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How should vehicle emission standards be integrated into the broader spectrum of climate policy?

Do the policies in the U.S. and Germany reflect the goals of environmental efficacy and economic efficiency of vehicle emission standards?

Mitigating Transport CO2 Emissions in the United States and Europe - An Assessment of Recent Fuel Economy and Vehicle Emission Regulations

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Introduction

The transport sector accounts for one-fourth of the carbon dioxide (CO2) emissions in the European Union and almost one-third in the United States, primarily in the form of road transport. In light of its significant and still rising share of aggregate greenhouse gas (GHG) emissions,[1] the transportation sector has come under increasing political pressure to be integrated into a future climate policy regime and to contribute its share to ambitious GHG reduction targets. Toward that end, the European Union passed legislation limiting the specific emissions of passenger cars to 130 grams CO2 per vehicle kilometer. In the United States, the Obama administration recently adopted California's ambitious tailpipe regulations for GHG emissions, now aiming at targets equivalent to 35.5 miles per gallon (MPG) by 2016.[2]

These vehicle emission standards and the closely related fuel economy standards strive for a mitigation of CO2 emissions as well as a reduction of oil dependence and energy security costs by setting upper limits to the specific CO2 emissions and specific fuel consumption, respectively.[3] In 1975, the United States was the first country to introduce Corporate Average Fuel Economy (CAFE) regulations in the wake of the 1973 oil crisis. For the purpose of this essay, it is not differentiated between vehicle emission standards and fuel economy standards, as most results hold true for both approaches.

This essay will, first, briefly highlight the general economic rationale for mandatory vehicle emission standards as well as crucial factors that determine the environmental efficacy and economic efficiency of this regulatory approach. Second, noticing that vehicle emission standards are not stand alone measures, the embedding of such standards in the broader context of climate policy is explored. The interdependencies of fuel economy standards with other climate policy instruments can have considerable impacts on the efficiency and efficacy properties of the entire policy setting. Finally, the recent European legislation as well as the upcoming U.S. regulation will be briefly assessed in light of the previous considerations.

Economic Rationale of Vehicle Emission Standards

In general, economists trust in market solutions and they are rather skeptical toward regulatory market interventions that curtail consumer and producer sovereignty. Indeed, in the absence of market failures the transmission of price signals—including climate and energy security costs—by means of fuel taxes, carbon taxes, or CO2 allowance prices facilitates achieving the optimal vehicle efficiency. However, if policy fails in giving the right incentives or market participants do not react appropriately, suboptimal levels of fuel economy will result.

The justification for mandatory vehicle emission standards is typically a combination of failures in inducing intended behavioral changes through the transmission of price signals and political infeasibility of sending sufficiently strong fuel price signals, whereas the latter applies rather to the U.S. than to European fuel price levels. Behavioral studies find that, when purchasing durable energy consuming goods, consumers seem to act myopically, demanding rapid paybacks for fuel economy investments (3-year payback time rather than the 14-

year lifespan of the car)[4]; furthermore, they may lack sufficient information for rational decision-making, or rely on simple decision heuristics due to limited cognitive capabilities.[5] Consequently, they do not take future fuel costs appropriately into account when choosing a new car, leading to underinvestment in fuel economy even if the net marginal abatement costs are negative. Consumers' reluctance to pay upfront for higher fuel economy may also stem from loss aversion in combination with uncertainty regarding gasoline prices and actually realized on-road fuel economy, in particular when other vehicle attributes have more certain benefits.[6]

However, the assumption of excessive implicit discount rates applied to vehicle purchase decisions is not without contention; some studies find that discount rates in the market for automobile fuel economy are in line with normal private discount rates.[7] More generally, not all explanations for the seeming undervaluation of fuel economy necessarily imply the presence of a market failure that requires intervention; in some cases, it may reflect legitimate consumer preferences that should be respected by policymakers.

