in Figure 4 and Figure 5 (for specific slope values given in Table 3).

The distribution of relative retail price increases over market segments is presented in Figure 6. Alternative representations of the distributional impacts are presented in Figure 7and Figure 8 for the slope values 40% and 80%.

Figure 9 Absolute retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b0=b1.

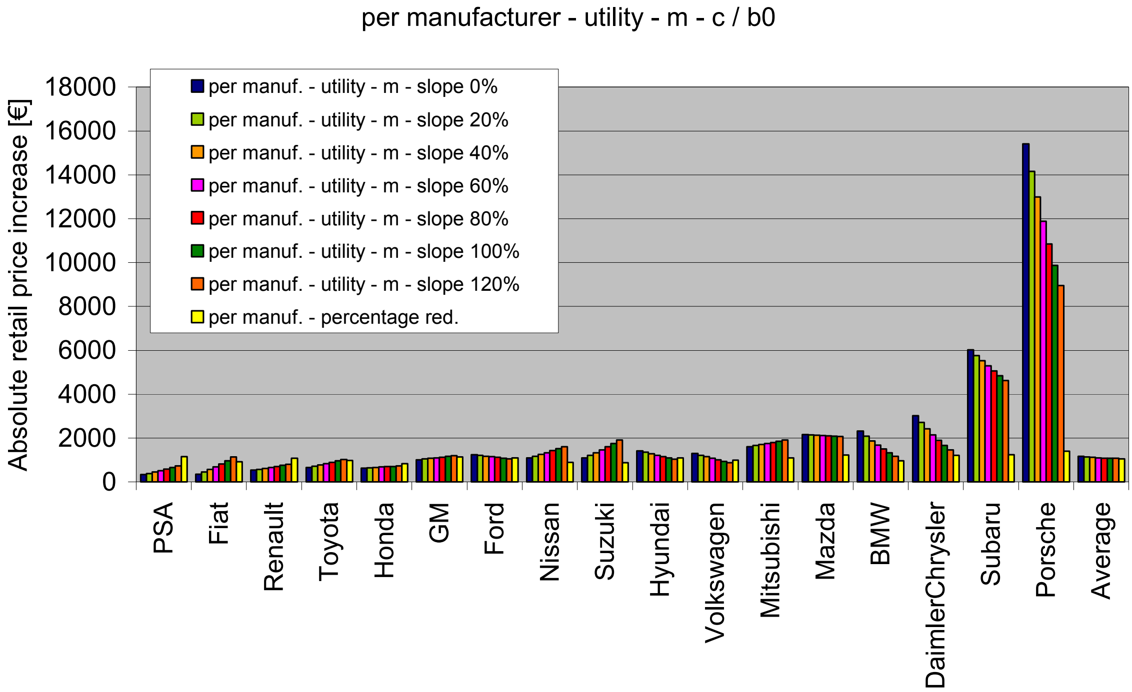


Figure 10 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b1 (AMI compensated).

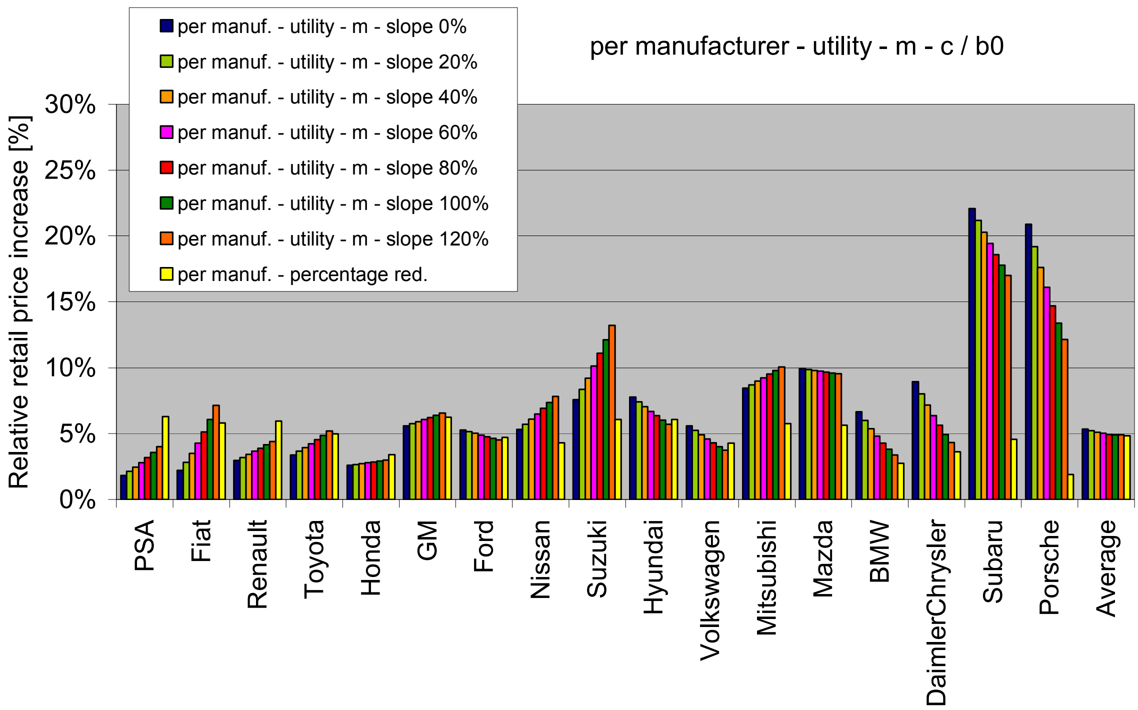
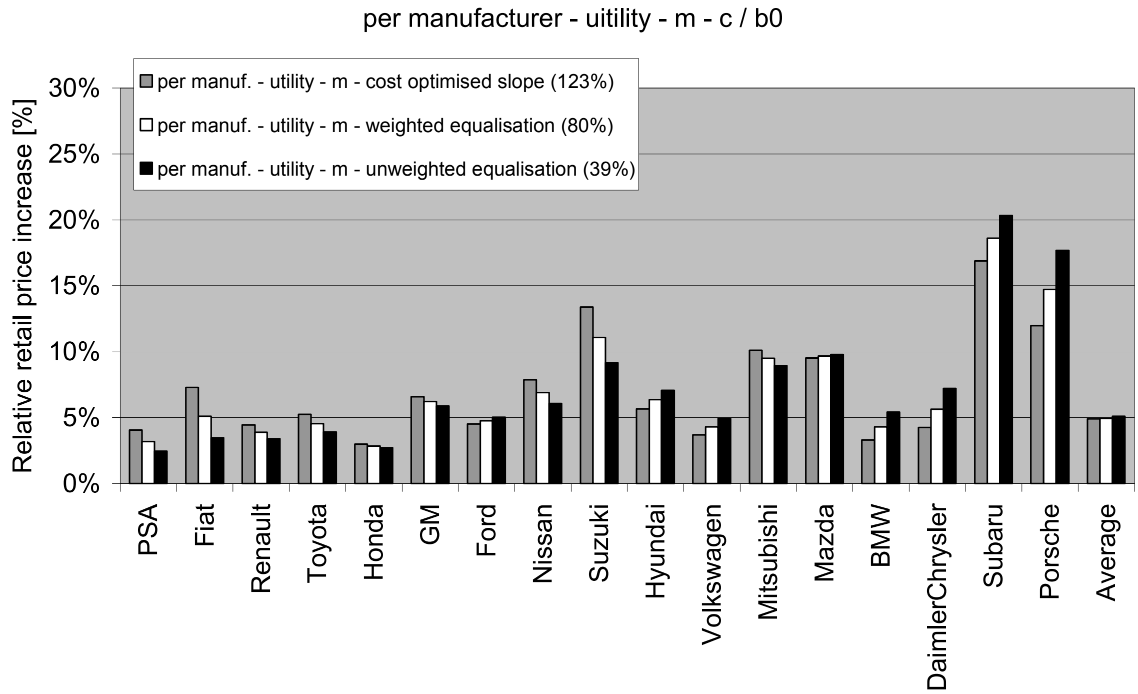


Figure 11 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b0=b1, for specific slope variants.



Note: Porsche and Subaru have been excluded from both equalisation approaches and therefore retail price increases are relatively high for these manufacturers.

Figure 12 Relative retail price increase per segment for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b0=b1.

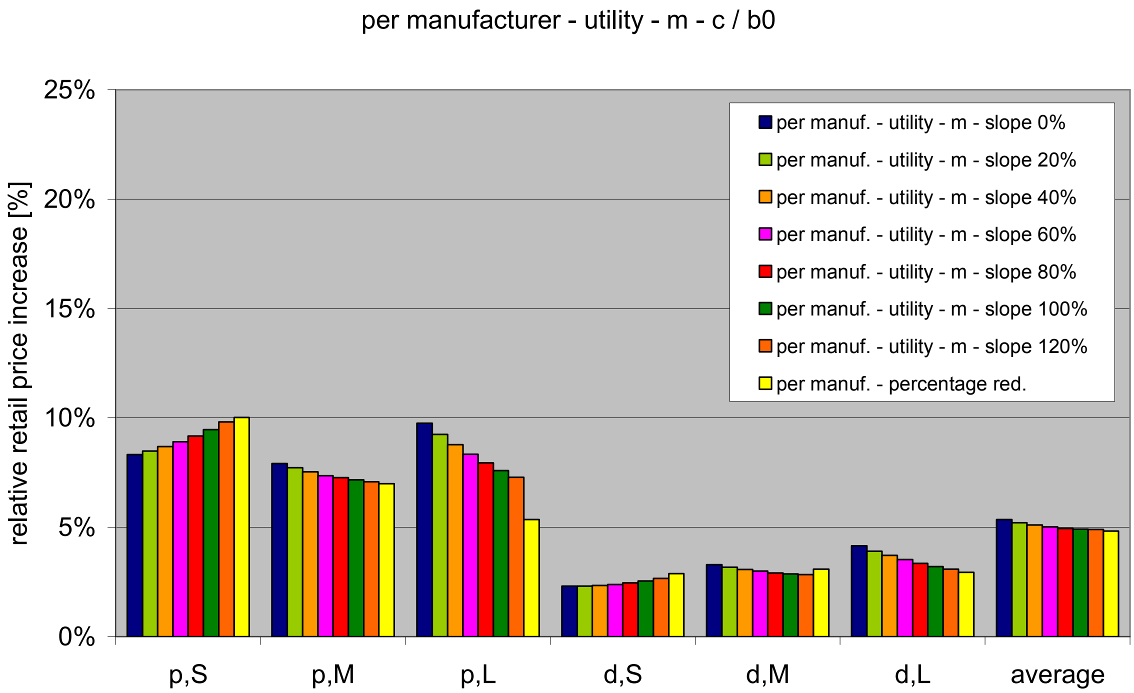


Figure 13 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b0=b1, slope = 40%.

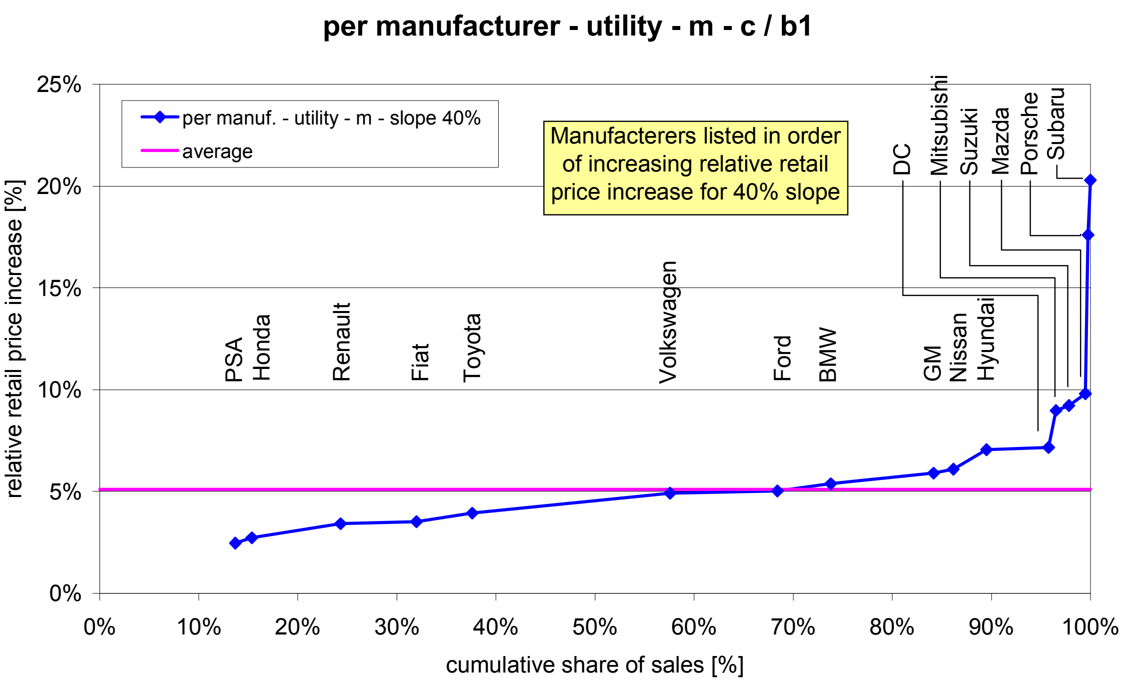
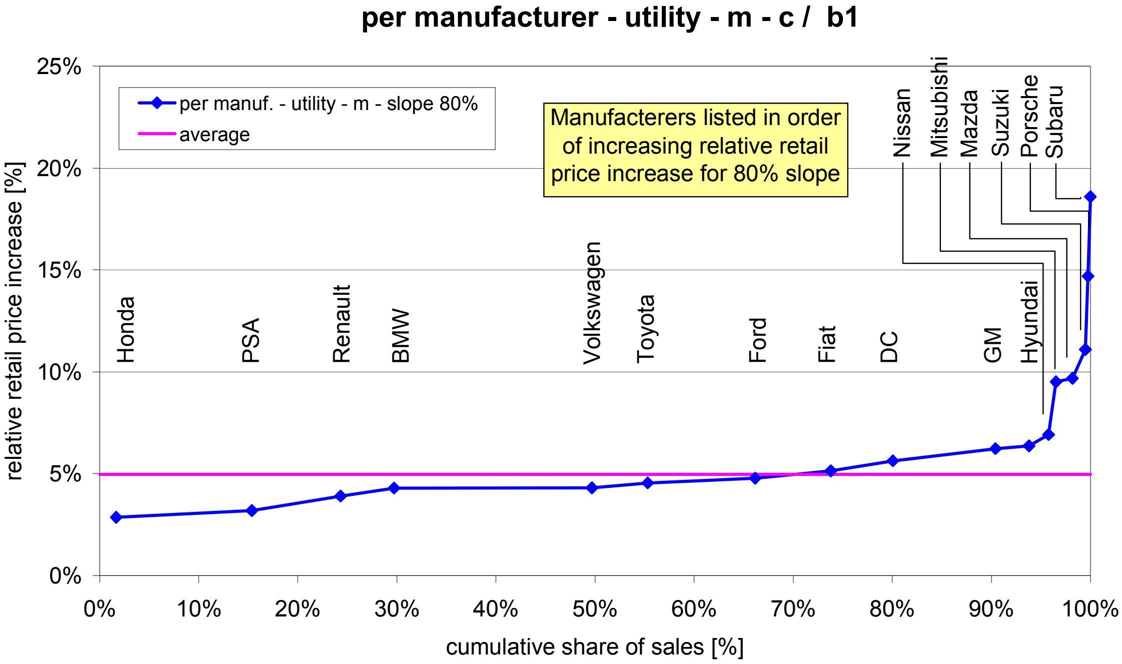


