, citation and similar papers at core.ac.uk

brought to

provided by Research P

Ruhr Economic P

Manuel Frondel, Christoph M. Schmidt
and Colin Vance

A Regression on Climate Policy

The European Commission's Proposal to Reduce CO_2 Emissions from Transport

#44

RWI
ESSEN

Ruhr Economic Papers

Published by

Ruhr-Universität Bochum (RUB), Department of Economics
Universitätsstraße 150, 44801 Bochum, Germany

Technische Universität Dortmund, Department of Economic and Social Sciences
Vogelpothsweg 87, 44227 Dortmund, Germany

Universität Duisburg-Essen, Department of Economics
Universitätsstraße 12, 45117 Essen, Germany

Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI Essen)
Hohenzollernstrasse 1/3, 45128 Essen, Germany

Editors:

Prof. Dr. Thomas K. Bauer
RUB, Department of Economics
Empirical Economics
Phone: +49 (0) 234/3 22 83 41, e-mail: thomas.bauer@rub.de

Prof. Dr. Wolfgang Leininger
Technische Universität Dortmund, Department of Economic and Social Sciences
Economics – Microeconomics
Phone: +49 (0) 231 /7 55-32 97, email: W.Leininger@wiso.uni-dortmund.de

Prof. Dr. Volker Clausen
University of Duisburg-Essen, Department of Economics
International Economics
Phone: +49 (0) 201/1 83-36 55, e-mail: vclausen@vwl.uni-due.de

Prof. Dr. Christoph M. Schmidt
RWI Essen
Phone: +49 (0) 201/81 49-227, e-mail: schmidt@rwi-essen.de

Editorial Office:

Joachim Schmidt
RWI Essen, Phone: +49 (0) 201/81 49-292, e-mail: schmidtj@rwi-essen.de

Ruhr Economic Papers #44

Responsible Editor: Christoph M. Schmidt
All rights reserved. Bochum, Dortmund, Duisburg, Essen, Germany, 2008
ISSN 1864-4872 (online) – ISBN 978-3-86788-045-9

The working papers published in the Series constitute work in progress circulated to stimulate discussion and critical comments. Views expressed represent exclusively the authors' own opinions and do not necessarily reflect those of the editors.

Ruhr Economic Papers

#44

Manuel Frondel, Christoph M. Schmidt
and Colin Vance

A Regression on Climate Policy

The European Commission's Proposal to Reduce CO_2 Emissions from Transport

RWI
ESSEN

Bibliografische Information der Deutschen Nationalbibliothek
Die Deutsche Nationalbibliothek verzeichnet diese Publikation in der Deutschen Nationalbibliografie; detaillierte bibliografische Daten sind im Internet über http://dnb.d-nb.de abrufbar.

ISSN 1864-4872 (online)
ISBN 978-3-86788-045-9

Manuel Frondel, Christoph M. Schmidt and Colin Vance*

A Regression on Climate Policy – The European Commission's Proposal to Reduce CO_2 Emissions from Transport

Abstract

As part of its efforts to reach the targets of the Kyoto Protocol, the European Commission is currently considering a new directive to reduce the per-kilometer CO_2 emissions of newly registered automobiles. This paper critically assesses this proposal with respect to its economic and technological underpinnings. We argue that the proposal's reliance on targets based on per-kilometer emissions not only conceals the true costs of compliance and thereby stifles informed public discourse, but is also less cost-effective than alternative measures such as emissions trading. We further examine the proposal's underlying assumptions, finding that these misrepresent the current state of automotive technology and therefore may overestimate the feasibility of achieving the suggested emissions targets. Alternative targets are consequently proposed that are argued to more accurately reflect the industry's technological evolution to date.

JEL Classification: L98, Y10

Keywords: Technological progress, private automobiles, efficiency standards

April 2008

---

* Manuel Frondel and Colin Vance: RWI Essen; Christoph M. Schmidt: RWI Essen and Ruhr University of Bochum. – The authors thank Walter Krämer, Matthias Peistrup, and Joachim Schmidt for valuable comments and suggestions. – All correspondence to Manuel Frondel, Rheinisch-Westfälisches Institut für Wirtschaftsforschung (RWI Essen), Hohenzollernstraße 1-3, 45128 Essen, Germany, e-mail: frondel@rwi-essen.de.

1. Introduction

Alongside electricity generation, the transport sector constitutes the largest source of greenhouse gas emissions in the industrialized world. In 2005, this sector was responsible for 20% of CO2 emissions in the European Union (EEA 2007:64), roughly three fifths of which can be attributed to private automobiles (COM 2007b:2). While emissions have decreased in sectors such as industry and agriculture, both dropping by 11% between 1990 and 2005, road traffic is one of the few sectors in the EU-15[1] in which emissions have increased, rising by 26% over the same period (EEA 2007:65). This trend threatens to thwart efforts to achieve the targets of the Kyoto Protocol, under which the EU is to reduce greenhouse gases by 8% relative to the 1990 level by 2012[2].

Against this backdrop, the European Commission (hereafter Commission) is currently considering a new directive to reduce the per-kilometer CO2 discharge of newly registered automobiles. The proposed directive, which is based on legally codified targets, is motivated by two principal considerations. The first is that the transport sector has thus far not been integrated into the EU's Greenhouse Gas Emissions Trading Scheme (ETS), which commenced operation in 2005 as the largest multi-country certificate trading scheme worldwide. Secondly, it is now a foregone conclusion that the voluntary commitment of the European Automobile Manufacturers Association (ACEA) to reduce average emissions to 140g CO2/km by 2008, negotiated with the Commission in 1998, will not be met.

