Car Taxes and CO_2 emissions in EU

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Summary

The fuel efficiency of passenger cars is often emphasised as one of the most significant areas of action in terms of limiting the transport sector's CO2 emission levels. This could be achieved either on the supply side through the technological development of cars, or through demand-side measures such as influencing first time buyers' choice of car.

The aim of this article is to present a model for analysis of the demand side, more specifically the relation between the CO_2 emissions from new cars and the car taxation related to new car purchases in EU. The purpose of the model is twofold. Firstly, it should be used to analyse the CO_2 efficiency of the car taxation in each member state. Secondly, results from model calculations should be used to illustrate what are the possibilities for the individual member states to reduce their CO2 emissions from new cars. It should be noted that this paper mainly covers methodological aspects and results, since no CO_2 reduction results are available at this stage.

The model is based on a revised and enhanced version of the Danish Car Choice model from 1997 combined with car characteristics, socio-economic data and car taxation data from the EU member states.

Introduction

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

An important step is, however, that the agreements between the Commission and the car manufacturer, ACEA, KAMA and JAMA, respectively, is supposed to reduce average new car CO_2 emissions, mainly through technical developments down to 140 grams per kilometre by 2008/2009.

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

The purpose of this study is to analyse the CO_2 efficiency of the national taxation systems using a "common yardstick", and thereby enabling individual Member States to assess their own possibilities to improve the energy efficiency of new cars through fiscal measures.

The analysis is carried out under the guidance and supervision of the EU DG-ENV, the EU DG-TAXUD and a Sub Group consisting of experts from the member states. The work was initiated late year 2000 and it is expected that the Commission will publish the results from the study in the beginning of year 2002.

Analysis framework

The purpose of the analysis is to provide the member states with information on the relation between the car tax structure and the CO_2 efficiency of new cars.

To do this, the tax system in each in each individual country is analysed in a systematic manner in a scenario approach. The scenario approach applied to each country consists of the following elements:

- Studying the potential for CO_2 reductions
- CO_2 effectiveness of the existing national taxation systems
- General modification of the national tax structure
- CO_2 based tax structure
- Country specific calculations

Studying the potential for CO_2 reductions

In order to illustrate the technical conditions, under which the fiscal measures will operate in the national environments, two calculations illustrating the potential for CO_2 reduction are made:

- The technical potential
- Break-even for diesel cars

None of these calculations include the behavioural effects of the fiscal measures, but only illustrate the maximum potential for CO_2 reduction. The starting point is the base case 2008 and the associated CO_2 emissions.

In the first calculation it is assumed that the emissions of all cars within each category (Mini, Small, Lower medium, etc) attain the fuel efficiency levels of the best performing vehicle within the category. This calculation is only illustrative, since it would not be possible to change consumers’ behaviour so radically by using only fiscal incentives. It also has nothing to do with measuring market distortions. However, it illustrates the purely *technical* possibilities for increasing the fuel efficiency of the new car purchase. It is within this range, that the fiscal measures can operate, and the technical potential has to be larger than that needed to reach the CO_2 target.

CO_2 effectiveness of the existing national taxation systems

The second wave of scenarios concerns the CO_2 effectiveness of the existing national taxation system. In these scenarios the tax base and basic structure of the existing national taxation systems are unaltered, but the level of taxation is increased.

There are two types of calculations in these scenarios. In the first set of calculations, the existing taxes are increased, using the existing differentiation of taxes according to e.g. weight or value. In the second set of calculations, the differentiation of the existing taxes is altered to improve the CO_2 incentives of the taxation system, but still using the existing parameters.

For example, in the first set of calculations a national weight tax could be increased with a certain percentage for all cars, using the existing weight categories. The second set of calculations could be a steeper differentiation according to weight, as this would be likely to improve the CO_2 efficiency of the new car purchases.

Inclusion of CO_2 element in existing tax structure

In the third wave of scenarios, the existing national taxation systems are supplemented with a differentiated CO_2 element for either the registration tax or the circulation tax.

Using the example with weight tax mentioned above, the starting point would be the current national weight tax (without increases or increased differentiation). A CO_2 differentiation circulation tax could be added to this existing tax. The tax would then be a combination of a weight tax and a CO_2 based tax.

CO_2 based tax structure

The fourth wave of scenarios comprise scenarios where it is assumed that the existing national taxation systems are completely replaced by a taxation system with CO_2 performance of the cars as the tax base. The CO_2 differentiated taxes could be introduced for both registration tax and circulation tax. The tax structure will be determined in a CO_2 optimal way for each national tax system.