Figure 14 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = mass, scenario c (AMI = 0.0% p.a.) and baseline b0=b1, slope = 80%.



3.2.3 Conclusions regarding the case: mass-based limit function or percentage reduction applied per manufacturer for AMI scenarios a and c, and relative to baseline b1

Note: The choice of AMI scenario and baseline impacts on the calculated overall cost of the scheme, but other generalisations regarding distributional impacts, slopes of lines, etc also hold good for other mass-based limit function scenarios.

- For each manufacturer average costs per vehicle scale linearly with the slope of the limit function. For manufacturer with a sales-averaged mass below the overall average mass the costs increase with increasing slope while for manufacturers with above-average mass the costs decrease with increasing slope. Sensitivity to changing slope is very different for the different manufacturers depending on the difference between the average mass of the manufacturer and the overall average mass.
- Overall average costs are sensitive to the slope of the utility based limit function but the sensitivity is limited: the highest value (for uniform slope) is only 10% higher than the lowest value. For slopes between 80% and 120% the costs can be considered almost independent of the slope. Lowest costs are achieved for the 123% slope.
- Optimisation of the slope to yield the lowest average retail price increase per vehicle leads to a very high value for the slope (123%), resulting in relatively low costs for large vehicle and high relative price increases for small cars.

- Preferably the absolute and relative price increase should both increase with vehicle size and CO_2 emission. This is generally achieved for slopes of 100% and smaller although the relative price increase for small petrol vehicle remains higher than for medium petrol vehicles.
- The slopes determined by minimising the squared distance for all manufacturers to the average relative retail price increase value ("weighted equalisation" and "unweighted equalisation") still show a strong scatter in the absolute and relative retail price increase values per manufacturer. Apparently a linear utility based limit function can not be tailored to fully equalise the burden per manufacturer.
- The most equal distribution of absolute retail price increase over manufacturers is achieved by the percentage reduction option. As a consequence the relative costs strongly decrease with increasing car price, CO_2 value or utility, which is undesirable. Another undesired impact of the percentage reduction option is that it locks manufacturers into their present market positions, in the sense that they are discouraged from moving "up market". Conversely, the 'high end' manufacturers retain the option of moving "down market", so they gain a market advantage which appears unfair and contrary to the polluter pays principle.
- Especially when looking at the relative cost increase some manufacturers will be faced with a higher burden than other manufacturers with similar average CO_2 emissions. The most notable "anomalies" can to a large extent be explained based on information in the bubble graphs depicted in Technical Note 7 (Note on bubble graphs).
    - **Fiat**: For Fiat the high costs are caused by the high share of small vehicles in the sales, and by the fact that these vehicles have above average (i.e. compared to the sales weighted fit of CO_2 vs. utility) CO_2 emissions. The average Fiat is smaller and lighter than the average PSA vehicle, but average CO_2 emissions are somewhat higher. Effects are enhanced by the relatively low price of the vehicles from Fiat.
    - **Suzuki**: The absolute costs for Suzuki are very similar to those of Nissan but the relative costs are much higher and much more sensitive to the slope of the limit function. 2006 CO_2 values for Suzuki and Nissan are almost the same but the average mass and l x w are smaller for Suzuki leading to tighter CO_2 limits values and thus to higher costs than is the case for Nissan. A further important difference is the fact that the average retail price for Suzuki is about 25% lower than for Nissan.
    - **Mitsubishi**: The sensitivity of Mitsubishi is caused by a high share of heavy SUVs in the large diesel segment. The average costs and sensitivity are greatly reduced when internal averaging is allowed. Relative price increase is still relatively high however.
    - **Subaru**: Subaru only sells petrol vehicles and its models generally have larger engines and better performance than other vehicles with the same utility value. 2006 CO_2 emissions are thus relatively high and all reductions have to be made in the petrol segments. Average mass and pan area of Subaru vehicles are also high compared to the petrol sales of other manufacturers. This gives a higher CO_2 target, but as the average CO_2 emissions for Subaru are so far above average (i.e. compared to the sales weighted fit of CO_2 vs. utility), this does not help significantly to reduce the costs of meeting the 2012 target.
    - **Porsche**: Porsche only sells large petrol vehicles in 2006. For these sports vehicles and SUVs CO_2 emissions are well above average for the segment and

above average for their utility value. For 2012 it is assumed that the Cayenne will also be sold in a diesel version.

3.2.4 Limit function based on pan area (l x w) or % reduction applied per manufacturer for AMI = 0.82% p.a.

The absolute retail price increase per manufacturer resulting from applying a mass-based CO2 limit functions with different slope values or a percentage reduction at the level of manufacturers for the case of AMI = 0.82% p.a. is depicted in Figure 15. Dividing absolute retail price increase by the average base retail price per manufacturer yield the relative retail price increase as depicted in Figure 16 and Figure 17 (for specific slope values given in Table 3).

The distribution of relative retail price increases over market segments is presented in Figure 18. Alternative representations of the distributional impacts are presented in Figure 19 and Figure 20 for the slope values 40% and 80%.

Figure 15 Absolute retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated)

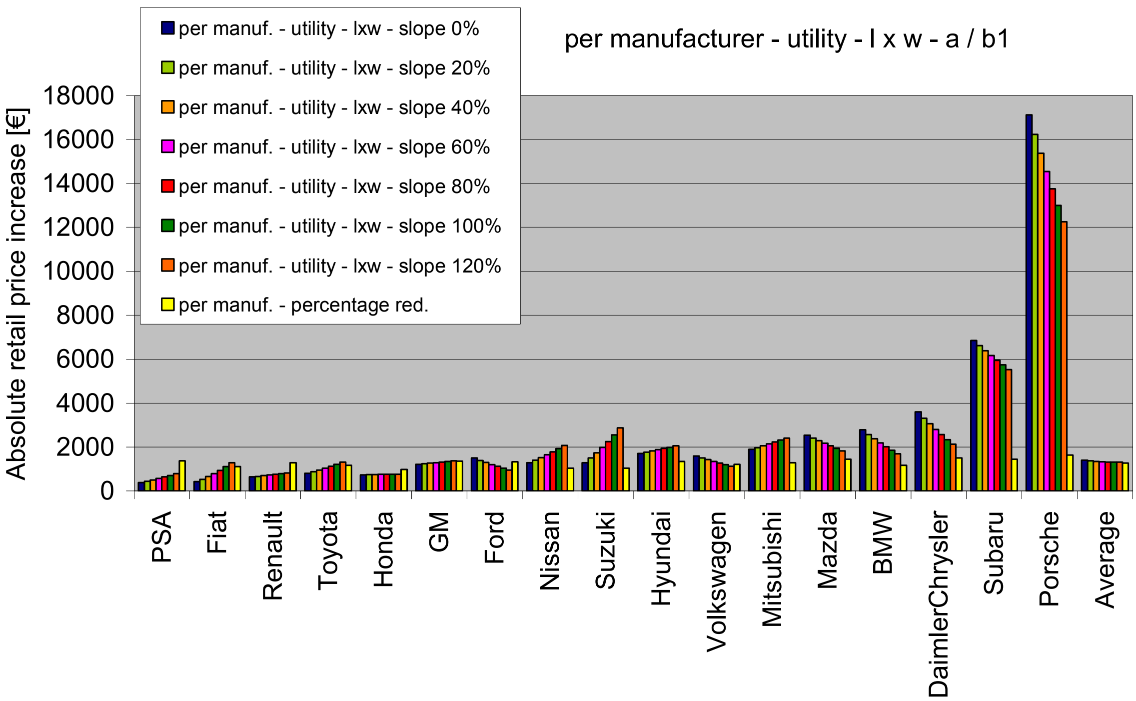


Figure 16 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated)

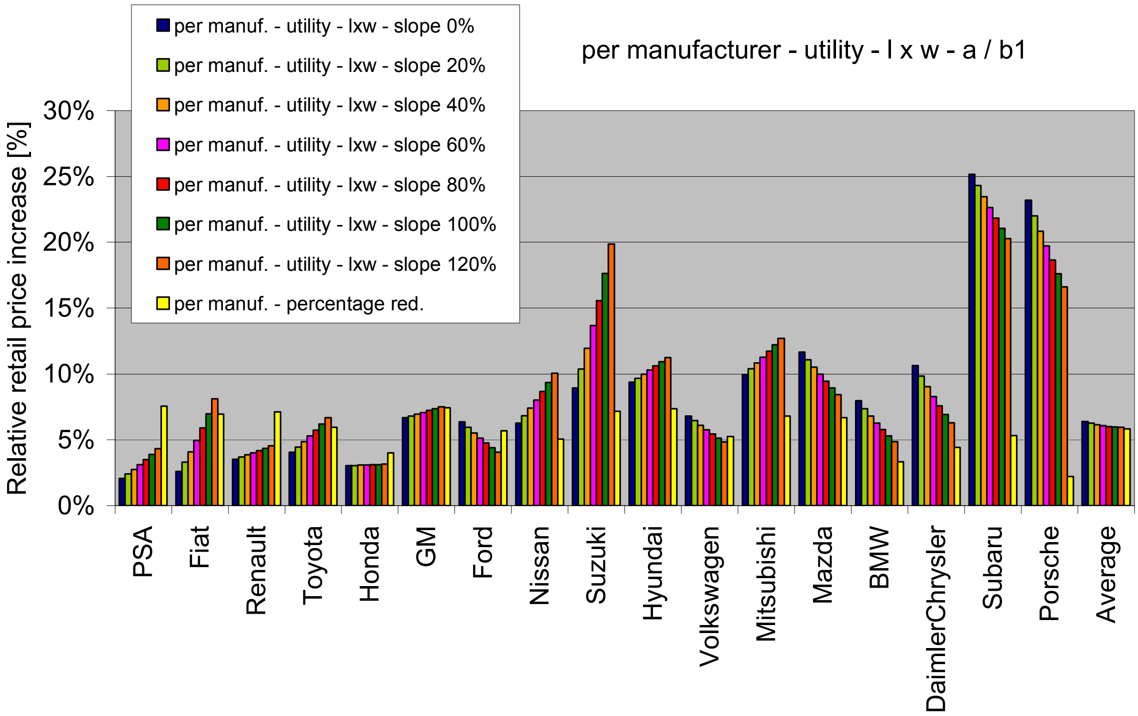
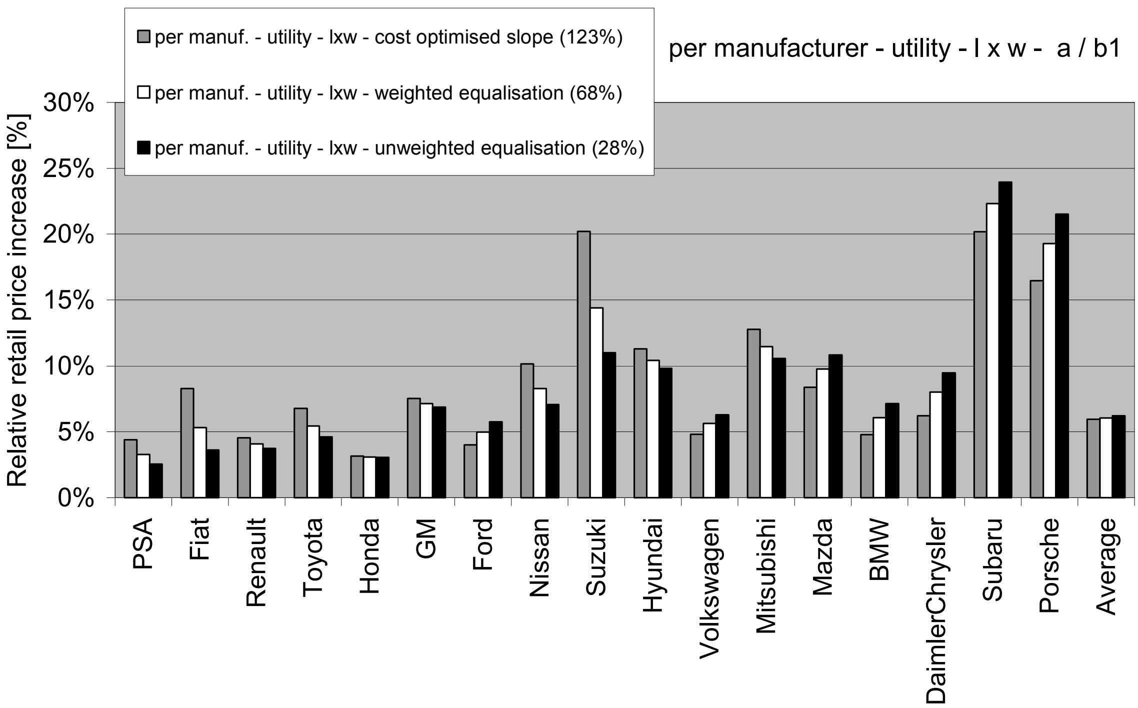


Figure 17 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), for specific slope values.