To maintain climate protection policy on track, the Commission published in December 2007 a proposal for reducing the CO2 emissions from private automobiles that would set maximum allowable emissions for 2012 depending on the mass of the vehicle. The core of the proposal is a so-called *limit value curve* relating the vehicle

[1] The EU-15 refers to the 15 original Member States of the European Union. We use the term EU to refer to the enlarged union, which includes these members in addition to the 10 new Member States.

[2] The increase in emissions from the transport sector is attributable to several factors, including increases in vehicle kilometers traveled and growing rates of automobile ownership. In 1990, for example, there were 355 vehicles per 1,000 residents in the EU, a figure that increased by 31 % to 465 vehicles by 2003. The growth in the number of newly registered cars in the EU over this time interval reached 36 %, rising from 156 to 212 million (COM 2007a:5).

mass to a corresponding CO2 emission limit, which is set in such a way that a fleet-average of 130 grams of CO2 per kilometer is achieved. A key implication following from this curve is that the emission reduction required of heavy vehicles is disproportionately higher than that of light vehicles. Despite the proposal's attempt to consider vehicle mass, it has been met with vigorous opposition, particularly from Germany.

In this paper, we explore the basis for the Commission's proposal from both an economic and technological angle. The following section begins with an overview of the proposal's background and terms, subsequently focusing on its economic implications for the highly differentiated automobile market as well as on its cost-effectiveness in reducing emissions relative to other instruments, such as emissions trading. Section 3 scrutinizes key assumptions underpinning the proposal, finding that these misrepresent the current state of automotive technology and therefore may overestimate the feasibility of achieving the suggested emissions targets. In Section 4, alternative reduction targets are consequently proposed that are argued to more accurately reflect the industry's technological evolution to date. Section 5 concludes.

2. The Commission's Proposal and its Economic Valuation

In recognition of the accumulating scientific evidence on global warming, the Commission has for several years taken an offensive posture in formulating policies that aim at mitigating the role of human agency in climate change (COM 2007a). The stabilization and, ultimately, reduction of greenhouse gases in the EU is regarded to be a cornerstone of this effort. By 2004, however, greenhouse gas emissions in the EU-15 decreased by only 1.5% relative to the base year of 1990, a modest achievement relative to the Kyoto target of an 8% reduction by 2012 (EEA 2007:24). Much is consequently riding on the success of the Emissions Trading Scheme (ETS) in realizing this goal. This instrument was introduced in 2005 as a centerpiece of climate policy, and is considered in the environmental economics literature to be an economically efficient means of effectively reducing emissions (Baumol, Oates 1971:47).

Among the participants of the ETS are electricity producers and the most energy-intensive industry branches. Road transport is not included. Rather than pursuing the integration of this sector, as is planned for air traffic, the Commission is submitting a legislative proposal for reducing the CO2 emissions of private automobiles. This proposal falls under a more general strategy for the reduction of CO2 emissions from road traffic, which is based on three pillars: (i) voluntary commitments of the associations of European, Japanese, and Korean auto manufacturers, (ii) guidelines on labeling and the provision of information to consumers, and (iii) tax measures that favor vehicles that have light fuel requirements. After reviewing the strategy in 2007, the Commission concluded that without additional policy measures, the goal of reaching the level of 120g CO2/km by 2012 could not be reached (COM 2007a:8). The prevailing view is that these three pillars should now be complemented by legislative limits on CO2 emissions from newly registered vehicles, which are to be enforced with the threat of penalty payments for non-compliance (COM 2007b:21).

In December 2007, the Commission published a draft of a new directive that allows per-kilometer CO2 discharges to increase with the mass of vehicles (COM 207b:26). The core of this draft is a so-called limit value curve, whose slope is such that manufacturers of heavier vehicles, which arguably also tend to be safer and more comfortable than lighter vehicles, must achieve higher percentage reductions in emissions than manufacturers of lighter vehicles. The limit value curve is given by the following linear equation:

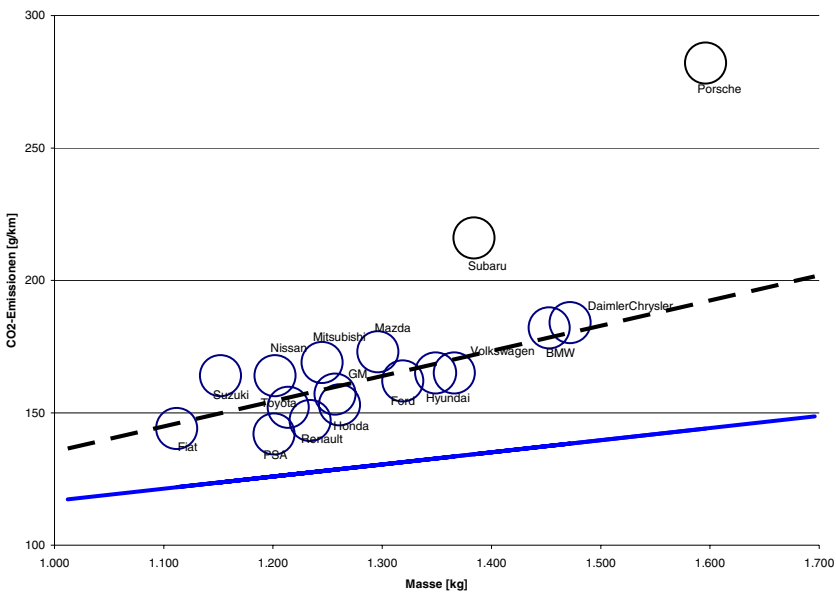
(1) $$E_{CO2} = 130 + 0{,}0457\,(M - 1.289),$$

where M is the vehicle mass in kilograms and E_{CO2} are the allowed per-km emissions. According to Equation (1), the CO2 discharge of a new car with a mass of 1,289 kg, which is nearly identical to the current sales-weighted average of 1.288.8 kg (COM 2007 c:5), must be reduced to 130 g CO2/km by 2012.

