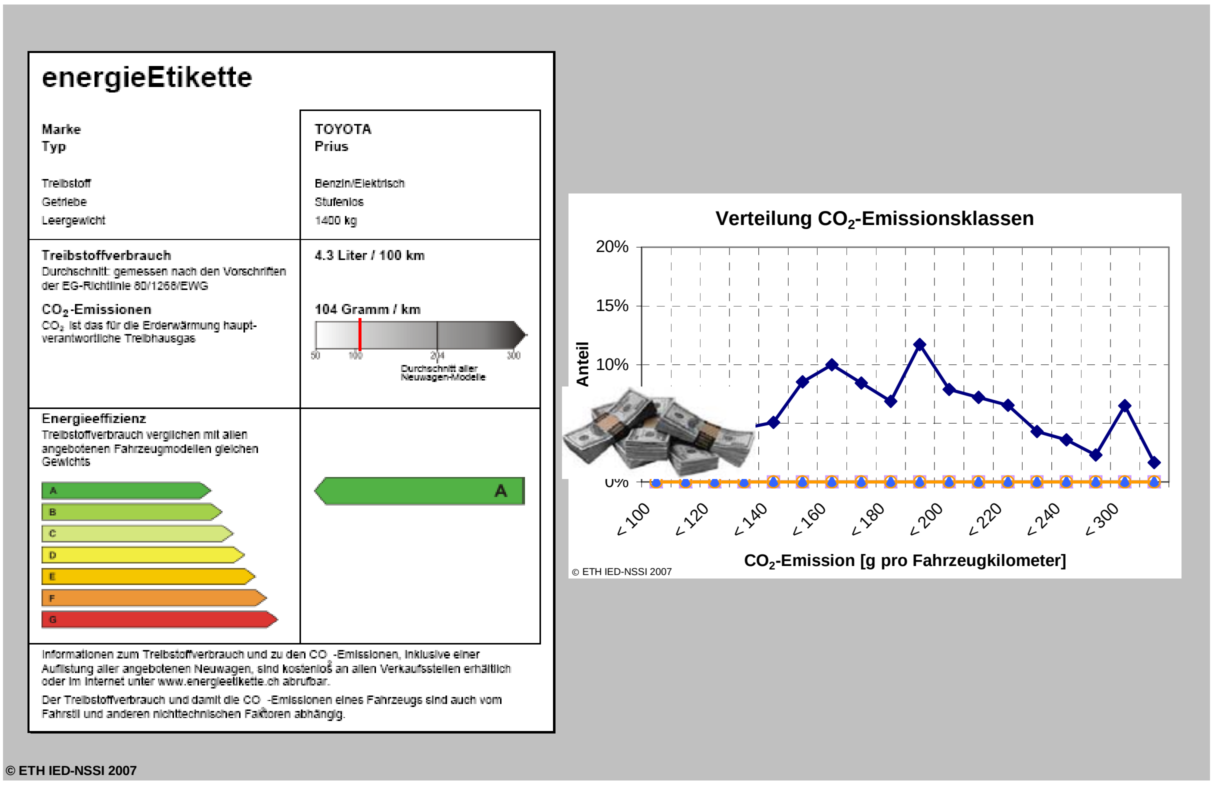

Reducing CO_2 emissions from passenger cars by promoting energy-efficiency

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Conference paper STRC 2007

STRC

7th Swiss Transport Research Conference
Monte Verità / Ascona, Sept. 12. – 14. 2007

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September 2007

Abstract

In this paper we simulate the Swiss car market in order to forecast the effects of governmental feebate systems. For the simulations we apply a multi-agent based approach with a discrete choice model of the logit type and with different coefficients for 40 agent types. It is described and validated using historical market data for Switzerland. Main strengths of the simulation model are its elements ensuring bounded rationality, and the incorporation of psychological effects relevant to incentive payments. In order to simulate and evaluate changes in average car size induced by feebate systems, we use a highly resolved fleet of available new cars (over 2000 different combinations of make, model, engine, and power-train). Market simulations are performed for different feebate systems, consisting of an incentive payment for vehicles with high energy-efficiency, and a general sales tax increase in order to ensure revenue neutrality. Eligibility for feebates payments is based on a relative energy-efficiency, i.e., CO_2 emission in relation to curb (empty vehicle) weight. This is compared to the use of (absolute) CO_2 emissions alone as the basis for incentive eligibility. We conclude that feebate systems based on relative energy-efficiency perform equal to those based on absolute CO_2 emissions.