Note: Porsche and Subaru have been excluded from both equalisation approaches and therefore retail price increases are relatively high for these manufacturers.

Figure 18 Relative retail price increase per segment for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated)

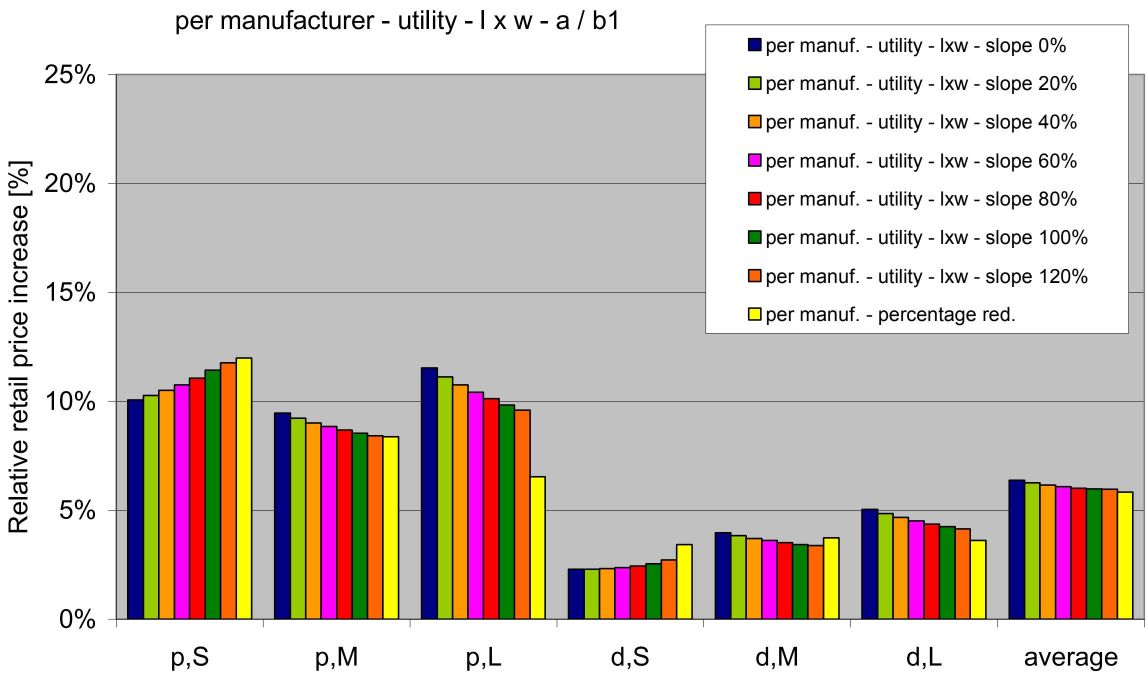


Figure 19 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), slope = 40%.

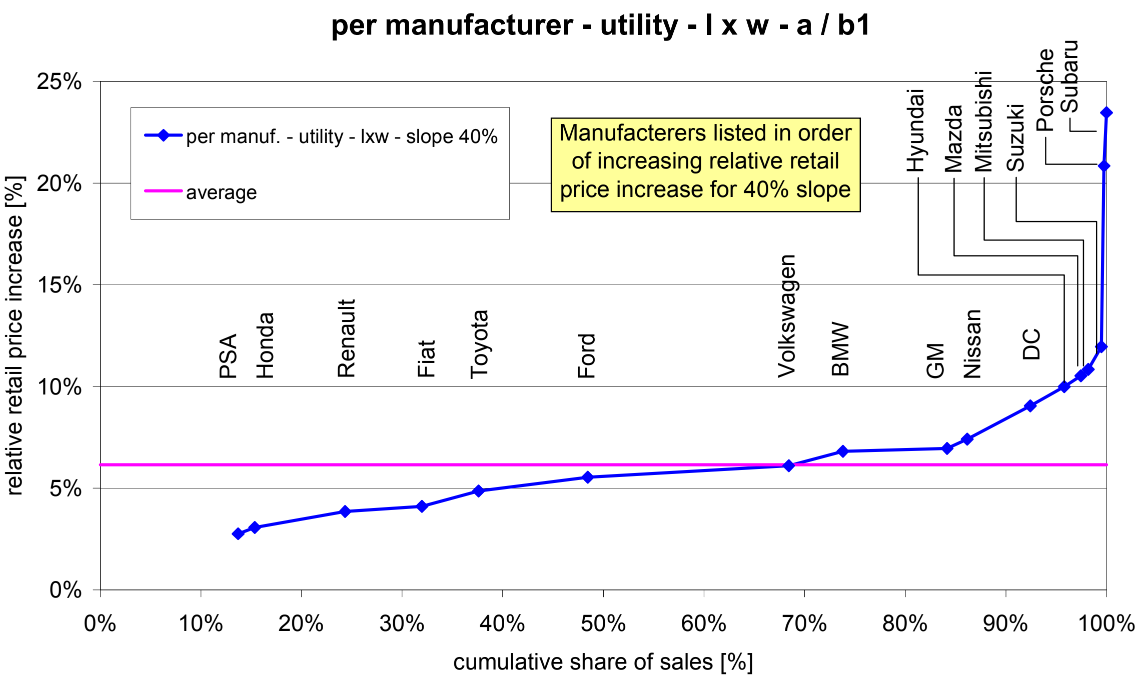
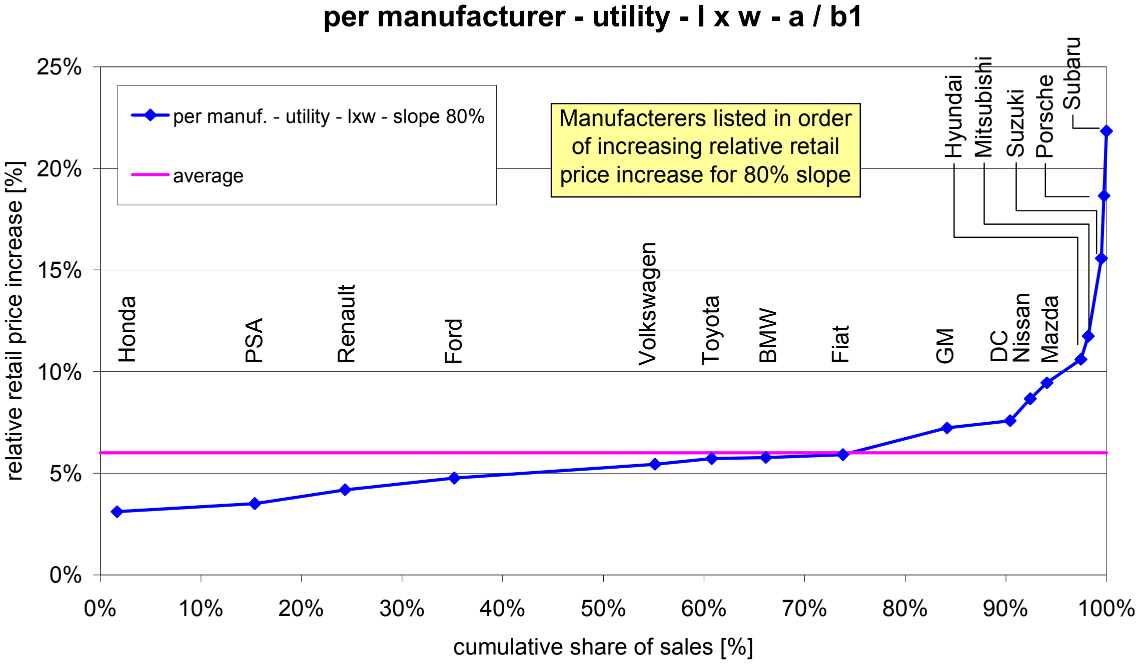


Figure 20 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario a (AMI = 0.82% p.a.) and baseline b1 (AMI compensated), slope = 80%.



3.2.5 Limit function based on pan area (l x w) or % reduction applied per manufacturer for AMI = 0.0% p.a.

In the absence of autonomous mass increase (AMI = 0.0% p.a.) the CO_2 emissions of vehicles do not change between 2006 and 2012. As a consequence no costs need to be made for maintaining emissions at the 2006 level in baseline **b1**. For this reason the results for scenario **c** are the same for the baselines **b0** and **b1**.

The absolute retail price increase per manufacturer resulting from applying a mass-based CO_2 limit functions with different slope values or a percentage reduction at the level of manufacturers for the case of AMI = 0.0% is depicted in Figure 21. Dividing absolute retail price increase by the average base retail price per manufacturer yield the relative retail price increase as depicted in Figure 22 and Figure 23 (for specific slope values given in Table 3). The distribution of relative retail price increases over market segments is presented in Figure 24.

Figure 21 Absolute retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario c (AMI = 0.0% p.a.) and baseline b0=b1

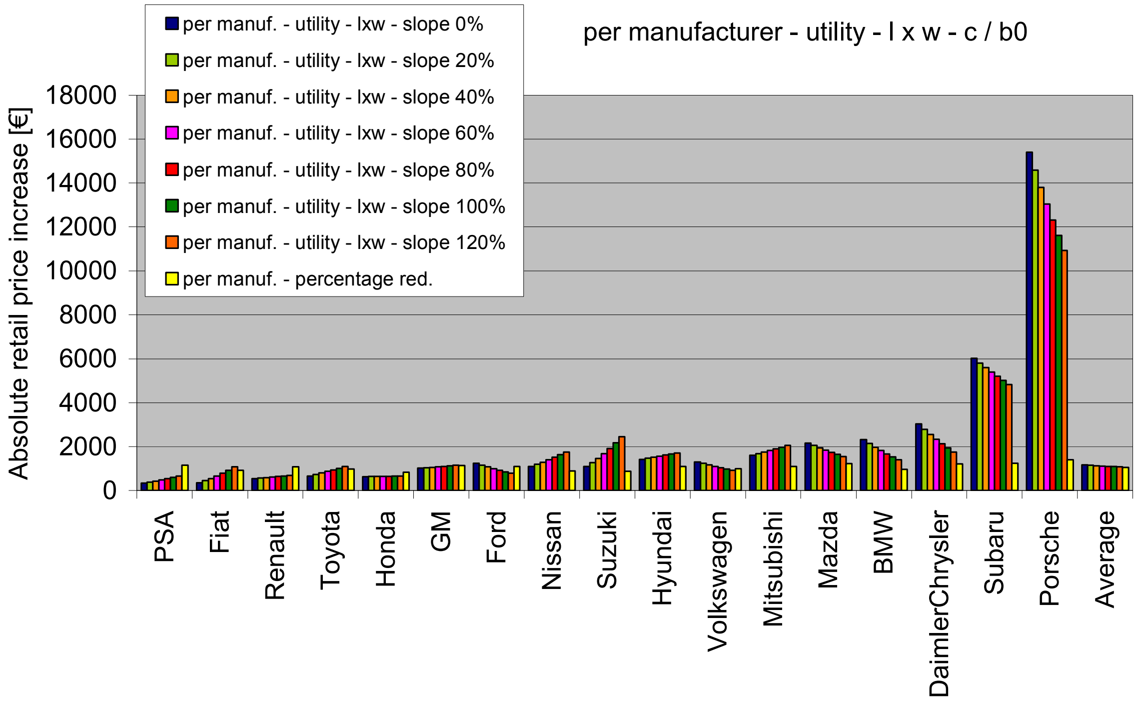


Figure 22 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario c (AMI = 0.0% p.a.) and baseline b0=b1