A convincing justification for the shape of this curve, reproduced in Figure 1, has regrettably been absent from the Commission's public communications. In particular, the slope of 0.0457 of the limit value cure is a critical parameter that inexplicably

remains completely unmotivated and seemingly arbitrary. Indeed, whether the proposed limit value curve reflects the future state of technological development and thereby the most cost-effective means of reaching the emission targets remains an open question of immediate relevance from a public welfare perspective.

Figure 1. Average-specific CO2-Emissions of the major vehicle manufacturers 2006 (COM 2007c:4)



(– –) the Commission's reference line: $E_{CO2} = 162{,}8 + 0{,}095\ (M - 1.289)$
(—) the limit value curve: $E_{CO2} = 130 + 0{,}0457\ (M - 1.289)$

Of equal relevance are the likely market impacts. It is reasonable to assume that the proposed limits on per-km emissions will have varying effects on the highly differentiated market segments of the automobile industry, so that the competitive position of individual manufacturers will necessarily change relative to the current market equilibrium. Manufacturers situated in market segments in which the specified emissions are relatively difficult to attain will incur higher compliance costs than other manufacturers, and these increases will tend to be passed on to consumers in the form of higher prices. This transfer of higher costs will not occur without undermining the manufacturer's competitiveness, however, because the demand for its own vehicles will not least depend on the prices of other vehicles in the same

market segment.[3] In contrast to the transfer of costs that are borne by all manufacturers, the directive is likely to result in a shift in demand away from those manufacturers that incur a relatively high increase in costs. To craft a directive that did not influence the competitive situation of the individual manufacturers in such a highly interdependent market would require close consideration of the technical possibilities for emissions reductions as well as the market structure. Such an analysis, however, is not recognizable in this case.

Based on a reading of the Commission's public documents, the working assumption seems to be that the measure will induce considerable incentives for the development of fuel-saving technologies, as non-compliance with the allowable emissions will result in heavy fines starting in 2012. For that year, a fine of 20 € for each additional gram of CO2 per kilometer over the allowed limit is suggested. Multiplying this figure with the annual number of vehicles sold in a fleet yields the total penalty. From 2013 until 2015, the specific fines are to rise successively, initially to 35, then 60, and finally 95 € (COM 2007b:21). If, for example, Mitsubishi were neither able to reduce the average per-km emissions nor the average weight of its vehicles by 2012, it would discharge 41g/km more CO2 than would be allowed according to the limit value curve, thereby requiring that the manufacturer pay a fine of 820 € to the Commission with the sale of each car. By 2014, a fine of 2,460 € would be due, increasing to 3,895 € by 2015. It is reasonable to conclude that the cost increases resulting from either these fines or from the technological investments to avoid them would at least partially be passed onto consumers.

The CO2 abatement costs that emerge from this penalty structure are substantial. For example, given a total of 100,000 kilometers driven over the life of the automobile, the penalty of 20 € in 2012 for each gram of CO2/km exceeding the limit curve (or 20

[3] The automobile market is a textbook example of an interdependent market structure – the individual manufacturers each face a demand for their product that is both a function of price-awareness as well as product loyalty. Due to these two influences, the demand for the product is negatively related to its own price and positively related to the prices of its competitors. The demand for automobiles in each individual market segment is likely to be considerably more elastic than for the automobile market as a whole. Given the modest number of manufacturers, this creates considerable strategic interaction in the setting of prices. An additional important factor is that the automobile industry is comprised of manufacturers who set prices based on the other manufacturers in their market segment, but which are also oriented to consumers with different preferences, particularly with respect to the mass and other associated characteristics of the vehicle.

Million € for each ton of CO2/km) would imply a CO2 price of 200 €/ton. If the life of the automobile was increased to 150,000 km, the corresponding figure would be 133 €/t, and would fall to the still high price of 100 €/t for an automobile driven 200,000 km. If we instead reference the penalty of 95 € for each gram of CO2/km announced for 2015, the corresponding CO2 abatement costs are 950 €/t, 633 €/t and 475 €/t, respectively. An appreciation for the sheer magnitude of these figures is given by a comparison with Böhringer and Löschel's (2002) estimate of 30 €/t for the medium-run price of certificates on the ETS, which sets the benchmark for CO2 abatement costs and has to date not been exceeded.

Reliance on the ETS as a mechanism for reducing greenhouse gases from road transport, as is planned for air traffic, thus appears to be a sounder approach than the legislative mandates proposed by the Commission. The caps on emissions in the participating sectors and the possibility of trading certificates among them ensures that emissions will tend to be reduced in those sectors where it is economically most efficient to do so. The trading scheme therefore can be expected to serve as a substantial and cost-effective contribution to reaching the EU's climate protection objectives. Moreover, such a scheme affords greater transparency by revealing the actual technological advancement of the individual manufacturers, as it obliges them to decide between directly reducing emissions and alternatively acquiring emission certificates. Fuel taxation, of course, represents an equally transparent policy measure, as it directly confronts motorists with increased costs of driving. Such taxes can therefore serve to internalize the social costs of fuel combustion, in turn reducing fuel consumption and emissions, while at the same time providing a source of public revenue (Storchmann 2001).