In these scenario of calculations, a CO_2 incentive will also be included. The CO_2 incentive will provide a subsidy for the most energy efficient cars, and be balanced against a CO_2 based tax for the less CO_2 efficient cars. A calculation on a simultaneous change in registration tax, circulation tax and CO_2 incentive will be carried out as a part of the wave of calculations.

Country specific calculations

Further to the general principles for modifications of the tax structure, member state specific calculations will be carried out, to the extent that such requests have been put forward by the national authorities.

Boundary conditions

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

- Fleet composition neutrality (i.e. no downsizing),
- Revenue neutrality,
- The share of diesel cars.

Analysis is carried out through an iterative process, seeking to maximise CO2 reductions subject to the boundary conditions. In practice this is done by making small changes to the taxes and recording the marginal changes in CO2 emissions relative to the "costs" in terms of boundary conditions. The model itself does not include such a tool. In the calculation this is carried out in a co-run between excel and access.

Analytical tool, the car choice model

The analysis tool is based on a further developed version of the Danish Car Choice model (presented at Trafikdage 1999).

Improvements

- Modelling allocation between company cars and private cars
- Inclusion of company car taxation
- New model implementation
- Validation

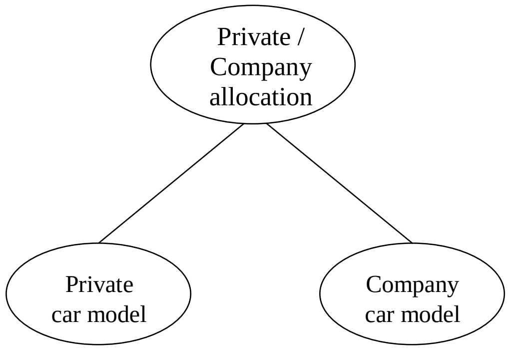
The following subsection describes the revised model. After that a few examples of the model validation is given.

The revised car choice model

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

The car choice model framework

The car choice model consists of three sub models.



Private/company split

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

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

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

$$P(Companycar) = \frac{e^V}{e^V + 1} \qquad V = \beta * B + \alpha * C$$

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

The private car model

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

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

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

The probability for choosing car i is based on the explanatory variables.

$$P(i,j) = P(j) * P(i \mid j) \qquad = \frac{e^{\theta \log \sum_{i \in J} e^{V_i}}}{\sum_{j \in J} e^{\theta \log \sum_{i \in J} e^{V_i}}} * \frac{e^{V_i}}{\sum_{i \in J} e^{V_i}} \quad \text{(Nested logit)}$$

Company car model

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

- Cost of acquisition (Company cost and Personal company car taxation)
- Running cost (including company car taxation)
- Size of the car (length) and Luggage capacity
- Acceleration and Horse power

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

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

Validation

The tests have comparred results from model calculations with recorded data in order to assess the models ability to calculate the actual demand within a tolerable level of accuracy. The following three parameters have been considered:

- CO_2 emission levels
- New car registrations
- Estimates of parameter (elasticities).

The validity of the model parameters has been tested against similar parameters at EU level (i.e. considering 11 Member States (as many as there were data available on at the time of testing). These tests and more detailed tests confirmed the general validity of the model.

CO_2 emission levels

The following figures show the results of the validation tests for both petrol- and diesel-fuelled cars, respectively. The calculations have been made separately for company cars and private cars due to the difference in emission level trends among these two groups.

Figure 1. Modelled CO_2 emissions compared to observed CO_2 emissions for petrol cars in Germany and Denmark (1999/2000)