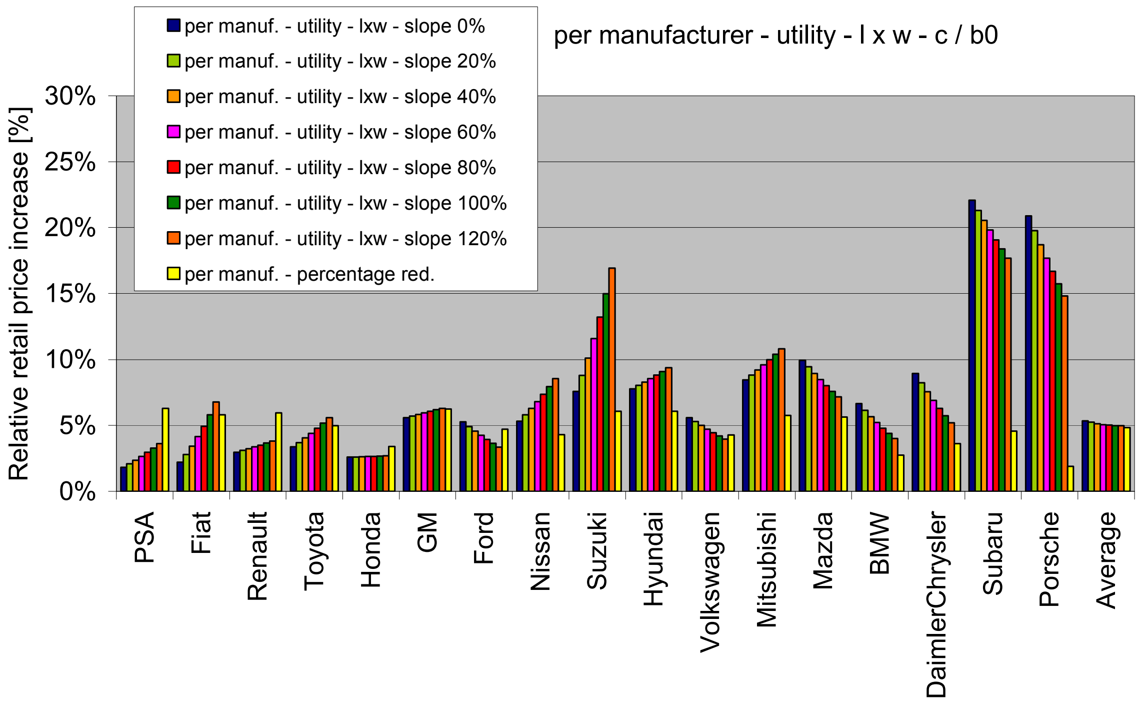
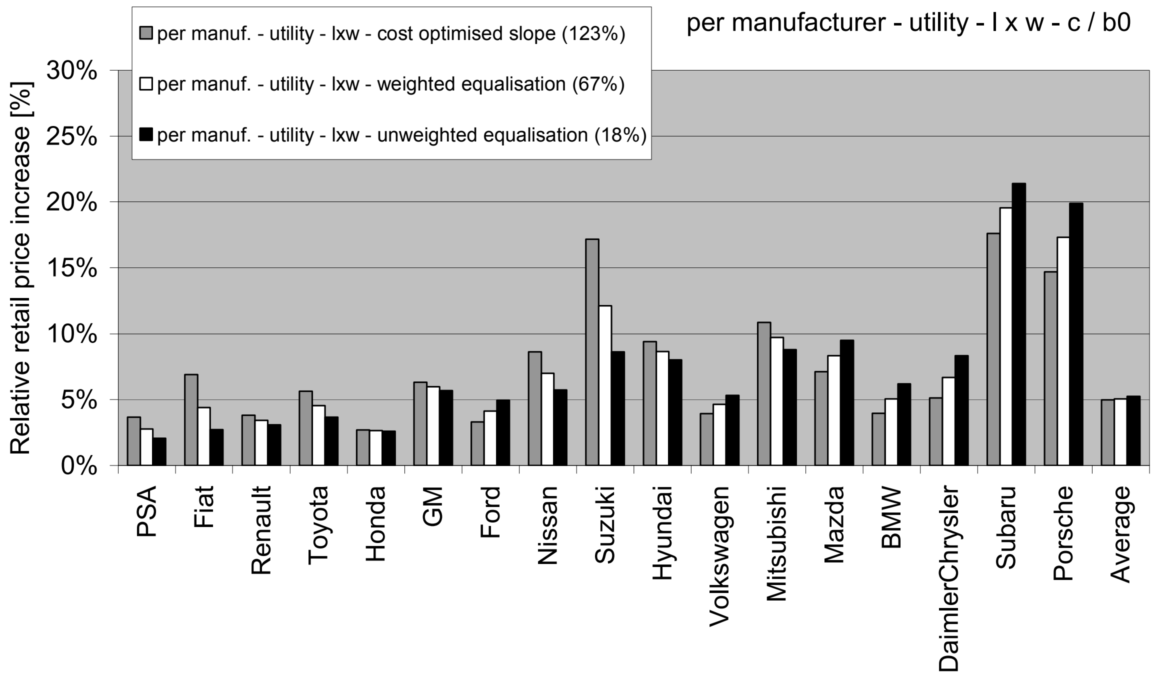
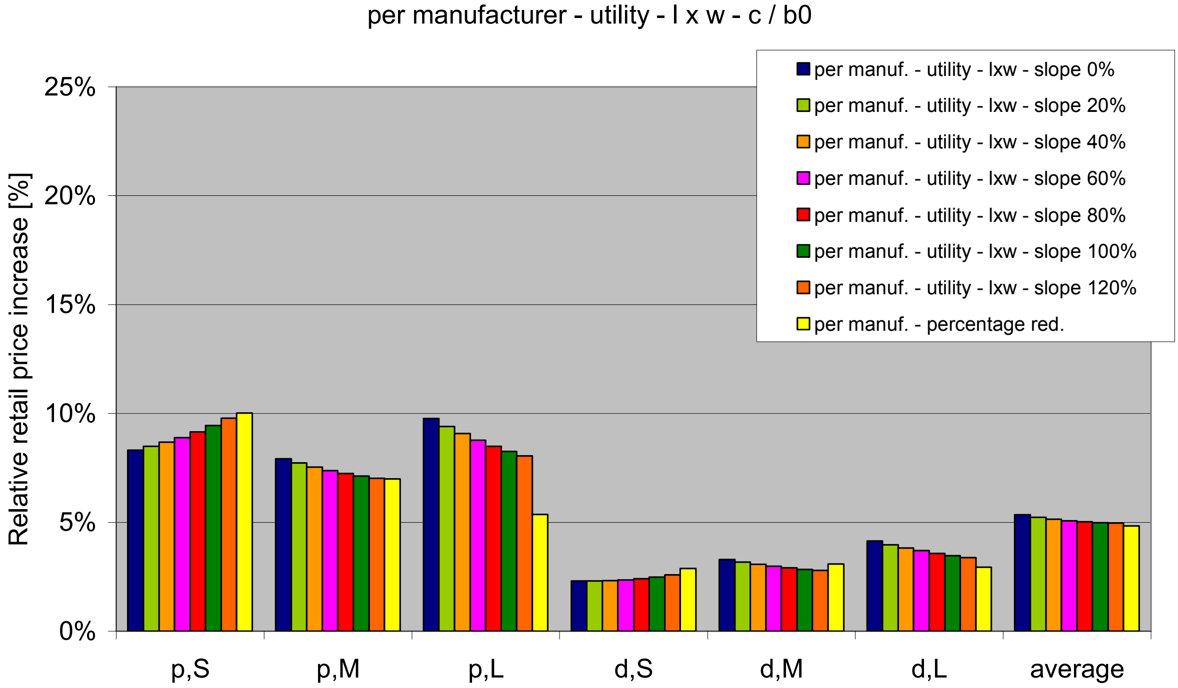


Figure 23 Relative retail price increase per manufacturer for utility based limits applied per manufacturer for U = pan area, scenario c (AMI = 0.0% p.a.) and baseline b0=b1, for specific slope values.



Note: Porsche and Subaru have been excluded from both equalisation approaches and therefore retail price increases are relatively high for these manufacturers.

Figure 24 Relative retail price increase per segment for utility based limits applied per manufacturer for U = pan area, scenario c (AMI = 0.0% p.a.) and baseline b0=b1



3.2.6 Conclusions regarding the case: pan area-based limit function or percentage reduction applied per manufacturer for AMI scenarios a and c, and relative to baseline b1

Note: The choice of AMI scenario and baseline impacts on the calculated overall cost of the scheme, but other generalisations regarding distributional impacts, slopes of lines, etc also hold good for other pan area-based limit function scenarios.

- The overall picture for limits functions based on l x w and applied per manufacturer is very similar to that of mass based utility functions applied per manufacturer.
- Again for each manufacturer average costs per vehicle scale linearly with the slope of the limit function. For manufacturer with a sales-averaged pan area below the overall average mass the costs increase with increasing slope while for manufacturers with above-average pan area the costs decrease with increasing slope. Sensitivity to changing slope is very different for the different manufacturers depending on the difference between the average pan area of the manufacturer and the overall average pan area.
- Optimisation of the slope to yield the lowest average retail price increase per vehicle leads to a very high value for the slope (123%), resulting in relatively low costs for large vehicle and high relative price increases for small cars.
- Also for l x w the slopes determined by minimising the squared distance for all manufacturers to the average relative retail price increase value (“weighted equalisation” and “unweighted equalisation”) still show a strong scatter in the absolute and relative retail price increase values per manufacturer. Apparently also a linear utility based limit function on the basis of pan area can not be tailored to equalise the burden per manufacturer.
- The sensitivity of **Suzuki** to increased slopes is significantly more enhanced when l x w is used as utility parameter.
    - This can be explained by the fact that for l x w Suzuki is further below the overall average than for mass (see bubble graphs in Technical Note 7 (Note on bubble graphs).
- For e.g. **Ford**, **Nissan**, and **Mazda** the sensitivity to the value of the slope is enhanced compared to the case of mass as utility parameter.
    - For l x w the average values for these manufacturers are further away from the overall average than for mass (see bubble graphs in Technical Note 7).
- For **Renault** and **Honda** the sensitivity to the slope is reduced compared to the case of mass as utility parameter.
    - For l x w the average values for these manufacturers are closer to the overall average than for mass (see bubble graphs in Technical Note 7).
- For **Hyundai** the sensitivity is completely reversed compared to the case of mass as utility parameter.
    - This is caused by the fact that the average pan area for Hyundai is below the overall average while for mass the average value for Hyundai is above the overall average (see bubble graphs in Technical Note 7).

3.3 Overall Conclusions on Quantitative Analysis

The conclusions presented below are derived from the complete set of assessments as presented in Technical Note 9 (on quantitative results).

3.3.1 Average costs vs. distributional effects

- The average additional retail price increase associated with meeting the 130 g/km target is not strongly variable according to the range of assumptions and detailed design parameters for the CO_2 legislation.
- The absolute retail price increase per car between 2006 and 2012 to be attributed to the CO_2 legislation is of the order of € 1050 to € 2400, depending on the level of assumed autonomous mass increase (0.0%, 0.82%, 1.5% or 2.5% p.a.) and baseline scenario. This is equivalent to a 5 to 11% relative retail price increase overall.
- Differences in distributional effects between the different options analysed are much larger than differences in impact on average cost per vehicle. In fact, the impact of different slopes of the utility based limit function on overall costs is always limited to several tens of percents. A 10% difference in absolute retail price increase corresponds to about 130 €/vehicle, which still equals 1.8 billion Euro p.a. for a total EU 15 sales of around 14 million p.a.. This is 0.6 to 0.8% of the total turnover (incl. taxes) of automobile sales in Europe. For the "per manufacturer" options the difference in costs for the 60% and the 100% slope are about 40 €/car, which equals 0.6 billion Euro p.a. for a total EU 15 sales of around 14 million p.a.. Accepting these additional costs as "relatively insignificant" allows optimisation with respect to other criteria than overall cost effectiveness.

3.3.2 Applying a uniform limit or utility-based limit function per vehicle

- Applying a CO_2 limit at the vehicle level leads to the most pronounced differences in additional (absolute and relative) retail price increases per manufacturer, especially for a uniform limit or low values of the slope of a utility-based limit function.
- To meet the 130 g/km average almost all models in the market in 2006 will have to undergo significant CO_2 reductions. A significant proportion of models will require larger reductions than available according to the cost curves. This not only includes sports cars and SUVs but also model variants of small and medium size "normal" vehicles. To avoid that these models have to be excluded a penalty would have to be introduced at the level of the marginal costs of the highest available level of CO_2 reduction. This has to be accompanied by a further tightening of the limit (function) to assure that the 130 g/km is met in 2012.
- Similar remarks apply to imposing a uniform limit value to each manufacturer. Even with internal averaging, the costs here would be very much higher for some manufacturers than others owing to the far greater effort required to meet the target. Such a system could only be considered in conjunction with a trading option, as this would reduce costs and disparities to some extent.
- A limit or limit function per vehicle is very inflexible as there is no possibility to compensate for less efficient cars by extra CO_2 reduction on other models. This leads to higher average costs than applying a limit function at the level of the sales averaged CO_2 emission per manufacturer (internal averaging).

3.3.3 Determination of the optimal slope of a utility-based limit function applied per manufacturer

General remarks

- Only linear utility-based limit functions, with mass and pan area as utility parameters, have been investigated. Different slopes of the linear limit function lead to different distributions of the burden of meeting the 130 g/km target over the different manufacturer groups.
- Analysis discussed further in Technical Note 9 on quantitative results proves that using a non-linear utility-based limit function will not improve the equalisation of the relative retail price increase over the manufacturers.
- It should be emphasized that the same percentage value of the slope has different distributional effects and average costs for different utility parameters (in this case mass and pan area). The choice of the slope is thus not entirely independent of the choice of utility parameter.
- The distribution of costs over manufacturers (distributional impact) is depending on the utility parameter for a given slope %, as is indicated by the different slope values for which maximum equalisation is realised for mass and pan area. The "evenness" distribution achieved by a 48% slope for a mass based limit in scenario **a** (AMI = 0.82% p.a.) is reached at a 28% slope for pan area in the same AMI scenario. Specific distributional effects for individual manufacturers will be different at the same level of "evenness" as manufacturers have significantly different ratios of sales averaged mass and pan area.
- Petrol vehicles in general show a larger retail price increase than diesel vehicles for the per manufacturer options. This is not due to the lower efficiency of petrol vehicles but to the differences in cost curves. Under cost optimisation per manufacturer all segments deliver CO_2 reductions up to the same marginal costs. For petrol vehicles a given level of marginal costs represents a higher reduction and higher associated costs than for an equivalent diesel vehicle.