By contrast, it remains unclear whether the Commission's proposal can lead to an actual reduction of CO2 emissions, as it focuses on emissions per driven kilometer – that is, on energy efficiency – rather than on the absolute emissions level. Reason for skepticism is illustrated by the U.S. experience with the so-called CAFE standards implemented in 1975, the reliance on which has left the U.S. car fleet one of the least efficient in the industrialized world. Recent trends in Europe cast further doubt on the effectiveness of increased efficiency in achieving environmental objectives: At the

same time that the energy efficiency of new cars was improving, increasing by an average of 15% between 1995 and 2005, both vehicle mass and performance were increasing in tandem, by some 28% over the same time period (COM 2007a:5). Although this resulted in a 12.4 % reduction of the per-km emissions in the EU-15 between 1995 and 2004, from 186 to 163 g CO2/km (COM 2007 c:2), the total discharge of CO2 emissions in the transport sector increased considerably over the same time interval.

This increase can at least be partially attributed to the so-called rebound effect, a behavioral response to more efficient technology whose impact typically receives short shrift in the analysis of efficiency standards. In the case of automobiles, the rebound effect refers to the tendency to drive more when the per kilometer costs of driving is decreased through increased efficiency. A report from the United Kingdom's Energy Research Centre concludes that if rebound effects are ignored, the contribution that energy efficiency makes to reducing carbon emissions will be overestimated (Sorrell 2007). This conclusion is bolstered by a recent econometric analysis of car-owning households in Germany (Frondel, Peters, Vance 2007), which finds that up to 60% of the potential greenhouse gas savings from improved efficiency could be lost to more driving from the lower per-kilometer costs of vehicle usage.

3. The State of Technology and its Progress

Irrespective of these economic considerations, there still remains the question of how the limit value curve was conceived. Ideally, it would represent the lowest per-km emissions achievable given the future state of technology. Assuming that this ideal limit value curve could be determined precisely, this foundation would provide for a compelling argument for the obligatory compliance with this upper bound, both for the public and the manufacturers. After all, those at the technological vanguard would be saddled with relatively lighter emission reduction obligations and would thereby incur lower costs than the stragglers.

Since such an ideal limit value curve refers to both the current state of technology and future technological developments, it is, of course, not directly observable. Yet, it could be substituted by referring to an estimate based on the current state of technology. As suggested by the Commission's publications (COM 2007c:4), such an estimate is represented by the reference line in Figure 1. Depending on expectations concerning the pace of technological development, the future requirements could then be defined by referring to this line in order to approach the desired average target. For example, one could set the compulsive targets at a uniform absolute reduction with regard to this reference line, irrespective of vehicle mass. Consequentially, the limit value curve would lie parallel to the reference line such that the targeted average of 130 g CO2/km would just be achieved.

By ascribing the limit value curve a much smaller slope than the reference line displayed in Figure 1, however, manufacturers of heavier vehicles must contend with higher reduction liabilities – even in percentage terms – than their competitors producing lighter vehicles. This relation, according to which future compulsory reduction liabilities disproportionately increase with the mass of the vehicle, is shown in the last two columns of Table 1. Presumably, the assumption underlying the limit value curve (1) is that manufacturers of vehicles with higher masses and engine power have correspondingly higher potential for achieving cost-efficient reductions in emissions relative to the current state. Although this may well be true, it would nevertheless be desirable to provide convincing evidence to buttress this assumption.

Even more disconcerting, though, is the fact that the reference line put forward by the Commission (COM 2007c:4) does not accurately reflect the current state of technology, as a closer look at Figure 1 reveals. Although a clear explanation of how the line was estimated is lacking, it can be readily shown that its slope of roughly 9.5 g CO2/km for each 100 kilograms of vehicle mass is based on a linear regression that excludes the average values for both Subaru (1384 kg and 216 g CO2/km) and Porsche (1596 kg and 282 g CO2/km). As both manufacturers produce vehicles that are among those with the highest average masses, their inclusion in the estimated regression would result in a substantial increase of the slope to 21.6 g CO2/km for

each 100 kg vehicle mass, over double that of the Commission's reference line (Figure 2). Ignoring this data in the calculation not only fails to reflect the technological status quo, but also implies that both manufacturers have neglected opportunities to reduce emissions given current technologies, a rather serious accusation for which no justification is provided.

Table 1. Key Figures for major Manufacturers and Targets of the Commission (COM 2007c:5).

	Figures from 2006			Targets		
	Mass	**Emissions**	**Sales**	**Emissions**	**Reduction by**	
Manufacturer	[kg]	[g CO2/km]	[in 1 000]	[g CO2/km]	[g CO2/km]	[%]
PSA Peug.-Citr.	1201	142	1882.2	126.0	16.0	11.3
Renault	1234	147	1232.2	127.5	19.5	13.3
Fiat	1112	144	1050.9	121.9	22.1	15.3
Honda	1261	153	229.8	128.7	24.3	15.9
Toyota	1214	152	773.3	126.6	25.4	16.7
GM	1257	157	1424.8	128.5	28.5	18.1
Ford	1319	162	1490.3	131.4	30.6	18.9
Volkswagen	1366	165	2744.8	133.5	31.5	19.1
Hyundai	1349	165	461.9	132.7	32.3	19.6
Nissan	1202	164	273.9	126.0	38.0	23.2
Suzuki	1152	164	178.6	123.7	40.3	24.5
Mitsubishi	1245	169	101.1	128.0	41.0	24.3
Mazda	1296	173	229.1	130.3	42.7	24.7
BMW	1453	182	740.0	137.5	44.5	24.5
DaimlerChrysler	1472	184	860.8	138.4	45.6	24.8
Subaru	1384	216	31.5	134.3	81.7	37.8
Porsche	1596	282	39.1	144.0	138.0	48.9
Average*	**1288.8**	**159.2**		**130.0**		

*weighted by 2006 sales shares.