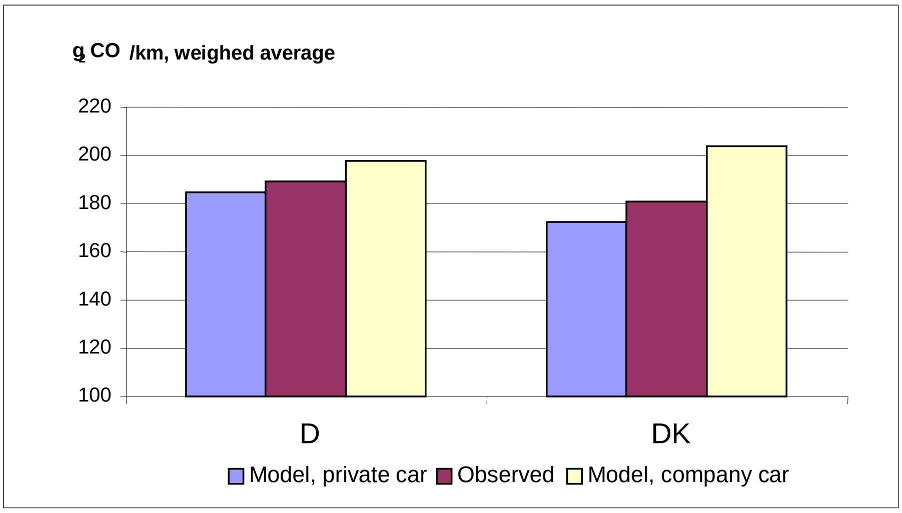
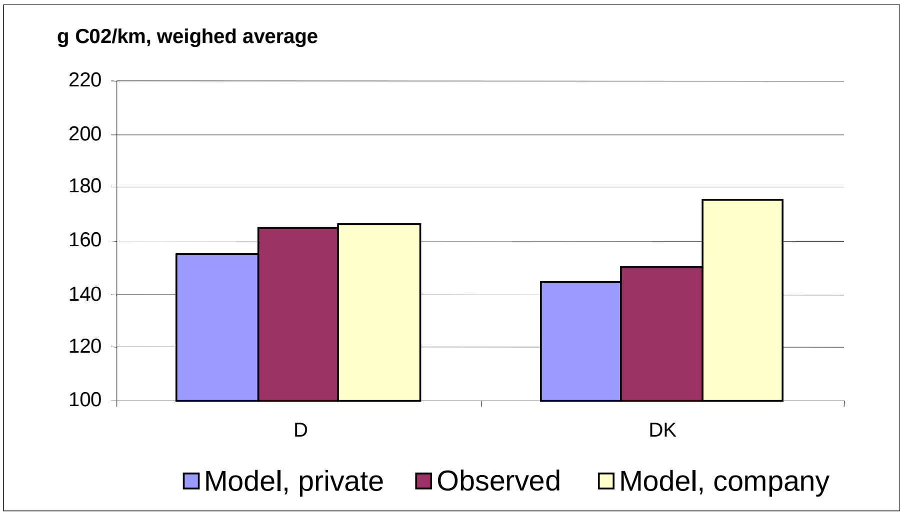


Figure 2 Modelled CO_2 emissions compared to observed CO_2 emissions for diesel cars in Germany and Denmark (1999/2000)



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

New car registrations

The following figures show results from a more detailed validation test. On an overall level, the number of registrations calculated by the model correlate well with observed data. However, there are also some deviations from the observed data that cannot be explained by the model. For example, Figure 3 shows that the model calculates too many registrations in the region of 165g of CO_2 per km. These unexplained deviations are largely caused by country-specific preferences that the model cannot capture. However, the effects from such country specific preferences are assessed to be minor in the context of this study.

Figure 3 Number of registrations as a function of CO_2 emissions for petrol cars (g per km) in Germany

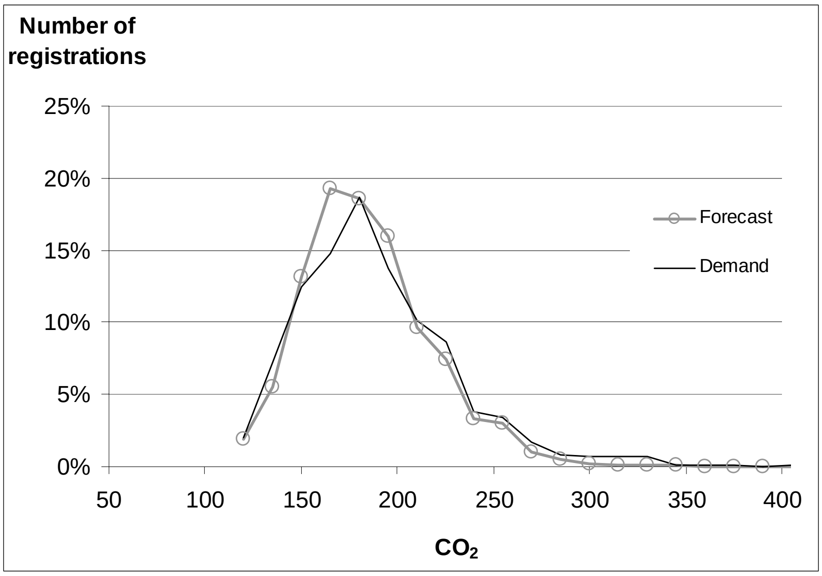
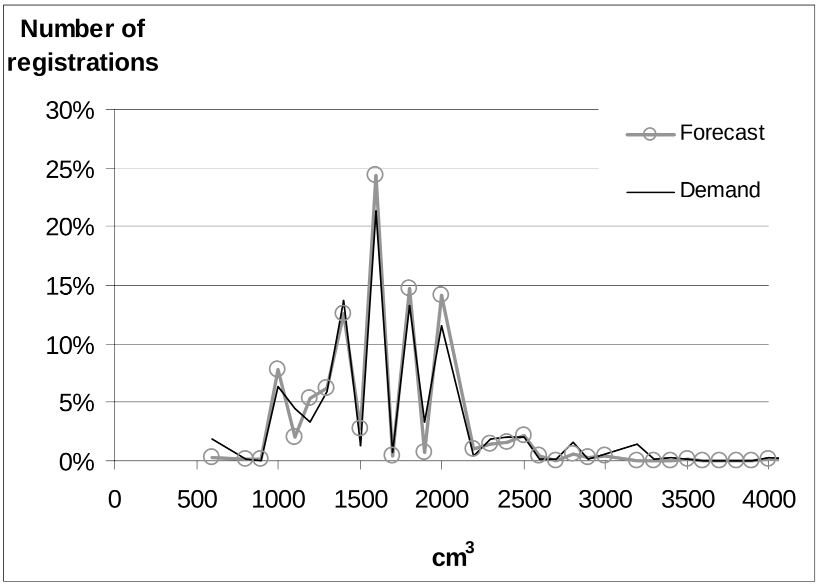