Impact of slope in relation to various assessment criteria

For the case of mass or pan area (l x w) as utility parameter and a utility-based limit function applied to the sales averaged CO_2 emissions per manufacturer (without trading) the following conclusions can be drawn regarding the optimal slope of the limit function in relation to various assessment criteria:

Overall cost effectiveness:

- For both utility parameters the lowest average retail price increase per car is reached for a slope of 123%. Average costs increase with decreasing slope.

Disincentives for perverse effects and unwanted market trends:

- In the case of mass as utility parameter, for slopes above 80% mass increase (accompanied by adjustment of installed power to maintain performance) brings a vehicle closer to the 2012 target (as the target increases faster with mass than the vehicle's CO_2 emissions), as is explained in Technical Note 8 (Note on definition of limit functions). To avoid stimulation of perverse effects or market trends which cause the 2012 average CO_2 emissions to increase above 130 g/km the slope of a mass-based limit function should thus be considerably below 80%.
- For a slope of around 80% a mass-based limit function excludes weight reduction as a technical option for meeting the target set per manufacturer. The CO_2

reduction resulting from weight reduction is about the same as the tightening of the limit that is associated with weight reduction under an 80% slope. Ideally the slope should be kept significantly below the 80% threshold in order to maintain an incentive to use weight-reduction measures to reduce CO_2.

- Obviously weight reduction always leads to net CO_2 reduction and as such helps to meet the overall 130 g/km target.

Impacts on consumers:

- For petrol vehicles there is no slope that meets the criterion that the relative retail price increase should not be lower for larger vehicles than for small vehicles. For a 0% slope the relative retail price increase for small vehicles is about the same as that for large vehicles, but still larger than that for medium-sized vehicles. For diesel vehicles this condition is met for all slopes between 0% and 120%, with cost increasing more pronounced with vehicle size class for the lower slope values.
- The lifetime fuel cost savings at the consumer level (i.e. incl. taxes) is around € 2240, which is higher than the vehicle retail price increase for all scenarios except the one assuming an autonomous mass increase of 2.5% p.a.. As a consequence the 130 g/km legislation is largely cost effective at the consumer level, even with full pass-through of costs.

Distribution of the burden over various manufacturers:

- Excluding Porsche and Subaru (which are characterised by selling only petrol vehicles with above average CO_2 emissions) from the analysis, the most even distribution of relative retail price increase per car is achieved for slopes between about 50% and 80% for mass as utility parameter and between about 30% and 70% for pan area as utility parameter. Nevertheless the scatter of relative retail price increase per manufacturer is ± 4% around the average value of about 6%.
- Higher slopes than those for which equalisation of relative retail price increase per car is achieved lead to decreasing relative retail price increase per car with increasing average utility (mass or pan area). For lower slopes the relative retail price increase per car will generally increase with increasing average utility, and so from this perspective the lower slopes appear more equitable.
- A linear utility based limit function can not be tailored to fully equalise the burden per manufacturer in terms of relative retail price increase.
- Scatter plots of relative retail price increase per manufacturer against average mass for the “weighted equalisation” and “unweighted equalisation” slopes do not show any linear or non-linear correlation in the residue (i.e. remaining difference between relative retail price increase per manufacturer and the average relative retail price increase). This proves that using a non-linear utility-based limit function will not improve the equalisation of the relative retail price increase over the manufacturers.
- In general it can be concluded that a linear limit function leads to higher costs for manufacturers producing vehicles that are less efficient than the average for a given utility value.
- For both mass and pan area and for both the 40% and the 80% slope it can be concluded that for 80% or more of the vehicles sold in Europe the average relative retail price increase per manufacturer is below or around the average value. It can not be concluded from this that the relative retail price increase is below or around

the average for 80% of all vehicle models sold in Europe, however. This 80% market share includes all European "mainstream" manufacturers (PSA, Renault, Fiat, Ford, Volkswagen and GM), as well as Japanese manufacturers Toyota and Honda. Whether BMW and DaimlerChrysler are within the bandwidth of "below or around the average" relative retail price increase strongly depends on the utility parameter and the slope.

- For Porsche the relative retail price increase is a factor of 2 to 3 times the average depending on slope and utility parameter. A separate assessment presented in Technical Note 10 on pooling of Volkswagen and Porsche shows that these severe impacts for Porsche can be resolved by pooling the CO_2 target for VW and Porsche. The costs per vehicle of meeting a combined target are only marginally higher than the costs per car for VW alone. The option of pooling is also possible for Toyota and Subaru. However, due to the smaller ratio of sales numbers the effect on the retail price increase per car for Toyota + Subaru is expected to be markedly higher.
- For Japanese manufacturers other than Toyota and Honda and for the Korean manufacturer Hyundai the relative retail price increase tends to be significantly above average. For Hyundai this is more so for pan area as utility parameter than for mass.
- For the utility parameter and slope value that are chosen in the end as basis for the CO_2 legislation, there will always be several manufacturers that are faced with costs per car that are markedly higher or lower than the average costs per car, independent of the utility parameter and slope value that are chosen. Depending on the option chosen, consideration must be given to whether it is fair or for other reasons acceptable that these manufacturers face higher or lower costs than average. In principle higher (or lower) costs than average are fair if a manufacturer produces vehicles that are less (or more) efficient than comparable models from other manufacturers. The difference in efficiency may be partly related to differences in mass. It can also be considered fair that the absolute and relative retail price increase is higher for manufacturers of sports vehicles, other high performance vehicles or luxury vehicles. This is consistent with the "polluter pays" principle.
- Specific attention should be paid to manufacturers for which high costs are caused by either a high share of large SUVs (with high mass, relatively low pan area, and relatively high CO_2 emissions) in the sales or a high share of van-based vehicles that fall in the M_1 category. Large SUVs are not all "Chelsea tractors" (e.g. BMW X5, Range Rover Freelander) but also include 4x4 off-road vehicles which are often used professionally e.g. in forestry (e.g. Toyota Land Cruiser and Land Rover). These SUVs and van-based vehicles serve practical functions which are clearly not correctly covered by mass or pan area as utility parameter. An example of this is Mitsubishi which sells SUVs in the large diesel segment with very high mass and CO_2 emissions.
- For those cases where it is difficult to fully justify the fairness of the impact of a given manufacturer (i.e. where meeting other evaluation criteria leads to a relatively unfair situation for a few manufacturers) one could consider the option of fines as a safety valve or explore whether there is an easy way for this manufacturer to avoid the specific unfair impacts. For example, Subaru and Porsche can reduce the impact of the CO_2 legislation by either offering diesel versions of the available models, or by "teaming up" with another manufacturer for the manufacturer average. Porsche could e.g. share the target with the

Volkswagen group with which it already has close connections, and Subaru could team up with Toyota, which has already a 30% stake in Subaru.

3.3.4 Impact of trading on costs and distributional effects

- Adding trading to the "per manufacturer" options leads to a more even distribution of relative retail price increase. When trading is allowed the change of costs per manufacturer as a function of the slope of the limit function, are somewhat less then without trading.
- Slopes below 100% lead to negative costs for small diesel vehicles. This is caused by the fact that manufacturers can earn money by reducing these vehicles beyond the target for this segment and to sell the additional reduction as CO_2 emission credits.
- With trading, the desired situation of costs increasing with vehicle size is achieved for slopes of 60% and lower. For 80% slope the costs per vehicle are about equal for the three petrol segments, but increase as function of size for the diesel segments.
- Traded amounts of CO_2 credits (in g/km) are relatively small (1 - 3%) compared to the total reduction (reduction per car multiplied by total sales), but the monetary value of the traded volumes is a significant share (10 – 20%) of the total costs of reaching the 130 g/km target. Traded volumes are significant enough to justify the set-up of a trading system in principle. The impact of trading on average or total costs is less than 10%. Impacts on costs per manufacturer seem of the same order of magnitude but need to be further analysed.
- The main benefit of a system with trading is that it reduces excessive burdens for a limited number of "specialised" manufacturers with sales distributions or model portfolios that strongly deviate from the average.

3.3.5 Applying a percentage reduction target per manufacturer

- With a percentage reduction target the goal of 130 g/km is met at lower average costs per car than for a utility-based limit function.
- A percentage reduction target leads to a seemingly even distribution of the relative retail price increase per car over all manufacturers. The distribution, however, should be considered unfair as the relative retail price increase per car is higher for manufacturers of small / light / low CO_2 emitting cars than for manufacturers of large / heavy / high CO_2 emitting cars.
- An important drawback of the percentage reduction option is that it locks the manufacturers of small / efficient vehicles in their present market position, while manufacturers of large / inefficient vehicles can meet their target by increasing their market share in the small and medium size vehicle segments.
- A percentage reduction target leads to higher costs for early movers as they have to climb further on the cost curve to meet the target, and this can be argued to be unfair.

3.3.6 Conclusions w.r.t. other criteria

- In practice, it is difficult to assess to what extent a specific measure or slope value treats early movers appropriately. This is mainly caused by the fact that it is difficult to point out which manufacturers are early movers. Overall, however, the condition seems to be generally met that manufacturers of relatively inefficient vehicles (based on CO_2 emissions per unit utility) are faced with above average costs for meeting the 130 g/km.

- It should be noted here, however, that it is dangerous to label high CO_2 in general or per unit utility as "inefficient". Differences in average CO_2 emissions between manufacturers for a given size segment may be caused by differences in efficiency of comparable vehicle models offered by these manufacturers, but also to differences in the product portfolio within a size segment. This is especially the case for manufacturers which sell substantial amounts of sports vehicles (low mass per unit pan area) or SUVs (high mass per unit pan area).

3.3.7 Conclusions with regards to choice of utility parameter

- Mass and pan area have been assessed as candidate utility parameters. In the absence of data on footprint (wheelbase x track width) results on pan area can also be seen as a proxy for the impact of using footprint.
- From the cost assessment presented in Note 9 the overall costs per vehicle appear slightly higher when pan area is used as utility parameter. For the options per manufacturer and intermediate slope values the difference is of the order of 1% or less. This is certainly below the level of accuracy of the cost assessment methodology used here. Furthermore it should be emphasized that for the assessment of limit functions based on mass and pan area the same cost curves have been used, although using mass a as utility parameter is known to decrease the cost effectiveness of weight reduction as a CO_2 reduction option and may thus increase the costs of meeting the target. Overall it should thus be concluded that the small difference in the assessed average costs for meeting the 2012 target between mass-based limit functions and limit functions based on pan area should be considered **not significant**.
- Overall distributional effects are very similar for mass and pan area. For a limited number of manufacturers, however, the burden strongly depends on the choice of utility parameter, depending on their average utility value for both parameters compared to the overall EU sales average.
- Mass as utility parameter reduces the contribution of weight reduction as a technical measure to reach emission reduction targets at the vehicle or manufacturer level and may also limit the number of possible packages of measures by which manufacturers can realise the required CO_2 emission reduction. In effect it fails to fully reward CO_2 reduction packages that include weight reduction.
- Mass as utility parameter has the risk of promoting perverse effects and stimulating market trends towards heavier cars. However, for slopes below 80% mass increase (accompanied by measures applied to the powertrain to maintain performance) does not help manufacturers to reach their target (which increases with increasing vehicle mass) more easily. Mass increase without performance adjustment, however, will still bring vehicles closer to the target line for slopes of 50% and more.
- For both mass and pan area market trends towards heavier and or larger cars respectively will lead to not meeting the target of 130 g/km in 2012, if this trend exceeds the amount of assumed autonomous trend which is factored into the setting of the limit function for 2012.

- Pan area accentuates the impact of the CO_2 legislation on certain vehicle classes, especially for SUVs which have relatively high mass and relatively low pan area.

3.3.8 Impact on costs and distributional effects of different assumptions on autonomous mass increase

- Different assumptions on autonomous mass increase have negligible impact on the distributional effects of a given measure, or on the relative cost different variants eg the slope of the curve. The impact of autonomous mass increase on the average costs per car, however, is significant. Absolute retail price increases for the different measures and combinations of AMI scenarios and baselines vary between € 1100 for AMI = 0.0% p.a. to € 1900 and € 2400 respectively (depending on baseline) for the case of AMI = 2.5% p.a.. Impacts are roughly the same for mass and pan area as utility parameters.

3.3.9 Impact on costs and distributional effects of different assumptions on the baseline for 2006-2012 without CO_2 emission legislation

- Different assumptions on autonomous development of CO_2 emissions at the vehicle level have negligible impact on the distributional effects of a given measure, or on the relative cost different variants eg the slope of the curve. The impact of assumptions on autonomous development of CO_2 emissions at the vehicle level between 2006 and 2012 on the average costs per car for meeting the 130 g/km target in 2012, however, is significant. When costs are compared to baseline **b0**, the costs for meeting 130 g/km in scenario **b** with 1.5% p.a. autonomous mass increase are about € 250 higher than in the case when costs are calculated relative to baseline **b1**. For scenario **c** with 0.0% p.a. autonomous mass increase the baselines **b0** and **b1** are identical so that costs compared to both scenarios are the same. Impacts are the same for mass and pan area as utility parameters.

3.3.10 Overall conclusions based on quantitative assessments

- Application of single limit values at either vehicle or manufacturer levels would incur very high costs, and the latter might be considered only in conjunction with trading.
- Application of a limit or target at vehicle level also appears costly as it is inflexible.
- From the quantitative assessments application of a utility-based limit function to the sales weighted average CO_2 emissions per manufacturer emerges as the most favourable option for implementation of the CO_2 legislation for passenger cars. Distributional impacts, i.e. the evenness and fairness of how the burden is distributed over various manufacturers, can be optimised by choosing an appropriate value of the slope of the limit function.
- Allowing trading among manufacturers in combination with targets set at the manufacturer level does further improve distributional impacts and slightly reduces the average costs per vehicle for meeting the target.
- For mass as utility parameter a slope of 40 to 60% seems optimal as it largely avoids incentives for perverse effects or market trends towards higher mass and leads to a relative retail price increase that on average increases with the average

mass per manufacturer, and at least for diesel vehicles also increases with size segment.