This misleading illustration has considerable implications for the evaluation of the current state of the industry. According to the Commission's reference line, the French and Italian manufacturers are currently at the technological forefront, as they produce cars whose per-km emissions fall under the supposed industry average

(Figure 1). By comparison, the German manufacturers have an average performance, whereby Volkswagen is slightly below the reference line and the heavier BMW and Daimler-Chrysler vehicles are slightly above it, while Porsche falls clearly short of an environmentally acceptable performance.

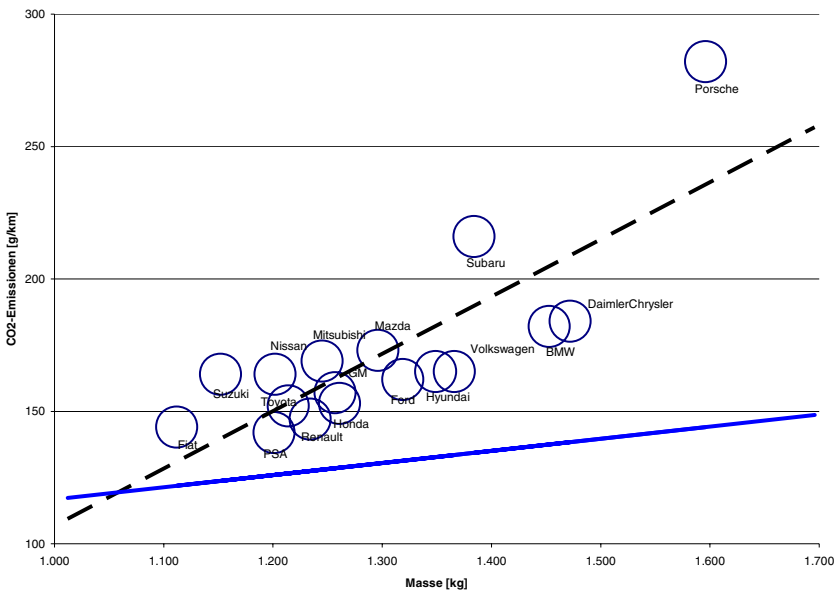
If one refers the actual reference line obtained from a regression that includes Subaru and Porsche, then the impression gleaned from Figure 1 changes markedly (Figure 2). As before, it is quite obvious that the per-km emissions of vehicles from Porsche are quite high. But a reversal has occurred for Fiat's fleet, which now lies above the actual reference line and is thus identified as environmentally lagging. In contrast, the fleets of the large German manufacturers Volkswagen, BMW, and Daimler-Chrysler now all lie below the reference line, indicating that these are the front runners. In fact, their average emissions lie even further below the actual reference line than the French manufacturers, which according to the Commission's depiction are among the leaders.

By taking into account the technological advancements that have been achieved to date, the proposal's allocation given by the limit value curve has far-reaching and acute consequences: While the actual reference line indicates a current increase of the per-km emissions of roughly 21.6 g CO2/km for each additional 100 kilograms of mass, the limit value curve indicates a considerably smaller increase of roughly 4.6 g CO2/km for each 100 kilograms. It is only such a comparison that clearly reveals the high requirements on manufacturers of large vehicles that are imposed by the Commission's proposal.

In sum, the Commission's plan implies ambitious reductions of per-km emissions for manufacturers of cars with higher masses. In particular, BMW and Daimler-Chrysler must contend with liabilities of up to nearly 25 %, whereas French and Italian manufacturers are in a relatively favourable position, with future reduction liabilities ranging between 11 % and 15 %. In light of potential effects on the competitive positions of the individual manufacturers, the emerging criticism of the Commission's proposal from the German public as well as from the German Federal Government appears to be understandable. In this regard, it bears emphasizing that

even a uniform proportional liability of 20 % for all manufacturers would lead to higher absolute reduction liabilities for producers of vehicles with higher masses compared to their lower-mass competitors. In the case of BMW, for example, the required reduction would be 36 g CO2/km, compared with less than 30 g CO2/km for Fiat.

Figure 2. Average CO2 Emissions of Major Vehicle Manufacturers 2006 (COM 2007c:4).



(– –) actual reference line: $E_{CO2} = 169{,}3 + 0{,}2163\ (M - 1.289)$
(—) limit value curve: $E_{CO2} = 130 + 0{,}0457\ (M - 1.289)$

Primarily, though, this criticism is justified by the Commission's questionable illustration of the current state of technology, which fails to put the previous technological efforts of the German car industry in perspective: the relatively low emissions of Volkswagen, BMW, and Daimler-Chrysler revealed by Figure 2 are obviously not acknowledged. The following section consequently presents three alternative allocation rules that consider the progress made by these manufacturers to a greater extent.

4. Alternative Types of Allocation

Each of the three alternative proposals discussed below takes the average reduction target of 130 g CO2/km as given. The proposals are constructed such that the goal would be reached if all the manufacturers maintained their current sales figures and reduced the per km CO2 emissions according to the proposed limits. Obviously, numerous other allocation rules can be justified that lead to the same average reduction of 130 g CO2/km, including rules based on non-linear reference targets. To maintain the tenor of the Commission's original proposal, the following alternatives are all based on linear reference lines.