Keywords

car market, energy efficiency, feebates, bonus-malus scheme, carrot-and-stick policy, CO_2 tax, environmental policy

1. Introduction

There are many reasons to reduce consumption of non-renewable energy resources. Along with the complementing strategies of shifting to renewable energy sources and reductions in demand, a drastic increase in energy efficiency is needed for significantly reducing consumption of non-renewable energy resources. In OECD countries, road transport is the second-largest sector of energy consumption (IEA and OECD, 2003). Together with air transport, it is the only sector in the EU where energy consumption is still growing instead of decreasing.

While engineers make stunning progress in improving efficiency of internal combustion engines, a large potential for improvement in energy efficiency persists in increasing consumer adoption of energy-efficient cars (DeCicco, 2006). This delineates the mechanisms of consumer behavior in general and of car purchase behavior in particular as decisive factors in reducing energy consumption.

Feebate systems combining fees for the purchase of highly energy inefficient vehicles with rebates for very efficient ones are proposed as a feasible instrument to change consumers' car choices (see also Johnson 2007). They offer various advantages compared to measures like fuel economy standards or fuel taxes (see Greene et al. 2005). Such feebate systems have been widely considered by various governments (Greene et al. 2005) and have become implemented in various European countries in recent years. While real-world experience mostly have not been evaluated yet, various studies have modeled effects of feebates (Langer 2005, Bendor and Ford 2006).

The term feebate comes from the combination of rebates awarded to products with good environmental performance with additional fees for products which have above-average environmental impact. Rebates might also take the form of cash payments, tax refunds, or other incentives. Fees might be either surplus taxes or a separate registration fee that is billed separately from any other existing type of tax. In terms of policy instruments, a feebate can be described as an emissions tax combined with a refunded (i.e., negative) consumption tax, the balance of which can be either positive (a fee) or negative (a rebate) depending on how a taxed product's emissions compares to the market average.

In this paper we investigate refunded tax schemes (also proposed by Johnson (2007) as solution to the dilemma between cap-and-trade instruments on the one hand and emission taxes on the other). BenDor and Ford (2006) analyze feebate schemes and analyze possible changes in purchasing behavior regarding various fuel types (gasoline, alcohol, electricity and compressed natural gas). However, there is a lack in current research for simulation tools that can actually predict how consumers react on feebate schemes and other incentives that aim at influencing car purchase behavior in the direction of increased energy-efficiency. Consumers may react by changing to smaller cars or by changing to smaller (i.e., more energy-efficient) engines. Survey results as well as common sense let us expect that consumers are more likely to change to smaller engines, and only a smaller share of effective behavioral changes will be due to decreases in car size. We therefore present a simulation approach that should be able to allow for, and to distinguish both types of behavioral changes.

In the following section we frame our area of research, starting from the EU’s strategy to reduce CO2 emissions from cars, and the resulting need for fiscal policy tools to influence consumer behavior when purchasing new cars. In Section 3 we introduce the specific class of policy tools that we want to investigate further, feebate schemes. Section 4 presents the microsimulation method used to predict consumer reactions, financial volume, and environmental benefits of four different feebate schemes. We discuss these findings in Section 5 and draw conclusions for future research in Section 6.

2. Fiscal measures to reduce CO_2 emissions from passenger cars

2.1 Current EU strategy

The strategy of the European Union to reduce CO_2 emissions from cars (EU 1995) consists of three pillars, the first one being agreements with manufacturers to bring down average CO_2 emissions of new car registrations to 140 g/km in 2008 (European car makers) or 2009 (Korean and Japanese car makers). There is an annual reporting scheme to observe the progress being made. The strategy's second pillar is consumer information (including booklets reporting fuel consumption of all car models on the market, and compulsory information posters at the point of sale), with the most important part being compulsory energy-labels for all new cars being on display for sale. These labels must contain fuel consumption and CO_2 emissions; on a voluntary basis member states may also prescribe additional information where the car in question is rated or ranked in a certain category (see Section 3.1). The strategy's third pillar consists of fiscal measures that aim at influencing the behavior of consumers when purchasing new cars.

The mid-term target of the European Commission is 120 g/km by 2010 or 2012 at the latest (EU 2005). As the observed progress slowed down from over 1% CO_2 reduction annually (from 1995 to 2003) to 0.6% annually (since 2004), this mid-term target can hardly be reached. Therefore the European Commission wants to introduce additional, fiscal measures (EU 2007). The present paper investigates one widely debated type of measure that complies with strategy's third pillar.