- For pan area as utility parameter a slope of 30 to 40% seems optimal as it leads to a relative retail price increase that on average stays equal or increases with the average pan area per manufacturer, and at least for diesel vehicles also increases with size segment.

4 OTHER IMPACTS OF THE MEASURE

4.1 Introduction

Assessment criteria have to follow the Impact Assessment Guidelines (SEC(2005) 791). These, however, do not give very practical criteria for comparing details of various implementation options in specific cases such as the 130 g/km measure. For a number of the major criteria, however, our work to date and/or proposed methodology have already translated these into a more operational form.

In addition, it was agreed at the KoM that we would need to give close attention to the political statement of intent set out in Section 3.2 of the Communication (COM(2007) 19 final). That is, the proposed solution must be

- competitively neutral,
- socially equitable,
- equitable to the diversity of manufacturers,
- and should avoid unjustified distortion of competition between manufacturers

In essence these aspects are however covered by the criteria mentioned in the Impact Assessment Guidelines. Most of the key criteria are in fact driven by the cost and distributional analysis as summarised in the previous section. In the sections below criteria are listed as derived from the IA Guidelines and comments on the relevance of all IA aspects is given.

Important for how a certain criterion is to be assessed is the distinction of whether a certain aspect/impact is influenced by:
- the 130 g/km measure as a whole, regardless of the specific implementation, or
- the details of the implementation of the 130 g/km measure.

In terms of impacts on business clearly the second of these is the case; however for many of the other criteria the impacts should be regarded as largely generic.

4.2 Economic Impacts

4.2.1 Competitiveness, trade and investment flows

- Does the option have an impact on competitive position of EU firms in comparison with their non-EU-rivals?
    - Effects on competitiveness on EU-market can be assessed through winners-losers analysis, by grouping manufacturers based on association. Refer to Technical Note 8 for details. Technical Note 13 argues that high standards should improve the competitiveness of the European manufacturers within their home market and drive innovation that will also be of benefit elsewhere.
    - All manufacturers have to meet the same regulation and are thus treated equally, but the impact on individual manufacturers will depend on the way in which the 130 g/km measure is implemented, especially how it affects vehicles in different market segments. Technical Note 12 gives details on this point.

  - Effects on competitiveness on markets outside EU can not be assessed quantitatively. Qualitative considerations can be given based on e.g. analysis of CO_2 policy measures in other countries, and these are discussed in Technical Note 13.
- Does it provoke cross border investment flows (including relocation of economic activity)?
  - This can not be analysed in a quantitative way but qualitative considerations are given Technical Note 13. The extra costs might lead to further relocation of some manufacturing plant. Much of this appears likely to be to the newer Member States.
  - Investments from EU-firms in e.g. production facilities outside the EU will result from the need to reduce production costs. This need might be enhanced by the 130 g/km measure. The need for cost reduction could be higher if the details of the 130 g/km measure impose higher additional costs on the small vehicle segment. This is addressed in Technical Note 8. Technical Note 13 however suggests that the degree to which extra demands are supplied by imports may be limited, with stronger knock-on effects through the value chain within the EU (ie the requirement for more sophisticated equipment will in turn demand extra value added from the suppliers of parts and equipment and increase their turnover).
- Are the proposed actions necessary to correct undesirable outcomes of market processes in European markets?
  - This question does not seem relevant. Too much CO_2 can possibly be viewed as an undesirable outcome of market processes, but that is a general motivation for the CO_2-legislation, not for a specific implementation.

4.2.2 Competition in the internal market

- Will the policy lead to a reduction in consumer choice, higher prices due to less competition, the creation of barriers for new suppliers and service providers, the facilitation of anti-competitive behaviour or emergence of monopolies, market segmentation, etc.??
  - 130 g/km measure may lead to some reduction in consumer choice by raising the price of high-emitting models significantly, but if so this effect can be considered wanted – ie a reduction in demand for certain variants with highest CO_2 emissions in the market. Nonetheless the quantitative analysis is designed to minimise this by paying close attention to cost distribution. The model analysis is also based on the assumption that technology costs are incurred in order to achieve compliance with the proposed measure.
  - Given the large number of manufacturers, it is not likely that the 130 g/km measure will lead to higher prices due to less competition.
  - The 130 g/km measure may make it somewhat more difficult for e.g. Chinese, Malaysian, etc. car manufacturers to enter the EU market, but will not directly discriminate against them. This is reflected in Technical Note 13.
  - The 130 g/km measure should be designed in such a way that new market players can be incorporated. This was one of the criteria for shortlisting.
  - The 130 g/km will stimulate competition between manufacturers on fuel economy. This may lead to changes in market shares, but this is to be considered a wanted effect.

4.2.3 Operating costs and conduct of business

- Will the option impose additional adjustment, compliance or transaction costs for businesses?
  - o Additional manufacturing costs (= compliance costs) are calculated with the cost assessment model. Results are set out above and in full in Technical Note 8. In cost estimates underlying the cost curves it is assumed that the costs of R&D are included in the additional component costs.
  - o There will be additional compliance costs depending on the system finally chosen. These should be assessed at that time.
- Does the option affect the cost or availability of raw materials, machinery, labour, etc…?
  - o Most technologies for reaching 130 g/km do not require scarce materials. Batteries for hybrids may be the exception. These, however, will use similar materials as batteries for portable electronic applications so the question is whether additional demand for vehicles will or will not significantly affect overall demand and prices.
- Does it affect access to finance?
  - o No. In fact, there are signs that reduced exposure to oil scarcity and climate change issues may in future improve a company's position in the financial markets.
- Does it impact on the investment cycle?
  - o Possibly. Manufacturers have 4 years to meet the goal which is about or somewhat shorter than the typical lead time for developing a new model. However the more flexible options do not require strict compliance by all models – internal averaging is usually allowed which would allow some models to be updated later. Also car models typically undergo a more limited 'makeover' half way through their product cycle, and this could be an opportunity for some limited reductions, for example by modifying some specific elements of the drivetrain or reducing the weight of some components. There might however be some acceleration required in the investment cycle.
- Will it entail the withdrawal of certain products form the market? Is the marketing of products limited or prohibited?
  - o This is a very relevant aspect which is strongly determined by the way in which the 130 g/km measure is implemented, as indicated in Technical Note 8.
- Will it entail stricter regulation of the conduct of a particular business? Will it directly lead to the closing down of businesses?
  - o The 130 g/km measure is solely aimed at the automotive industry and will effect the way this industry does business. It will e.g. affect their marketing strategies.
  - o The 130 g/km will not directly lead to closing down of businesses – such options would receive a strongly adverse score in the assessment. But it will increase competition wrt fuel economy and this competition may in the end have winners and losers.
- Are some products or businesses treated differently from others in a comparable situation?
  - o Some car manufacturers will be more affected than other car manufacturers as a result of their market position, product portfolio and technology position. This is shown in detail in Technical Note 8.

- The question here is what is meant by “comparable situation”. All manufacturers compete on the same market but are in different situations depending on their market position, product portfolio and technology position.

4.2.4 Administrative costs on business

- Does the option impose additional administrative requirements on businesses or increase administrative complexity?
    - Vehicle-based limits do not impose additional administrative requirements as CO_2-emissions are already measured in TA and reported.
    - Manufacturer based limits do impose additional administrative requirements as companies will have to monitor their sales-averaged CO_2 emissions, and very possibly more regularly than they do now.
    - Manufacturer-based limits with the option of trading increase administrative complexity.
    - This should be dealt with in a largely qualitative way. Options can be qualitatively compared. The costs of a trading system (for example) may be estimated in a quantitative way once a final scheme is selected.
- Do the costs weigh in relative terms heavily on SMEs?
    - In terms of market share only a small number of vehicles is produced by SMEs, and these may be at least partially exempted from the terms of the proposed legislation. It needs to be decided as an element of detailed design to what extent the 130 g/km will apply to small manufacturers.
    - The total number of SMEs involved in the supply chain for producing cars may be considerable, but some will benefit from increased demand for new types of components. The principal administrative burdens will fall on large manufacturers.
    - Most small manufacturers produce sports cars. This segment will generally be faced with the largest CO_2 reduction target, regardless of how the 130 g/km measure is implemented. It, however, is also a segment where fuel economy is not a real issue, with advanced technology and high margins, and consequently with good possibilities for cost pass through. Especially if trading or pooling is allowed the real economic impacts for this segment may be quite limited.

4.2.5 Property rights

- Property rights are not an issue for the 130 g/km measure, except wrt intellectual property which is covered below.

4.2.6 Innovation and research

- Does the option stimulate or hinder R&D?
    - The 130 g/km measure will strongly stimulate R&D, not only for new solutions for fuel efficient vehicles but also into ways to reduce costs of known solutions for increasing fuel efficiency.
    - For the moment it can be assumed that the impact on R&D does not depend on the way in which the 130 g/km measure is implemented.
- Does it facilitate the introduction and dissemination of new production methods, technologies, products?

- The 130 g/km measure will facilitate the introduction and dissemination of new production methods, technologies, products.
    - The technical solutions introduced may depend on the way in which the 130 g/km measure is implemented, but this is probably a second-order issue.
    - In general the introduction of new, advanced technologies / components offers new opportunities for automotive component suppliers, with important turnover and employment implications as set out in Technical Note 13.
- Does it promote or limit academic or industrial research?
    - The 130 g/km measure will stimulate R&D and will thus also promote academic or industrial research, regardless of the way in which it is implemented.
- Does it promote greater resource efficiency?
    - This question does not seem very relevant or easy to predict. It should certainly promote increased efficiency in the use of oil. Impacts of resource efficiency in vehicles are arguably of second order importance in comparison, and will depend on the technologies adopted.

4.2.7 Consumers and households

- Does the option affect the prices consumers pay?
    - Yes it does.
    - Average retail price increases have been assessed using the cost assessment model – Technical Note 8. Actual impacts will depend on cost pass-through, and will be offset at least in part by lifetime fuel savings. Results indicate very good payback in terms of fuel savings for most options.
    - Average price increases will not differ much between options. The most notable differences will be in the price changes for vehicles in different segments.
- Does it impact on consumers' ability to benefit from the internal market?
    - No.
- Does it have an impact on the quality and availability of the goods/services they buy, and on consumer choice?
    - The 130 g/km measure does not impact the quality of cars.
    - The 130 g/km measure may limit consumer choice depending on the way the measure is implemented. Some manufacturers may decide to stop production of models with high CO_2 emissions. For most target-measure combinations, however, it is expected that sufficient number of vehicles will remain available in all market segments but that costs of less fuel efficient vehicle types will increase more than costs in other segments.

- Does it affect consumer information and protection?
    - No.
- Does it have significant consequences for the financial situation of individuals / households, both immediately and in the long run?
    - The costs of buying a new vehicle will increase for most consumers.
    - Reducing the average type approval CO_2 emissions from 159 g/km in 2006 to 130 g/km in 2012 leads to lifetime fuel cost savings ranging from over € 2200 for a fuel price of 1.00 €/l to almost € 2700 for a fuel price of 1.20 €/l. These savings equal or exceed the average retail price increase of vehicles for all slope values and all AMI scenarios. For moderate assumptions about AMI

(0.82% p.a.) and moderate slope values (around 60%) the lifetime fuel savings are about twice the additional retail price.
    - o The value of existing vehicles in the fleet may actually increase, as second-hand car buyers may be more susceptible to fuel efficiency.
    - o Individuals and households may reduce (the perceived) costs of driving by buying smaller vehicles or by using other modes of transport. Due to limited price elasticities consumers will not fully compensate the cost increase by buying smaller vehicles or by using other modes of transport.
    - o Low income groups will be more affected if the cost impacts on small / medium size vehicles are higher. This may be a relevant issue, but in general poor motorists do not buy new cars. In the medium term buyers of older cars would benefit from improved fuel efficiency.
    - o The knock-on effects of new car prices on the second hand market might impact poorer motorists adversely, but the effect should be limited because second hand cars depreciate rapidly in value, and it is not clear how much extra cost of new cars could be passed through to the second hand market.
    - o The poorest do not generally have access to a private car, and might benefit if price changes led to any improvements in public transport.
- Does it affect the economic protection of the family and of children?
    - o No.

4.2.8 Specific regions or sectors

- Does the option have significant impact on certain sectors?
    - o The 130 g/km measure has impact on the automotive sector including suppliers. Reduced fuel consumption also impacts upon fuel suppliers.
    - o The impacts on the automotive industry are assessed through the other assessment criteria.
- Will it have specific impact on certain regions, e.g. in terms of jobs?
    - o Manufacturers from different countries tend to have different market positions, e.g. in terms of the division of sales over various segments. The structure of the industry is outlined in Technical Note 13.
    - o This aspect can be assessed quantitatively using the cost results in this study by grouping manufacturers by country and looking at average costs increases per car for each country of origin. However this is a rather imprecise approach for the reasons stated below.
        - A complicating issue is that manufacturers that have their head office in a certain country may have assembly plants in various EU and other countries. It is difficult to identify these ‘trickle down effects’ with any certainty. The diffuse supply chain however suggests that additional revenue will benefit manufacturers in a wider range of countries than those that are major manufacturers.
    - o Impacts on jobs have partly been assessed as a function of costs and value chains in Technical Note 13.
- Does it have specific consequences for SMEs?
    - o See above.

4.2.9 Third countries and international relations

- Does the option affect EU trade policy and international obligations, incl. in the WTO?
- Does it affect foreign policy and EU/EC development policy?
- Does the option affect third countries with which the EU has preferential trade arrangements?
- Does the option affect developing, least developed and middle income countries?