Alternative (i) takes the reference line published by the Commission – with its slope of 9.5 g CO2/km for each additional 100 kg – as a reference and binds the manufacturers to a proportional reduction of 20.2% instead of the disproportionate reduction given by the limit value curve. Manufacturers of vehicles with lower masses would consequently have a slightly higher burden than that suggested by the Commission. As an example, Fiat would be obliged to reduce their per-km emissions by 19 % instead of 15.3 % (Table 2). This alternative's moderately higher burden for manufacturers of lower-mass vehicles is formally shown by the associated new target line (Figure 3), whose slope of 0.0759 is significantly higher than the limit value curve's slope of 0.0457.

As with alternative (i), alternative (ii) would maintain the Commission's reference line – despite its questionable illustration of the current state of technology – but drop the line in parallel so as to comply with the average target of 130 g CO2/km. Manufacturers of smaller cars with per-km emissions located on the Commission's reference line would consequently have to achieve higher percentage reductions than their heavier competitors located further along the line. Accusations of unfairness could be rebutted by pointing out that this line's slope of 9.5 g CO2/km for each 100 kilograms is, in any case, not representative of the true relation between vehicle mass and specific CO2 emissions. With particular regard to the reduction requirements of the German manufacturers, alternative (ii) would recognize their technological competence in combining car performance and environmental sustainability. For

example, BMW would be obliged to reduce their emissions by 36 instead of 45 g CO2/km (Table 3). Similar to alternative (i), finally, alternative (ii) also has the virtue of rewarding low-emission manufacturers with modest reduction targets, while it simultaneously punishes the stragglers with ambitious targets.

Table 2: Current Emissions and Alternative Reduction Liabilities.

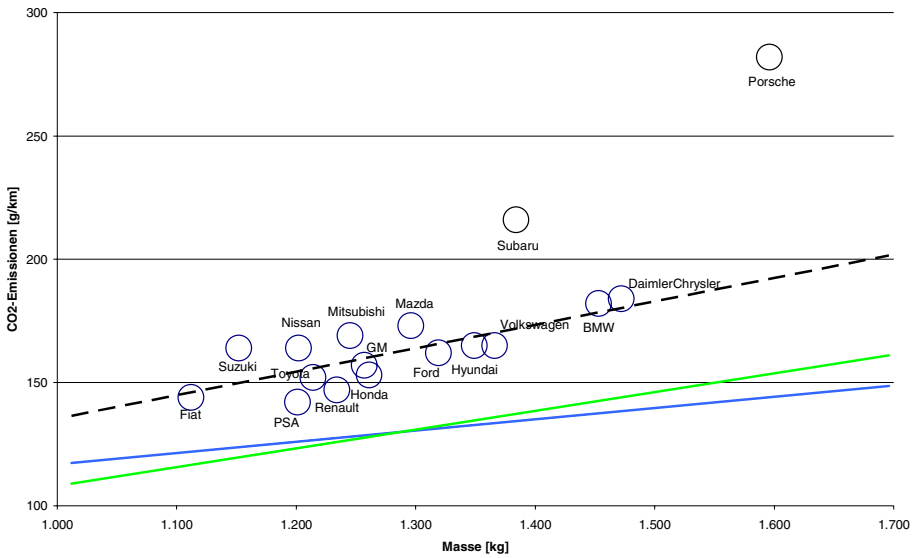
Manufacturer	Current emissions [g CO2/ km]	Plans of the Commission	Alternative (i): Proportional (20,2%) to the Commission's reference line	Alternative (ii): Same Slope as the Commission's reference line	Alternative (iii): Proportional (23,2%) to the actual reference line
PSA Peug.-Citr.	142	11.3 %	13.1 %	14.3 %	18.7 %
Renault	147	13.3 %	14.4 %	15.1 %	17.8 %
Fiat	144	15.3 %	19.0 %	21.4 %	30.1 %
Honda	153	15.9 %	16.4 %	16.8 %	18.0 %
Toyota	152	16.7 %	18.2 %	19.2 %	22.6 %
GM	157	18.1 %	18.7 %	19.1 %	20.6 %
Ford	162	18.9 %	18.3 %	18.0 %	16.7 %
Volkswagen	165	19.1 %	17.7 %	16.8 %	13.4 %
Hyundai	165	19.6 %	18.4 %	17.7 %	15.2 %
Nissan	164	23.2 %	24.7 %	25.8 %	29.5 %
Suzuki	164	24.5 %	27.1 %	28.7 %	34.6 %
Mitsubishi	169	24.3 %	25.0 %	25.5 %	27.4 %
Mazda	173	24.7 %	24.5 %	24.5 %	24.2 %
BMW	182	24.5 %	21.7 %	20.0 %	13.6 %
Daimler-Chrys.	184	24.8 %	21.8 %	19.9 %	12.8 %
Subaru	216	37.8 %	36.5 %	35.6 %	32.5 %
Porsche	282	48.9 %	45.6 %	43.5 %	35.8 %
Average	**159.2**	**130.0**	**130.0**	**130.0**	**130.0**

*weighted by 2006 sales shares.

The third alternative would refer the actual reference line from Figure 2, with its slope of 21.6 g CO2/km for each 100 kilograms, and introduce a proportional reduction of 23.2 %. Note that with respect to the actual reference line, Volkswagen, BMW, and Daimler-Chrysler emerge at the technological vanguard. They would consequently contend with a lighter emission reduction burden than that embodied

in the Commission proposal. Fiat, by contrast, would be penalized for its relatively high emissions given its low mass (Figure 5).