2.2 Overview of policy tools to reduce CO_2 emissions

There is a variety of possible actions to reduce fossil energy demand (and hence CO_2 emissions), and there is an intense debate which line of action should be preferred conditional to which sets of criteria. Industrialized countries may either reduce domestic energy demand, or transfer money abroad for more effective measures in other countries (e.g. Clean Development Mechanism within Kyoto protocol framework). Energy demand reductions might either be sought within the transportation sector (which shows low short-term elasticity of demand with respect to fuel price changes) or in other economic sectors (reducing energy needed for buildings or for industrial processes, or lowering consumption of energy-intensive goods). Within the transportation sector, options include individual mobility on the one hand, and commercial traffic, public transport and transport of goods on the other hand. The technical potential to reduce energy demand from individual mobility is considerable. Options include downsizing in engine size, switch to smaller cars, and technical improvements (more efficient engines, hybrid-electric powertrains, etc.). However past experiences have shown that the willingness-to-pay of individual consumers for larger and higher powered cars is still increasing and even overcompensates, together with steadily increasing annual mileage per inhabitant, the technical progress. In Switzerland for example, from 1996 to 2005, the fuel efficiency of passenger cars increased by 1.3% per year, but as vehicle miles traveled grew by 2.7% annually (driven by average annual population and GDP growth rates of 0.53% and 2.92%, respectively), CO_2 emissions from individual mobility actually increased by 1.4% on a yearly basis.

In this paper, we focus on energy demand reduction measures that limit themselves to decreases of domestic energy demand from individual mobility only. This is motivated by the fact that domestic individual mobility is the very sector still showing growing energy demand. We will show that the cost-effectiveness of the measures regarded is competitive with other measures that are either non-domestic or not in the individual transportation sector. We limit ourselves even further by only taking into account revenue-neutral incentive schemes that on average do not impact on the governmental budget. The income side of such incentive schemes covers the administrative costs, transfer costs, and premiums paid out. Other policy tools to lower domestic energy demand by individual mobility, like technical standards, higher taxes, voluntary agreements with manufacturers, information campaigns, emission certificate systems, etc., are not the scope of the present paper.

2.3 Effects of incentive schemes within and outside of simulation system boundary

Incentive schemes (including premium payments, tax breaks, etc.) have impacts both on the demand and on the supply side, and both short-term and long-term, as follows:

a) direct change of demand (price elasticity), i.e. higher demand for those fuel-efficient vehicles that are eligible for incentives;

b) indirect change of demand as incentive schemes also have a normative impact, causing changes in the norms and preferences of consumers and in their decision making;

c) short-term impact on supply side as manufacturers adapt their marketing and production mix to the new situation (driven by higher sales volumes for those vehicles being eligible for incentives);

d) long-term impact on supply side as manufacturers adapt their research and development means and ultimately bring new vehicle technology to the market that would not have entered the market at that time had the incentive scheme not been in place.

Typical research either deals with (a) or with (d), but hardly both effects together. We do not know of any literature on quantitative modeling of effects (b) and (c). This paper only deals with effects of type (a), and partly (b).

2.4 Possible benefits and drawbacks of incentive schemes influencing car purchase behavior

Incentive schemes have various impacts on the new car market and, intentionally, on the environmental load of new car registrations. Along the advantages is the internalization of external costs of road transport, which in principle leads to economic gains according to the theory of external costs. Other advantages are the promotion of fuel-efficient vehicles (the direct, intended effect) and of environment-friendly individual behavior. The latter may also influence consumer behavior in other energy-relevant consumption field, through increased perception of energy and climate issues (the indirect effect). However, incentive schemes in principle also have disadvantages. There is more governmental regulation with corresponding administrative costs, and every governmental intervention on the market economy runs at risk of lowering the efficiency of the market segment in question. Moreover, market actors experience adaptation costs, and any regulation is exposed to the risk of not being able to adapt fast enough to technological changes (Nilsson 2007). Another principal disadvantage is that consumers may feel overloaded with information, if other fiscal measures in other fields of energy consumption are active at the same time. Therefore, it is crucial to avoid or minimize these potential disadvantages when designing incentive schemes that aim at influencing new car purchase behavior of individuals.

3. Definition of feebates policies

3.1 Energy-efficiency labeling for passenger cars

Since 2003 all new cars in Switzerland on display for sale must carry an energy label in prescribed format. The label consists of seven arrow-shaped bars labeled from "A" (best fuel-efficiency) to "G" (lowest fuel-efficiency), color-coded from green ("A") to red ("G"). The label is similar in appearance to the one for household appliances in Europe. Several European countries use this type of label for passenger cars (United Kingdom, Belgium, Denmark, Netherlands, France, Spain) or consider to do so (Portugal, Germany). The label in principle merely serves as consumer information, and as such is part of the second pillar of the "Community Strategy to Reduce CO_2 Emissions from Cars and to Improve Fuel-Efficiency" of the European Union. Several countries now also use the classification of passenger cars into the categories A to G as a basis for incentive schemes or tax schemes (United Kingdom, Netherlands, Portugal).