  - It is argued that there should be few or no implications for WTO or developing countries.

4.2.10 Public authorities

- Does the option have budgetary consequences for public authorities at different levels of government, both immediately and in the long run?
  - If more fuel efficient cars are more expensive they lead to higher vehicle tax revenues in countries where vehicle tax is related to vehicle price.
  - Taxes based on vehicle mass or cylinder content may go down due to weight reduction measures and engine downsizing.
  - Revenues from fuel excise duties will decrease if vehicle become more fuel efficient.
  - The overall effects on tax revenues will not depend significantly on the way in which the 130 g/km is implemented.
- Does the option require significant establishing new or restructuring existing public authorities?
  - Options with trading require an organisation that performs the monitoring and that facilitates the emission credit trading.

4.2.11 The macroeconomic environment

- What are the overall consequences of the option for economic growth and employment?
- Does it contribute to improving the conditions for investment and for the proper functioning of markets?
- Does the option have direct or indirect inflationary consequences?

  - The 130 g/km legislation as a whole has macro-economic implications, but these will probably not depend very much on the details of the implementation. A range of positive respending effects are identified in Technical Note 13.

4.3 Environmental Impacts

4.3.1 Air quality

- Does the option have an effect on emissions of acidifying, eutrophying, photochemical or harmful air pollutants that might affect human health, damage crops or buildings or lead to deterioration in the environment?
  - Various technologies that may be employed to reduce CO_2-emissions may lead to changes in the emissions of CO, HC, NO_x and PM. However, as all

new vehicles have to meet the same emission standards it is assumed that if applied technologies (tend to) lead to an increase in engine-out emissions, that this will be compensated though improved engine management and improved or additional aftertreatment.
    - At the vehicle level the impact of the 130 g/km measure will thus be negligible. If, however, the price differential between petrol and diesel vehicles is affected by the 130 g/km measure, then the measure may lead to a shift in the sales distribution of petrol and diesel vehicles, which (given the different emission standards for the two) may lead to different fleet average emissions of specifically NO_x and PM. Results from Task B, however, have already shown that this effect is expected to be very small.
    - It is therefore not expected that the 130 g/km measure will affect the emissions of other pollutants from passenger cars.

4.3.2 Water quality and resources

- Does the option decrease or increase the quality or quantity of freshwater and groundwater?
    - No.
- Does it raise or lower the quality of waters in coastal and marine areas?
    - No.
- Does it affect drinking water resources?
    - No.

4.3.3 Soil quality or resources

- Does the option affect acidification, contamination or salinity of soil and soil erosion rates? Does it lead to loss of available soil?
    - These questions are not relevant.

4.3.4 The climate

- Does the option affect the emission of ozone-depleting substances and greenhouse gases into the atmosphere?
    - ozone-depleting substances: no
    - greenhouse gases: yes. In first instance it can be assumed that the overall impact on CO_2-emissions does not depend on the implementation of the measure. However, in practice the Mtonnes of CO_2 reduced will depend on the way in which the average reduction is divided over different vehicle segments which generally drive different annual mileages. This will be assessed based on TREMOVE fleet analysis.

4.3.5 Renewable and non-renewable resources

- Does the option affect the use of renewable resources more quickly than they can regenerate?
    - This question is not relevant.
- Does it reduce or increase the use of non-renewable resources (groundwater, minerals, etc.)?

- It is assumed that the technologies applied for reaching 130 g/km do not significantly affect the overall use of non-renewable resources for the production of vehicles.

4.3.6 Biodiversity, flora, fauna and landscapes

- Does the option reduce/increase the number of species in any area?
- Does it affect protected or endangered species or their habitats or ecologically sensitive areas?
- Does it split the landscape into smaller areas or in other ways affect mitigation routes, ecological corridors or buffer zones?
- Does the option affect the scenic value of protected landscape?
  - All the above questions would be relevant to e.g. biofuels. The 130 g/km solely concerns vehicle efficiency so that these aspects are all considered irrelevant.

4.3.7 Land use

- Does the option have the effect of bringing new areas of land into use for the first time?
- Does it affect land designated as sensitive for ecological reasons? Does it lead to a change in land use?
  - These questions are not relevant.

4.3.8 Waste production / generation / recycling

- Does the option affect waste production or how waste is treated, disposed and recycled?
  - In principle waste production and recycling may be affected by technologies applied for meeting the 130 g/km target. Especially weight reduction may lead to increased use of plastics, aluminium and composite materials to replace steel. The use of composites may counteract the improvements foreseen by the EU's "end-of-life" directive.
  - Also there may in principle be new materials or components introduced, but these are regulated by the ELV directive and others, so should not have a major impact.
  - It is assumed that the way in which waste production and recycling is affected does not depend on how the 130 g/km measure is implemented.

4.3.9 The likelihood or scale of environmental risks

- Does the option affect the likelihood or prevention of fire, explosions, breakdowns, accidents and accidental emissions?
- Does it affect the risk of unauthorised or unintentional dissemination of environmentally alien or genetically modified organisms?
- Does it increase the likelihood of natural disasters?
  - These questions are not relevant.

4.3.10 Mobility (transport modes) and the use of energy

- Does the option increase or decrease the consumption of energy and production of heat?
  - o The 130 g/km reduces energy consumption. In first instance it can be assumed that the overall impact on energy consumption does not depend on the implementation of the measure. However, in practice the TJ reduced will depend on the way in which the average reduction is divided over different vehicle segments which generally drive different annual mileages. This can be assessed based on TREMOVE fleet analysis.
- Will it increase or decrease the demand for transport (passenger or freight), or influence its modal split?
  - o Yes it will but only to a limited extent. This has already been assessed using TREMOVE calculations (Task B).
- Does it increase or decrease vehicle emissions?
  - o Yes, it reduces CO_2-emissions.
  - o Various technologies that may be employed to reduce CO_2-emissions may lead to changes in the emissions of CO, HC, NO_x and PM. However, as all new vehicles have to meet the same emission standards it is assumed that if applied technologies (tend to) lead to an increase in engine-out emissions, that this will be compensated though improved engine management and improved or additional aftertreatment.

4.3.11 The environmental consequences of firms' activities

- Does the option lead to changes in natural resource inputs required per output? Will it lead to production becoming more or less energy intensive?
  - o In principle the consumption of materials and energy for producing a car will increase as a result of the 130 g/km measure. It is assumed that this is limited and not depending on the way in which the 130 g/km measure is implemented.
  - o Per unit value the energy intensity of the car production will not be affected.
- Does the option make environmentally un/friendly goods and services cheaper or more expensive through changes in taxation, certification, product, design rules, procurement rules, etc.
  - o The average net costs of ownership of cars will increase as a result of the 130 g/km measure. Additional vehicle costs (retail price) will not be fully earned back by fuel cost savings.
  - o This aspect is assessed in the cost assessment model. It can be assessed at the level of "societal" costs as well as at the level of consumer costs. In general different ways of implementing the 130 g/km measure will lead to slightly different additional costs.
- Does the option promote or restrict environmentally un/friendly goods and services through changes in the rules on capital investments, loans, insurance services, etc.?
  - o No.
- Will it lead to businesses becoming more or less polluting through changes in the way they operate?
  - o The 130 g/km measure will not affect environmental performance of car and component manufacturers. It will improve the environmental performance of

companies using cars. This will not depend on the way in which the 130 measure is implemented.

4.3.12 Animal and plan health, food and feed safety

- Does the option have an impact on health of animals and plants?
  - Only indirectly by mitigating climate change.
- Does the option affect animal welfare?
- Does the option affect the safety of food and feed?
  - These questions are not relevant.

4.4 Social Impacts

4.4.1 Employment and labour markets

- Does the option facilitate new job creation?
- Does it lead directly to the loss of jobs?
  - Has already been assessed in part Task B.
  - Will depend on the way in which the 130 g/km measure is implemented – Technical Note 8 gives a strong indication, while Technical note 13 indicates the scale and direction of likely employment impacts.
  - Further quantitative assessment should be carried out by other parties under separate contract.

- Does it have specific negative consequences for particular professions, groups of workers, or self-employed persons?
- Does it affect the demand for labour?
- Does it have an impact on the functioning of the labour market?
  - The above questions are not relevant.

4.4.2 Standards and rights related to job quality

- Does the option impact on job quality?
- Does the option affect the access of workers or job-seekers to vocational or continuous training?
- Will it affect workers' health, safety and dignity?
- Does the option directly or indirectly affect workers' existing rights and obligations?
- Does it affect the protection of young people at work?
- Does it directly or indirectly affect employers' existing rights and obligations?
- Does it bring about minimum employment standards across the EU?
- Does the option facilitate or restrict restructuring, adaptation to change and the use of technological innovations in the workplace?
  - All the above questions are not relevant.

4.4.3 Social inclusion and protection of particular groups

- Does the option affect access to the labour market or transitions into/out of the labour market?
- Does it lead directly or indirectly to greater in/equality?

- Does it affect equal access to services and goods?
- Does it affect access to placement services or to services of general economic interest?
- Does the option make the public better informed about a particular issue?
- Does the option affect specific groups of individuals, firms, localities, the most vulnerable, the most at risk of poverty, more than others?
- Does the option significantly affect third country nationals, women, disabled people, the unemployed, the elderly, political parties or civic organisations, churches, religious and non-confessional organisations, or ethnic, linguistic and religious minorities, asylum seekers?

  - The only relevant issue here may be the impact on vulnerable groups, i.e. low income groups, for which the increased costs of cars may be a problem and may lead to “transport poverty” / social exclusion. See discussion above.

4.4.4 Equality of treatment and opportunities, non-discrimination

- Does the option affect equal treatment and equal opportunity for all?
- Does the option affect greater gender equality?
- Does the option entail any different treatment of groups or individuals directly on grounds of e.g. gender, race, colour, ethnic or social origin, genetic features, language, religion or belief, political or any other opinion, membership of a national minority, property, birth, disbility, age or sexual orientation? Or could it lead to indirect discrimination?
  - All the above questions are not relevant.

4.4.5 Private and family life, personal data

- Does the option affect the privacy of individuals or their right to move freely within the EU?
- Does it affect family life or the legal, economic or social protection of the family?
- Does the option involve the processing of personal data or the concerned individual’s right of access to personal data?
  - All the above questions are not relevant.

4.4.6 Governance, participation, good administration, access to justice, media and ethics

- Does the option affect the involvement of stakeholders in issues of governance as provided for in the Treaty and the new governance approach?
  - Not relevant.

- Are all actors and stakeholders treated on an equal footing, with due respect for their diversity? Does the option impact on cultural and linguistic diversity?
  - The second part of this question seems to suggest an entirely different interpretation, but this question could be related to how the 130 g/km measure impacts on different manufacturers.

- Does it affect the autonomy of the social partners in the areas for which they are competent?

- Does the implementation of the proposed measures affect public institutions and administrations, for example with regard to their responsibilities?
- Will the option affect the individual's right and relations with the public administration?
- Does the option affect the individual's right to justice?
- Does the option make the public better informed about a particular issue? Does it affect the public's access to information?
- Does the option affect the media, media pluralism and freedom of expression?
- Does the option raise (bio)ethical issues?
  - All the above questions are not relevant.

4.4.7 Public health and safety

- Does the option affect the health and safety of individuals/populations, including life expectancy, mortality and morbidity, through impacts on the socio-economic environment?
- Does the option increase or decrease the likelihood of bioterrorism?
  - All the above questions are not relevant.

- Does the option increase or decrease the likelihood of health risks due to substances harmful to the natural environment?
  - See under environmental impacts.
- Does it affect health due to changes in the amount of noise or air, water or soil quality in populated areas?
  - See under environmental impacts.

- Will it affect health due to changes in energy use and/or waste disposal?
- Does the option affect lifestyle-related determinants of health such as use of tobacco, alcohol, or physical activity?
- Are there specific effects on particular risk groups?
  - All the above questions are not relevant.

4.4.8 Crime, terrorism and security

- Does the option improve or hinder security, crime or terrorism?
- Does the option affect the criminal's chances of detection or his/her potential gain from crime?
- Is it likely to increase the number of criminal acts?
- Does it affect law enforcement capacity?
- Will it have an impact on the balance between security interests and the rights of suspects?
- Does it affect the rights of victims of crime and witnesses?
  - All the above questions are not relevant.

4.4.9 Access to and effects on social protection, health educational systems

- Does the option have an impact on services in terms of their quality and access to them?
- Does it have an effect on the education and mobility of workers?

- Does the option affect the access of individuals to public /private education or vocational and continuing training?
- Does it affect the cross-border provision of services, referrals across borders and co-operation in border regions?
- Does the option affect the financing / organisation / access to social, health and education systems?
- Does it affect universities and academic freedom / governance?
  - All the above questions are not relevant.

5 OPTIONS FOR INCLUDING LIGHT DUTY COMMERCIAL N1 VEHICLES

5.1 Introduction

A fuller version of this discussion is to be found in Technical Note 12.

According to (TNO 2006) the 2002 average CO_2 emission of N1 vehicles is 201 g/km. The baseline value (without policy aimed at efficiency improvement in N1s) for 2012 is expected to be around 190 g/km based on autonomous efficiency improvements stemming in part at least from technology improvements diffusing into light vans from equivalent passenger cars. A reduction to 175 g/km by 2012 thus equals a net CO_2 reduction through direct application of additional technical measures of 15 g/km, equal to a 7% reduction compared to current level (estimated for 2006 at 195 g/km). For comparison, M1 vehicles will be required to reduce by 21% from 2006 to 2012, so it can be seen that this first objective is a far less demanding requirement than that imposed on passenger cars.