Figure 3: Proportional Reduction of Emissions by 20.2% to the Commission's Reference Line.



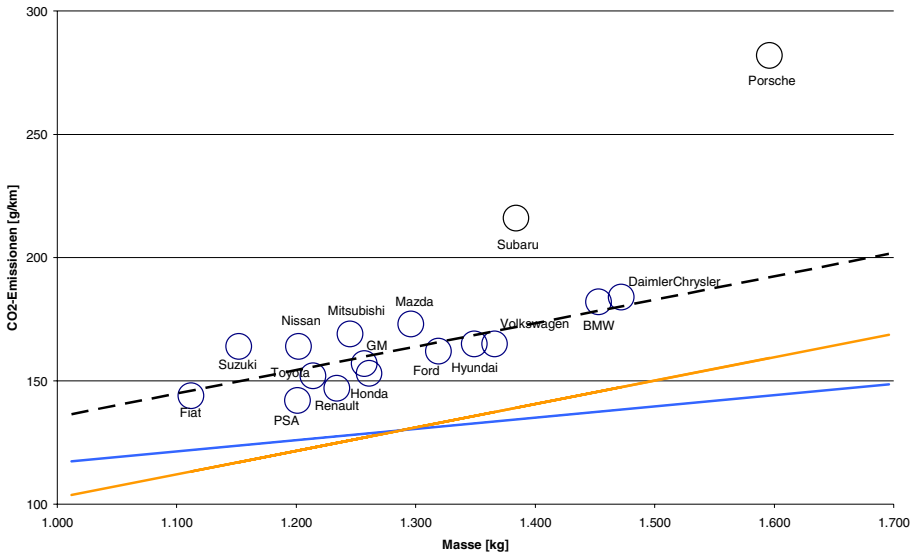
(– –) the Commission's reference line: E_{CO2} =162,84 + 0,0951 (M-1.289)

(—) limit value curve: E_{CO2} = 130 + 0,0457 (M – 1.289)

(—) proportional decrease by 20,2 %: E_{CO2} =130 + 0,0759 (M-1.289)

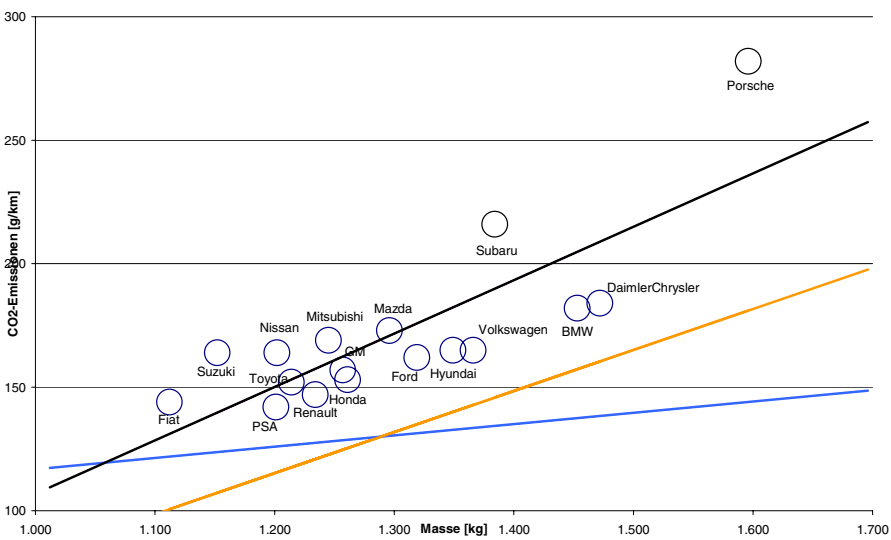
In particular, Fiat would have to reduce their per-km emissions by some 44 g CO2/km, roughly twice the amount suggested by the Commission proposal (Table 3). In contrast, the reduction liabilities of BMW and Daimler shrink by almost half. Nevertheless, it bears emphasizing that, in absolute terms, the technological pioneers and manufacturers of low-mass vehicles still have a lighter burden than the technological laggards and manufacturers of high-mass vehicles. Indeed, all three alternatives share the imposition of a high reduction burden for Porsche, the evident "ecological black sheep" with respect to emissions.

Figure 4: Parallel Reduction of Emissions to the Commission's Reference Line.



(– –) the Commission's reference line: E_{CO2} =162,84 + 0,0951 (M-1.289)
(—) limit value curve: E_{CO2} = 130 + 0,0457 (M – 1.289)
(—) decrease parallel to EC reference line: E_{CO2} = 130 + 0,0951 (M-1289)

Figure 5: Proportional Reduction by 23.2 % to the actual Reference Line.



(—) actual reference line: E_{CO2} = 169,3 + 0,2163 (M – 1.289)
(—) limit value curve: E_{CO2} = 130 + 0,0457 (M – 1.289)
(—) proportional decrease to the actual reference line: E_{CO2} = 130 + 0.1661 (M-1.289)

Table 3: Alternative Targeted Emissions Reduction Liabilities in g CO2/km.