While there is a certain degree of uniformity on the side of the appearance of the labeling system, every country has its own basis on which classification into categories A to G takes place. Under the "absolute" notion of energy-efficiency, only the absolute level of rated CO_2 emissions of the vehicle in question determines its energy-efficiency label (e.g., United Kingdom, Belgium, Denmark, France, each using different bounds between classes). As alternative approach, a "relative" energy-efficiency may be computed using the ratio of rated CO_2 emissions to car size. Car size may be operationalized by vehicle floorspace (e.g., Netherlands) or by curb weight (e.g., Switzerland).

For the present paper, we adopt the Swiss definition of energy-efficiency, *ee*, being defined as

$$ee = \frac{FC_m}{m_0 + m^a}$$

Where *FCm* is fuel consumption in mass units (for gasoline we assume an average density of 745 kg m^{-3}, for diesel 829 kg m^{-3}), $m_0 = 600$ kg is a constant in mass units, *m* is curb weight, and $a = 0.9$. The m_0 constant is introduced to compensate for the fact that small engines cannot reach the same thermodynamical efficiency as large engines. For the simulations in the present paper, boundaries between classes A and B, and so forth until boundary F/G, are *ee* = 3.671, 4.077, 4.483, 4.889, 5.294, and 5.700, respectively. According to Swiss law, these boundaries will be adjusted every second year in order to keep pace with technological development and to ensure that always one-seventh of all model types being on sale has an "A" label.

3.2 Design of revenue-neutral feebate schemes

A feebate scheme combines fees (additional payments or increased tax for the purchase of a product with high environmental burden) with rebates (tax breaks or cash incentive payments) for environment-friendly products. In most cases such schemes are revenue-neutral, i.e., the fees should amount to the sum of implementation costs and total volume of rebates. Feebate systems basically are a refunded tax.

Feebate systems have already been introduced in several European countries (see Section 2). They can be designed in a variety of ways, and the choice should be based on the need to maximize effectiveness and equity at the lowest possible transaction and implementation costs. Careful consideration should be given to simplicity and fairness in program design, compatibility and coordination with other local vehicle and tax-related programs, the likelihood of “leakage” and, most importantly, the potential for realizing significant emissions benefits.

Feebates could be designed to include only CO_2 (including other greenhouse gases [GHG] expressed in CO_2 equivalents) or both CO_2 and emissions of criteria atmospheric pollutants (CAP) like hydrocarbons, oxides of nitrogen, and carbon monoxide. If the latter, weights could be given to CAPs and GHGs, e.g., half of the feebate calculation would be based on fuel economy and the other half on tailpipe emissions of criteria pollutants. This makes the calculation slightly more complicated, but also rewards consumers of otherwise “clean” vehicles.

Another issue of ongoing debate is whether feebates should be based on relative or absolute energy-efficiency. This is not the topic of the present paper, we investigate this elsewhere.

4. Scenarios and model results

4.1 Simulation model

The car market microsimulation model described by Mueller and de Haan (200x) is employed. It has been developed by the authors and is primarily used to assess potential effects of fiscal measures to reduce CO_2 emissions from new passenger cars. The built-in decision model is a logit approach originally developed for European Commission's Directorate General for Environment (COWI 2002). Using a multi-agent system, we simulate individual car choice, using a synthetic population which represents the population of a country, e.g. Switzerland. As a result, the national characteristics (distribution among energy-efficiency classes, average fuel consumption, etc.) of the fleet of new passenger car registrations can be computed. Each household ("agent") owns a car with a certain age. Eventually (ruled by vehicle survival rate and a random component), the car will be replaced. The agent then selects a new car (see below for details).The present model version is static, that is, car choice parameters, demographic data of the population and the fleet of new passenger cars being on the market do not change. User inputs are:

> Fleet of new passenger cars currently on market (i.e., currently imported) with technical characteristics;

> Socio-economic groups (consumer groups) to be distinguished, and their car choice parameters;

> Prices of gasoline and diesel;

> Fiscal measure to influence CO_2 emissions (e.g., feebates schemes, etc.), if applicable;

> Demographic data on population;

> Data on current car ownership of population.

We simulate 1'000'000 new car sales. We supply the purchasing agent with the fleet of new car models on the market for sale as of Dec. 2005; a total of 2089 different car models which is representative for any European car market. Fuel prices employed are set to the average pump price for the year 2005. We also use retention rates for brand, car size class, and gearbox type, according to an analysis of a data set of vehicle transactions from 2005.

4.2 Definition of scenarios

In the following we compare the reference scenario to the outcomes under four different versions of incentive schemes (see Table 1 for details):

> Reference (no incentive scheme): Simulation of the Swiss car market for the year 2005; for validation and calibration see Mueller and de Haan (2007).