In the course of this study the authors confirmed that a full database of the required parameters for N1 vehicles is still not available. Directive 2004/3 now requires CO_2 emissions data to be measured and recorded for vans as it is for cars, but the requirements will not be fully applicable to Class II and Class III vans until 2008 at the earliest. As a result, it can be anticipated that the necessary data could in principle be available in a year or two. As a consequence possible utility-based limit functions cannot be investigated with any certainty. Beyond this, distributional effects can not be analysed. From the analysis for M1 vehicles it is clear that the most favourable slope for the limit function is especially determined by the impacts on distribution of the burden over different manufacturers, and this cannot yet be determined. Further discussion of possible utility functions is included in technical Note 12.

5.2 Technical Potential for CO_2 Reductions

The technical options available to reduce the CO_2 emissions of vans, as identified in TNO (2006), are largely of the same types as for passenger cars. Only costs and reduction potentials for application in N1s are in many cases slightly different than for application in M1s.

According to the study, the measures that would be required to reach a first step of 15 g/km reduction are cost effective from a societal cost perspective (i.e. excluding taxes) for fuel costs of 0.25 €/l (excl. tax) and above. As the share of tax in the fuel retail price is generally higher than the share of tax in the vehicle retail price, the measures required to reach this 15 g/km reduction are certainly cost effective from an end-user's point of view, and can therefore be considered as 'low-hanging fruit' that is relatively cheap to implement.

The total potential of technical measures identified in [TNO 2006] is about 60 g/km. This level of reduction does involve significant positive CO_2 abatement costs. However, due to the higher vehicle lifetime and higher annual mileage compared to M1 vehicles, the lifetime fuel cost savings associated with a 60 g/km CO_2 reduction in

N1s are higher than for the same reduction in M1s, and roughly equate to the increase in vehicle retail price. Note that, given the already high diesel penetration in the market, the scope for improvements simply through further dieselisation is relatively limited compared to the car market.

5.3 Characteristics of the N1 Market

The market for N1 vehicles is somewhat different to that for passenger cars. This will have an impact on the possible choice of instrument and overall policy design to regulate CO_2 emissions from N1s. The main differences between the markets are presented below:

- fewer brands than for M1s (9 compared with 17);
- fewer models than for M1s (around. 100 compared to over 300);
- larger product diversity within a model (vehicle body variants and engine variants) than for M1s (typically around 10 variants compared to 5);
- smaller sales volumes overall than for M1 (1.7 million compared to 14 million);
- three main classes (Class I, II and III), also used for exhaust gas emission legislation – these are objectively determined classes (based on reference mass – see Annex 2) that are generally accepted and understood as a form of segmentation of the fleet;
- significantly higher average CO_2 emissions; but
- lower power-to-weight ratios especially compared to large M1 vehicles; so although there is a trend towards higher specific power in the N1 market there is likely to be less variation in CO_2 for a given utility value (ie no 'sports car' effect);
- a large share of diesels in the new vehicles sales (around 70% according to [TNO 2006]); and
- likelihood of significant variations in the average CO_2 emissions from each brand or manufacturer, as some specialise more in M1-based vans (Class I) while some focus more on the larger (Class II and III) vans.

5.4 Considerations in Incorporating N1s into the Regulatory System

There is some preference, in terms of policy coherence, that the legislation for N1s be based on the same methodology as the legislation for M1s. In this way, it would be possible to exploit the benefits of combining some elements of the system for cars and vans, for example the monitoring and reporting requirements or sanctions system. However, as against this, the differences between cars and vans suggest that some differences between the two are inevitable. For example, there are as yet separate targets for the two, and analysis below suggests that there is little prospect of developing a unified utility curve for cars and vans in the near future.

Some policy options appear to be available for the regulation of CO_2 legislation for N1 vehicles. Ideally these should be tested with an in depth analysis once a comprehensive database of van models, the relevant sales data, CO_2 performance and other parameters become available. However, some initial results can be summarised as follows:

- Applying single limit values to each vehicle or manufacturer does not appear to be any more promising an option for vans than for cars. This is because of the expected wide range of CO_2 emissions between vans of different classes and between the sales-weighted averages of the range of vans offered by different manufacturer groups.
- Similarly, a percentage reduction applied to the sales averaged CO_2 emissions per manufacturer appears to be a possibility, but there is no immediate reason to suppose that this approach would not suffer from some of the same drawbacks tested for this measure applied to passenger cars. On the other hand, there is less of a risk of punishing early movers, as there have not been strong policy signals in this sector up to now, and the required effort is relatively small, so issues of 'fairness' may not weigh as heavily in this case as they do for passenger cars.
- There are good possibilities to apply a utility function to vans as to cars. Several options seem very attractive in principle, but there are nonetheless some drawbacks in practice.
- An important distinction between cars and vans is that for vans a simple and fairly meaningful market segmentation is available, and the variation in CO_2 performance within each class is (at least on the basis of the evidence so far available to us) likely to be smaller than is the case for cars.
- In principle trading between M1s and N1s could reduce the costs of overall compliance, as the marginal abatement cost is likely to differ between vans and cars, and might for example encourage extra effort to be made in relation to vans to reduce the effort on cars. However, since they have separate targets, this could cause one of the two targets to be missed, and might present other problems. Also, the relationship between test cycle and 'real world' emissions is likely to be different for cars and vans, so trading between them might have unpredictable consequences in terms of total emissions.
- As with cars, trading between manufacturers of N1s is in principle possible and should reduce the overall cost of compliance. However, it seems unlikely that the manufacturers of vans will be any more enthusiastic about trading with competitors than carmakers appear to be.

5.5 Considerations on Utility Parameters and Segments for N1s

The analyses developed so far by the authors (see also TNO 2004) have produced the initial considerations regarding the application of options of utility parameters and segments for N1s. These can be summarised as follows:

- Maximum payload and internal loading volume are conceptually the best representations of the utility of a light commercial vehicle for most typical purposes. Selection of a vehicle is in general based on one of the two, depending on the type of goods to be transported. A combination of the two might therefore be a good overall solution.
- GVW is strictly speaking not a measurable parameter. The maximum payload is defined by the manufacturer based on partly quantitative engineering principles. This value can thus not be independently verified and can easily be manipulated, although it is bound by the physical limitations of the vehicle and warranty issues.
- As a consequence also maximum payload (= GVW – empty mass) is not a measurable parameter. This is an important drawback that militates heavily

against its use in practice, in spite of its other attractions. Instead, vehicle mass would have to be preferred, even though it has significant drawbacks as a utility parameter for vans, similar to the ones stated elsewhere for cars.
- Loading volume is difficult to measure exactly (due to the complex shape of vehicle interior), and can, in the design phase of the vehicle, be increased without significant adverse effects on vehicle price or fuel consumption to achieve a less stringent CO2 limit for the vehicle. As a proxy for loading volume one could however use the dimensions of the largest rectangular box that fits into the freight compartment of the vehicle. This gives less room for manipulation and focuses on useful loading volume.
- Any option referring to the body or 'box' of the van itself (eg loading capacity) must also take account of the fact that some vans are certified and sold on a 'chassis-only' basis, ie without external bodywork, to have specialist bodies added by a third party. In these cases exception rules would be needed to deal with these.
- With this in mind, 'footprint' defined as l x w x reference mass should be considered an attractive composite parameter, i.e. pan area x mass. Loading volume x reference mass appears the best alternative if the relevant data were available.

There are conceptually good possibilities for applying a utility function to N1s, but there remain some practical issues to be overcome in doing so, as highlighted above. One simple utility function that could be applied to both cars and vans is of course vehicle mass. This suggests the possibility of applying a combined utility function to cars and vans under a single measure. However, our initial assessment[1] is that this is not in fact a practical proposition, as it would distort the slope of the utility function and significantly shift the burden of improvements and costs between car manufacturers, while bringing little benefit.

5.6 Considerations on Alternative Options

A class-based system for vans might be considered as an attractive alternative, given the smaller size of the van fleet and the relatively limited range of vehicles within each class. This at least until more data becomes available and/or more stringent targets are to be set in the future.

- A uniform limit value per class can probably not be met by all vehicles in a given class, and should therefore preferably be accompanied by either internal averaging per manufacturer or by trading between manufacturers.
- Internal averaging per manufacturer could be allowed within a class or for the total N1 sales over the three classes. Given the smaller number of models and smaller sales internal averaging per class probably does not provide enough flexibility for meeting the target and as a consequence might lead to unwanted

[1] Initial estimation of sales weighted average mass for N1 vehicles (based on top 25 vehicles) is 1700 kg (compared to 1300 kg for M1), so a separate weight-based utility function should thus be turned around the pivot point (1700 kg, 175 g/km CO_2), compared with (1300 kg, 130 g/km) for M1. Combining N1 & M1 vehicles, (with a limit line through both pivot points) would result in a slope of 0,11 = 150%. This is not realistic, and reflects the fact that the relationship of mass to emissions is significantly different for cars and vans, and that the target of 175 g/km CO_2 for N1s is a less stringent target than 130 g/km for M1s.

distributional impacts (affecting competitiveness of individual manufacturers). Internal averaging over all classes is therefore preferred, whereby the target per manufacturer is defined as the average of the targets per Class weighted by the sales of vehicles per class by that manufacturer in 2012.

- There does not seem to be any disadvantage to allow averaging over the three N1 classes to optimise the manufacturer's response and reduce cost. There is in principal no reason to set different limits per class. However, there is a strong suspicion that a single value could lead to significant distributional effects, and so separate targets for each class based on utility (and for which we have a reasonable analytical foundation) appear to be preferred as they should help to minimise these.
- Vehicle classes are based on 'reference mass' (see Annex 2). As reference mass is not at all a function of payload mass but a direct function of vehicle mass, it can only be manipulated or gamed by increasing actual vehicle mass, which is unlikely to be an attractive option except possibly at or near to the class boundary.

The table below is based on Table 8.8 from [TNO 2006]. CO_2 reductions per class for meeting an overall average of 175 g/km have been assessed by determining the cost optimal division of reductions over the various classes (and fuel types) for reaching the overall target. Cost optimisation is based on total EU-15 sales (all manufacturers) and therefore does not take into account possible sub-optimisations that would arise from cost optimisation per manufacturer. Using the sales shares of the fuel types per class, overall CO_2 targets per class can be defined as the sales weighted average of the cost optimal 2012 CO_2 emission per class / fuel type for 2012.

			Class I		Class II		Class III		average
			petrol	diesel	petrol	diesel	petrol	diesel	
2002 new vehicle sales			9%	19%	10%	23%	12%	27%	
2008 new vehicle sales			10%	18%	12%	21%	14%	25%	
2012 new vehicle sales			10%	17%	12%	21%	15%	25%	
2002 baseline CO2-emission		[g/km]	179	160	184	175	283	227	200,9
2002 average CO2 emission per class		[g/km]	166		178		245		200,9
2012 baseline CO2-emission		[g/km]	171	152	174	163	265	209	189,7
2012 baseline average CO2 emission per class		[g/km]	159		167		230		189,7
15 g/km reduction	ΔCO2	[g/km]	22,3	7,6	20,2	7,9	32,3	10,1	15,0
	ΔCO2 per class		13,1		12,5		18,4		15,0
	CO2	[g/km]	149	144	154	155	232	199	175
	combined class target	[g/km]	146		155		212		175

5.7 Conclusions and possible ways forward

CO_2 reductions per class for meeting an overall average of 175 g/km have been assessed by determining the cost optimal division of reductions over the various classes (and fuel types) for reaching the overall target.

Our knowledge of the van sector is not yet sufficient to undertake the full analysis of instrument designs that has been done for passenger cars. However, work done so far produced the following results on the inclusion of N1 in a regulatory system:

1. Van classes offer a viable and fairly robust segmentation of the van market. Also, for the market as a whole, the weighted averages reflect fairly robust estimates of the reductions that would be needed for each segment to achieve the 175 g/km target. The use of segmentation should in principle be limited by the use of a segmentation approach. In any case the reductions required are relatively modest for each segment, so neither the total cost nor the distributional impacts should be large.

2. Alternatively, there is no strong reason to assume that a similar framework to that for cars should not be used. However, to this end, a more robust assessment (eg of a suitable utility parameter and optimum slope) would be preferably deferred until more data became available.

The detailed design of the CO_2 legislation for N1s could be organised in a separate project. This would require:

- The set up of a data collection programme for the required vehicle statistics (sales, CO_2, mass, size, etc. per model) that are necessary to determine the exact design of the legislation (selection of utility parameter, slope of limit function, etc.);
- A detailed assessment using a model similar to that used for M1s; and
- The development of a detailed proposal for design of the CO_2 legislation for N1s, utilising elements of the framework for M1s as far as these were demonstrated to be suitable.

In either case, it will be highly desirable that better data are collected as of 2008. This might involve incorporating vans into the Monitoring Mechanism, but also seeking ways to obtain more detailed information on the individual models and variants sold, for example by incorporating N1s fully into the commercial monitoring systems already available. These data should include numbers of sales and the certified CO_2 values, but also the possible utility parameters (mass and dimensions) discussed above.

Annex: List of Technical Notes annexed to the Report

Technical Note 1: Overview of Regulatory Approaches in Other Countries

Technical Note 2: Discussion of the options for a legal instrument

Technical Note 3: Consultants' legal questions and answers

Technical Note 4: Choice of parameter for sloped (utility based) limit functions

Technical Note 5: Developing the list of options

Technical Note 6: Methodological aspects regarding update of the cost assessment model

Technical Note 7: Analysis of 2006 sales for all manufacturers

Technical Note 8: Definition of utility-based limit functions

Technical Note 9: Quantitative analysis of various options with updated model

Technical Note 10: Analysis of pooling for Volkswagen and Porsche

Technical Note 11: Analysis of specific impacts on DaimlerChrysler

Technical Note 12: Policy options for light duty commercial (N1) vehicles

Technical Note 13: Analysis of impacts on employment