Figure 4 Number of registrations as a function of engine size volume (ccm) for petrol cars in Germany



Input

This section gives a short description of what is needed to run the model.

- Socio-economic data for car purchasers
- Car characteristics
- Taxes related to acquistion and use of car

Socio-economics

The model is based on separate models for different types of families. To enable the model to resemble the situation in each country, information on family structure combined with income distribution in each country is needed.

Car characteristics

As mentioned above the driving force in the model is the following parameters:

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

The model needs information on these characteristics for each car on the market in each country.

Taxes

Taxes constitute an important part of the both running costs and car prices in most countries. The following table provides an overview of the registration tax in the Member states.

Registration tax

Table 0.1 Tax base on registration tax of passenger cars.

	Cm^3	Value	Fuel	Fixed	None
Ireland	X	X			
Belgium	X				
Spain	X				
Greece	X				
Portugal	X				
Austria		X	X		
Denmark		X			
Netherlands		X			
Finland		X			
Germany					X
France					X
Italy				X	
Luxembourg					X
Sweden					X
United Kingdom					X

There is no uniformity regarding the actual design of the registration tax among Member States, as can be seen from the table above. In some cases the registration tax is related to the physical characteristics of the car (e.g. cylinder capacity or fuel consumption) whereas in other cases it is related to the price of the car.

Circulation tax

From the following table it can be seen that all Member States impose some form of circulation tax on passenger cars. This tax is levied annually according to a variety of criteria among, e.g. weight, cylinder capacity, fuel consumption and engine performance of the vehicle.

Table 0.2 Tax base on circulation tax of passenger cars year 2000.

	Cm^3	HP	Weight	Fuel
Ireland	X			
Portugal	X			
Austria	X			
Germany	X			
Luxembourg	X			
United Kingdom	X			
Belgium		X		
Spain		X		
Greece		X		
France		X		
Italy		X		
Finland			(x)	
Netherlands			X	
Sweden			X	
Denmark				X

Please note that this table shows existing circulation taxes in year 2000. In the UK a new scheme came into force in March 2001. In this scheme, the tax is based on CO_2 emissions. The Dutch circulation tax has also been changed to a more CO_2 related tax since year 2000.

Results

There are three types of results from the study:

- Can the Danish model be used to analyse car demand in other countries?
- How should the study be structured in order to provide comparable results and at the same time take some of the political constraints into account?
- To what extent is it possible to improve the CO_2 efficiency of new cars by fiscal measures?

At this stage the analysis has shown that the revised model is capable to estimate car demand in other countries than Denmark with a reasonable accuracy, given that the model is supplemented with the relevant data (socio-economics and car characteristics).

Furthermore, the study has developed a scenario approach where a special routine seeks to maximise CO_2 reductions subject to a set of boundary conditions. This approach improves the comparability of the results between different countries.

Finally, at a later stage, when the analysis have been finalised it should be possible to give answers to questions such as:

- Is it possible to reduce CO2 emissions substantially without, at the same time, creating downsizing
- Can we obtain significant CO_2 reductions using the existing tax structures (tax base), e.g. by increasing taxes.
- Is the registration tax a more efficient means to obtain CO_2 reductions than the circulation tax
- How high a level of CO_2 differentiation is needed to obtain significant reductions.