> Refunded tax: Purchase tax is increased by 3% of list prices. This generates approx. EUR 770 per new registration (annual total for Switzerland is 200 mio. EUR, using a CHF/EUR exchange rate of 1.5), which allows for incentive payments to “A”-labeled vehicles of EUR 2550 each (a result gained from iterative simulation), also covering transaction costs of EUR 20 per incentive payment. The purchase tax increase does not lead to additional implementation costs, as a general purchase tax is already in force.

> Refunded tax with CO_2 limit: same as above, but cars are not eligible for an incentive if their emission exceeds the 160 g CO_2/km limit, even if they were labeled “A”.

> Feebates scheme: Those 15.3% of new registrations having lowest fuel-efficiency pays a fee of EUR 2250 each (the amount of EUR 2250 has been adopted to ensure comparability with the refunded tax approach introduced above), which allows for rebates (in fact, a cash premium paid out to the car purchaser) to those 14.7% of new registrations having highest fuel-efficiency, and also covers transaction costs of EUR 10 per premium and EUR 58 per fee.

> Feebates with CO_2 limit: same as above, but cars are not eligible for an incentive if their emission exceeds the 160 g CO_2/km limit, even if they were labeled “A”.

Our main target parameter is the reduction in rated CO_2 emission of the fleet of new car registrations, expressed as percentage of the rated CO_2 emission for the reference scenario. To quantify this relative reduction into absolute terms for Switzerland, we also give to total resulting CO_2 reduction, assuming that 260’000 new cars are sold per year and that on average each car runs 160’000 km. That is, we match an incentive scheme with an implementation duration of 12 months to the total life-time effect of the cohort of vehicles newly registered during those 12 months.

4.3 Results for refunded tax schemes

Figure 1 shows histograms of market parameters without (reference) and with incentive schemes. Aggregated market parameters are listed in Table 2. The refunded tax scheme leads to a reduction of CO_2 emissions of new registrations of 3.1% (for Switzerland, this corresponds to 245 kt CO_2 per year). Most notable is a shift towards car models fitted with the smallest available diesel engine. The market share of “A”-labeled vehicles increases, as expected, compensated by only minor market share reductions for categories “B” to “G”. The share of diesel vehicles increases. Due to low implementation costs, this incentive scheme has abatement costs of EUR 6 per tonne CO_2.

The introduction of the 160 g CO_2/km limit for eligibility to cash incentives does only lead to small changes that are hardly observable. Some cars, being “A”-labeled but above this limit, are not eligible to a rebate anymore. In order to ensure revenue neutrality, by iterative simulation the incentive payments (tax refunds) had to be increased by EUR 110 to EUR 2660. Overall, the average CO_2 emission drops by 3.2% (252 kt CO_2 per annum for Switzerland)

4.4 Results for feebate schemes

Figure 2 shows histograms of market parameters without (reference) and with incentive schemes. Aggregated market parameters are listed in Table 2 (two right-most columns). In constrast to the refunded tax approach, the feebate scheme clearly punished “G”-labeled “gas-guzzlers”. This causes a clear drop in market share for the “G” category. In contrast to the refunded tax approach, the feebates approach is selective in its steering effect both at when charging fees and when awarding rebates. This results in a higher efficacy: average CO_2 emissions of new car registrations drop by 3.9%. Note that this higher efficacy is also in part due to the psychological effects incorporated into the simulation model. Due to higher implementation costs, however, the abatement cost, at EUR 14 per tonne CO_2, is inferior to the one for refunded tax approaches.

Combining the feebate scheme with an upper limit of 160 g CO_2/km for eligibility to the incentive payments again shows only minor, but positive, effects, as listed in Table 1.

5. Discussion

The main purpose of our study is to simulate the environmental and market effects of policy instruments, especially incentive schemes, to influence car purchasing behavior. For assessment, we use two indicators. Policy efficacy is the amount of abated CO2. Policy efficiency is defined as administrative costs per abated ton CO2. Market impact is operationalized by changes in the curb weight distribution of new registrations.

We had two main expectations (hypotheses) regarding the incentive schemes under investigation:

> We expect a high policy efficiency, since energy-efficiency at present does not play in important role when purchasing new cars. Incentive payments therefore should be able to easily raise the relative importance of energy-efficiency, at least for some of the relevant consumer segments. As the variety of powertrains for most popular car models is wide, it is easy for consumers to switch to smaller engines without any loss in car size.

> We expect a low market impact, since for most models, a large range of engine sizes and powertrain configurations is available. Therefore consumers are able to react to incentive schemes, i.e. to change their purchase behavior in order to become eligible for an incentive payment, without being forced to switch to a smaller car.