Manufacturers	Current Emissions	Plans of the Commission		Alternative (i): Proportional (20,2%) to the Commission's reference line		Alternative (ii): Same Slope as the Commission's reference line		Alternative (iii): Proportional (23,2%) to the actual reference line	
PSA Peug.-Citr.	142	126.0	16.0	123.3	18.7	121.7	20.3	115.4	26.6
Renault	147	127.5	19.5	125.8	21.2	124.8	22.2	120.9	26.1
Fiat	144	121.9	22.1	116.6	27.4	113.2	30.8	100.6	43.4
Honda	153	128.7	24.3	127.9	25.1	127.4	25.6	125.4	27.6
Toyota	152	126.6	25.4	124.3	27.7	122.9	29.1	117.6	34.4
GM	157	128.5	28.5	127.6	29.4	127.0	30.0	124.7	32.3
Ford	162	131.4	30.6	132.3	29.7	132.9	29.1	135.0	27.0
Volkswagen	165	133.5	31.5	135.9	29.1	137.3	27.7	142.8	22.2
Hyundai	165	132.7	32.3	134.6	30.4	135.7	29.3	140.0	25.0
Nissan	164	126.0	38.0	123.4	40.6	121.7	42.3	115.6	48.4
Suzuki	164	123.7	40.3	119.6	44.4	117.0	47.0	107.3	56.7
Mitsubishi	169	128.0	41.0	126.7	42.3	125.8	43.2	122.7	46.3
Mazda	173	130.3	42.7	130.5	42.5	130.7	42.3	131.2	41.8
BMW	182	137.5	44.5	142.5	39.5	145.6	36.4	157.3	24.7
Daimler-Chry.	184	138.4	45.6	143.9	40.1	147.4	36.6	160.4	23.6
Subaru	216	134.3	81.7	137.2	78.8	139.1	76.9	145.8	70.2
Porsche	282	144.0	138.0	153.3	128.7	159.2	122.8	181.0	101.0
Average*	**159.2**	**130.0**		**130.0**		**130.0**		**130.0**	

*weighted by 2006 sales shares.

5. Summary and Conclusion

It is perhaps no surprise that those most adversely affected by a political intervention are often the loudest critics. Nevertheless, the analysis undertaken in this paper suggests that the resistance met by the Commission's proposal to limit per-km CO2 emissions, particularly in Germany, has merit and thus deserves consideration as the legislative process continues. Although one might expect that the basic concept underlying the proposal is well-founded, particularly given the extensive economic reverberations that are likely to follow, the logic underpinning the details of its implementation remains opaque. This lack of transparency applies especially to the cornerstone of the proposal, the so-called limit value curve, which relates future per-

km CO2 emissions to the vehicle mass, leaving the outsider with the impression that it was set arbitrarily.

A similar impression is unfortunately conveyed by the Commission's questionable depiction of the current state of technology, which completely ignores the influence of two manufacturers, Porsche and Subaru. We argue that any given curve specifying future allowable emissions must be based on both the correctly determined current state of technology and the expected technological progress. Since an accurate anticipation of the technological progress remains difficult, we used the Commission's proposal as a basis for developing three alternative curves ensuring that the target of 130 g CO2/km by 2012 is achieved while simultaneously allocating the reduction burdens to the various car manufacturers in different ways. Our primary concern was in providing justifications for the alternative allocation methods.

Given the high CO2 abatement cost linked to the Commission's proposal as well as the principal difficulties in determining and incorporating technological progress into per-km emissions targets, the question arises as to whether policy should instead be aimed at absolute reductions of emissions, which is, ultimately, what climate protection is about. The integration of road traffic into the Emissions Trading Scheme affords one promising alternative. Another promising option would be to harmonize and gradually increase petroleum taxation across Europe. In contrast to its standing in the Commission's proposal, this is an area in which Germany clearly stands out as one of Europe's leaders, with a fuel taxation rate second only to the United Kingdom's. With respect to per-km emissions, by contrast, this paper has shown that the identification of leaders and laggards is less evident, and may consequently be subject to highly contentious and ultimately counterproductive politicking.

References

Baumol, W.J., Oates, W.E. (1971) The Use of Standards and Prices for Protection of the Environment, *The Swedish Journal of Economics* **73(1)**, 42-54.

Böhringer, C., Löschel, A. (2002) Assessing the Costs of Compliance: The Kyoto Protocol, *European Environment* **12**, 1-16.

COM – EU-Commission (2007a) Results of the Review of the Community Strategy to Reduce CO2 Emissions from Passenger Cars and Light-commercial Vehicles: Impact Assessment, February 7, 2007, SEC(2007) 60.

COM – EU-Commission (2007b) Proposal for a Regulation of the European Parliament and of the Council: Setting Emission Performance Standards for New Passenger Cars as Part of the Community's Integrated Approach to Reduce CO2 Emissions from Light-duty Vehicles, December 19, 2007, COM(2007) 856 final, Brussels.

COM – EU-Commission (2007c) Questions and Answers on the Proposed Regulation to Reduce CO_2 Emissions from Cars, December 19, 2007, Memo/07/597, Brussels.

EEA – European Environment Agency (2007) Greenhouse Gas Emission Trends and Projections in Europe 2007 – Tracking Progress Towards Kyoto Targets, EEA report 5/2007, Copenhagen.

Frondel, M., Peters, J., Vance, C. (2007) Identifying the Rebound: Evidence from a German Household Panel, Ruhr Economic Papers 32, Essen, forthcoming in *The Energy Journal*.

Sorrell, S. (2007) *The rebound effect: An assessment of the evidence for economy-wide energy savings from improved energy efficiency*. UK Energy Research Centre (UKERC). Review of evidence for the rebound effect. www.ukerc.ac.uk.

Storchmann, K.H. (2001) The Impact of Fuel Taxes on Public Transport – An Empirical Assessment for Germany, *Transport Policy* **8**: 19-28.