As method we used a multi-agent based microsimulation with psychological effects and elements of bounded rationality (retention rates, choice set size). Agents are new car purchasers, and the steady-state simulation was performed for the year 2005. A highly disaggregated fleet of over 2000 car types on sale has been employed. This method seems to us to be sufficient but also necessary to account for within-model behavioral changes, the occurrence of which we expect and which are the basis for our two main expectations/hypotheses.

The main results of our study present themselves as follows. Because a purchase tax is already in force, its increase does not cause additional administrative costs. This is an inherent advantage of the refunded tax approach over a true feebate system. On the other hand, feebate systems have the advantage that both the fee and the rebate have a steering effect (both “push” and “pull”), where the purchase tax with flat rate does punishes both efficient and inefficient cars, and causes behavioral changes only by the tax refunds to category “A” cars (“pull”). Billing the fees however will be more expensive than paying out the tax refunds, as a much higher resistance and some debit losses are to be expected. These characteristics form the basis for the results from our analysis: The refunded tax approach is more cost-efficient, but the feebate system is more effective.

The maximum CO_2 reduction achieved is 3.1% (amounting to 245 kt CO_2 annually for Switzerland), which we consider as good for revenue-neutral incentive schemes. As mentioned, our simulation results should be regarded as minimum effect; indirect effects as sketched in Section 3 are likely to give rise to even higher effects. As greenhouse gas emissions have important externalities, the overall economic effect of incentive schemes will be positive.

With regard to reliability and validity of our modeling approach, the validation of the model with 2005 Swiss market data on an array of different market statistics, and in a second step the calibration of the model to exactly match 2005 market statistics (see Mueller and de Haan 2007 for details), ensures a level of robustness of the model results that we believe is superior to most other, mostly higher aggregated model approaches reported in literature. During model development we noted that the further disaggregation of the model approach in general did increase, not decrease, correspondence between model results and market observations. Especially, we exclude the possibility that two counteracting model errors compensate each other on an aggregated level, as such effects would have become visible during the analysis of disaggregated model results.

Limitations of the presented modeling approach are mainly those that apply to all models: We use past consumer behavior to predict behavorial changes under a future policy instrument, and hence assume that the norms, preferences and decision making strategies of new car purchases will not change. As we only investigated incentive schemes that can be implemented immediately, and that are already in force in several countries, and since the financial incentives typically do not exceed 10% of car sales prices, we believe to be well within the area of model applicability.

In our future research, we plan to further enhance the simulation model, by making commercial cars more explicit and by switching to a synthetic population of agents that actually is drawn from detailed census data. The latter will make the inclusion of a vehicle transaction model necessary, in order to forecast which agents will decide to purchase a new car (in our present simulation model, each agent is a new car buyer).

6. Discussion

Policy instruments to influence car purchase behavior are among the most discussed, and have been implemented in several countries already, to reduce the still growing greenhouse gas emissions from individual motorized transport. We presented results from a multi-agent microsimulation representative for European car markets for a refunded tax scheme and for a feebates system. We simulated both incentive schemes based on relative energy-efficiency and based on (absolute) energy consumption. Our results show that both schemes are suited to obtain substantial reductions in energy consumption and CO2 emissions without any otherwise significant impact on the car market, i.e., the statistical distribution of curb weight remains merely unaffected. This means that car purchasers in our simulation indeed rather stay with their originally intended car size class, and mostly change their purchase behavior by switching to a more energy-efficient (i.e., with smaller engine capacity) engine. This behavior was expected from survey-based stated preferences. For the simulation to be able to reproduce this anticipated behavior, it has been crucial to use a very detailed fleet of 2000+ make-model-powertrain-gear type combinations being on sale. Only with such a high level of disaggregation is it possible to reveal within-model changes in purchase behavior.

We believe that the method of microsimulation, using different groups of consumer types, combined with the use of highly disaggregated fleets of the cars being on sale, is crucial for the accurate prediction of the environmental and market effects of policy tools to influence car purchase behavior.

Administration costs for the incentive schemes regarded are rather low and thus CO2 abatement costs results that are lower than most other domestic (i.e., within OECD countries) CO2 reduction measures. However, these CO2 reduction effects will only take place in the first 10 years after the introduction of the policy scheme. After this period, the population of car purchasers will have adopted to a new equilibrium. The type of incentive schemes investigated in this paper, with should have a high public acceptance since it is revenue-neutral and does not have a great impact on the car market and on the average size of new car registrations, therefore is typically suited as the very first policy instrument aiming at influencing car purchase behavior, and it should be followed up, within 10 years after introduction, by a higher-profile, more constraining set of fiscal measures (like energy and/or CO2 taxes).

Figure 1 Distribution of new car market along curb weight classes (top panel), engine capacity classes (middle), and rated CO_2 emission classes (bottom panel), for the reference simulation (Swiss car market for the year 2005) and two refunded tax schemes.

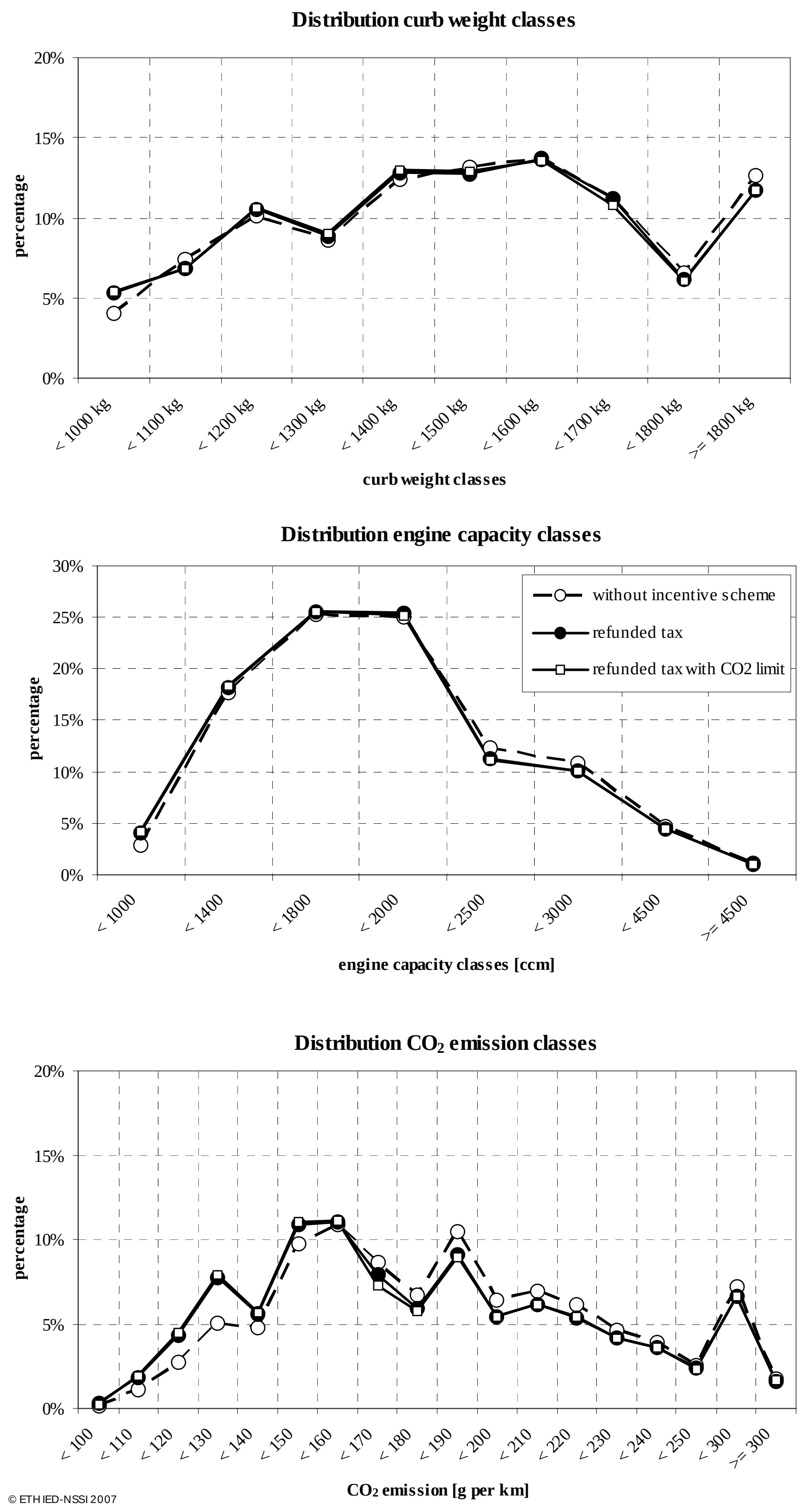

Figure 2 Same as Figure 1, but for two feebate schemes.

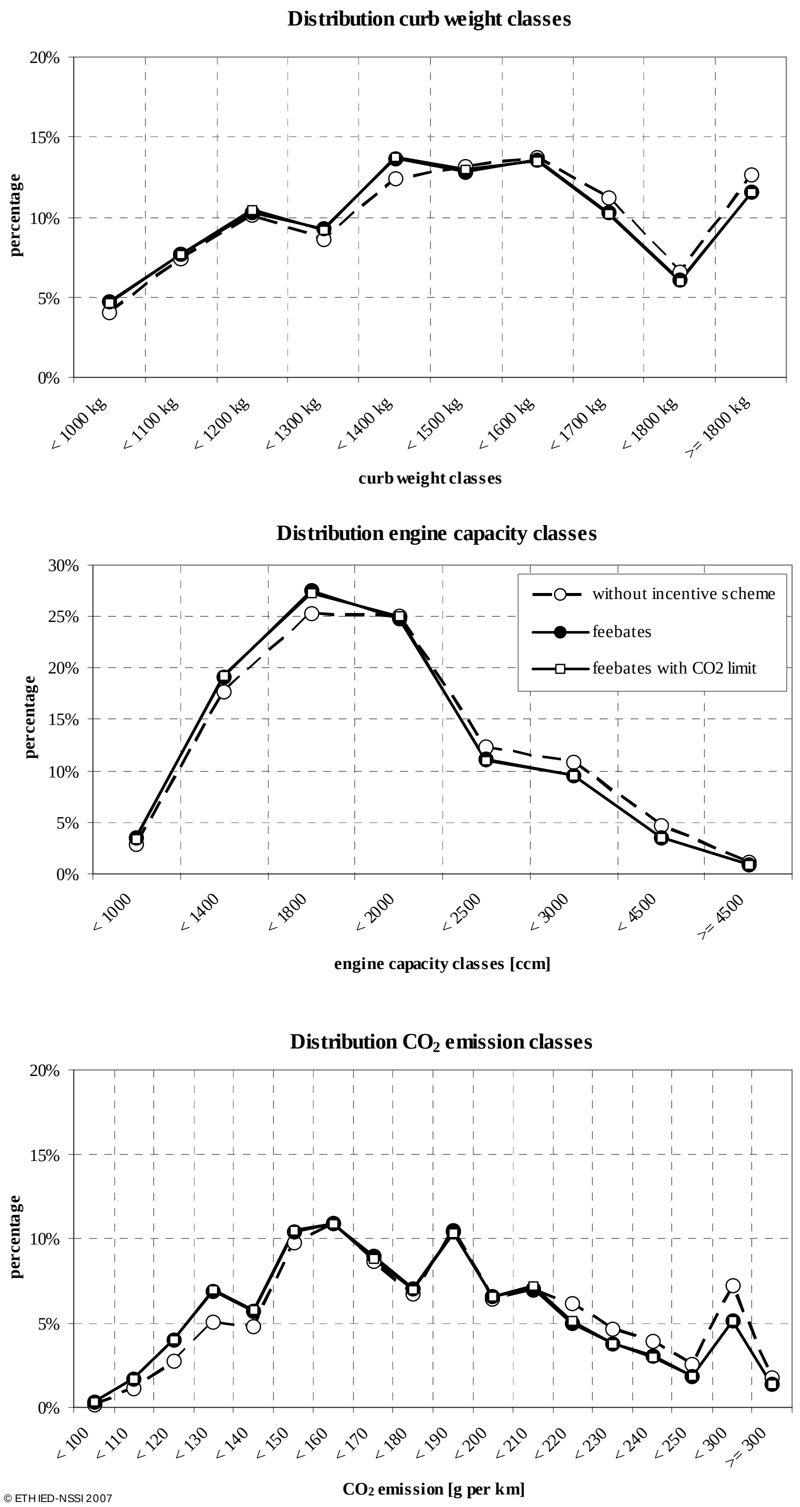

Table 1 Aggregated financial figures and environmental effects of the simulated scenarios.

Scenario	Income account	Expense account	Total Income	Total costs of implementation	CO_2 Reduction	Effectiveness : Effect CO_2	Efficiency = costs of implementation /CO_2
			[M€/a]*	[M€/a]*	[%]	[1000 t/a]**	[CHF/t]
Reference	None	None	0	0	0	0	0
Refunded tax	Purchase tax 3% for all categories	Refunded tax for A: € 2550	196.0	–1.5	–3.1%	–163.3	6.3
Refunded tax with CO_2 limit at 160 g CO_2/km	Purchase tax 3% for all categories	Refunded tax for A: € 2670	195.4	–1.5	–3.2%	–167.7	6.0
Feebates	Fee for G: € 2000	Refunded tax for A: € 2000	81.5	–4.1	–3.9%	–202.7	13.6
Feebates with CO_2 limit at 160 g CO_2/km	Fee for G: € 2000	Refunded tax for A: € 2000	77.7	–4.0	–3.9%	–202.9	13.1

* deficit = expense of the government, benefit = income of the government. Base: 260'000 new car registrations per year

** CO_2 effect over the technical life cycle of the new car registrations per year (i.e. per year of the current incentive scenario)

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