On the part of automobile manufacturers, incentive-oriented payment schemes for managers may contribute to underinvestment in fuel economy. If R&D efforts toward higher fuel economy pay off mainly in the long-term, they appear less attractive to managers who are paid based on current profits. Moreover, technology spillovers, i.e., positive external effects, as well as lacking credibility of climate policy could impede early R&D investments in fuel efficiency technologies.

Standard Design Options

When it comes to the implementation of vehicle emission standards, the first question arising is whether to apply a uniform standard to all manufacturers or to assign manufacturer-specific targets. In a heterogeneous vehicle market in which each manufacturer must separately comply with the regulation, uniform standards are likely to cause excessive abatement costs, as the marginal emission abatement costs for compliance with the standard can vary dramatically across manufacturers. Manufacturers of heavy, high-performance cars will find it harder and costlier to meet the same standard as manufacturers of smaller cars. Manufacturer-specific standards, on the other hand, are defined with respect to a certain vehicle attribute, such as weight or the vehicle footprint (track width x wheel base). By conditioning on such attributes, targets can take differences in the marginal abatement costs into account and provide a certain convergence.

Yet, attribute-based standards may distort the choice between different emission abatement options if changes in the reference attribute (or changes in the sales mix of vehicles with different attribute values) can contribute to reductions in fuel consumption: Emission mitigation attainable through an adjustment of the reference attribute (e.g., weight reductions) will be—at least partially—neutralized by a subsequent tightening of the manufacturer's specific standard; thus, such changes in the reference attributes lose some of their attractiveness as a means of emission mitigation. The manufacturers' decision on the appropriate mix of abatement measures is distorted to the detriment of changes in the reference attribute; they will be used less than socially optimal, while other abatement options are used to a greater extent than optimal. Consequently, the overall compliance costs are also higher than optimal.

Another design feature that adds flexibility to the regulation is to allow credit trading. Over- and under-compliance of certain vehicles with the standard could then be offset not only within a manufacturer's fleet, but also across different manufacturers.[8] This mechanism ensures that the marginal emission abatement costs will be equalized across manufacturers—at the level of the resulting credit price, thereby reducing the overall abatement costs.[9] Moreover, credit trading provides continuous incentives for further efficiency improvement even for those manufacturers that already comply with the standard as they can generate additional revenues from further emission reductions by selling excess credits.

Fuel Economy Regulations and Emission Trading

Emission trading is viewed by many as being an economically efficient and the politically most viable instrument to tackle anthropogenic GHG emissions. The Kyoto Protocol contains provisions for inter-country trading of GHG emissions. Emission trading schemes are also used at a subsidiary level to coordinate the emission reduction efforts among different sectors and sources in a cost-minimizing manner. The European Union Greenhouse Gas Emission Trading System (EU ETS) commenced operation in January 2005. It covers emissions from stationary emission sources in the industry and electricity generation sector. Starting in 2012, aviation emissions will be included in the EU ETS, but road transport will remain outside the scope of the scheme. In contrast, the prospective U.S. federal cap-and-trade emission trading scheme is likely to comprise motor fuels; according to the Waxman-Markey bill,[10] passed by the House of Representatives on 26 June 2009, motor fuels would be captured by the scheme by means of an upstream approach (i.e., refineries and fuel importers have to surrender allowances to the extent of the carbon content of their sold fuels).

The question whether motor fuels are under the cap determines the environmental effectiveness of vehicle emission regulations. Tightening of the vehicle emission/fuel economy standards will reduce overall emissions only if motor fuels are not covered by the emission trading scheme. If motor fuels are under the cap, fuel economy improvements have no impact on overall emissions since the reduced fuel demand—dampening allowance prices—will be offset by higher emissions of stationary sources. Thus, tightening of the standard has solely distributional consequences; it may increase costs for motorists (due to higher vehicle purchase costs),[11] while relieving stationary sources due to falling permit prices.

Although vehicle emission standards will not have an effect on the overall domestic CO2 emissions if transport fuels are included into the emission trading scheme, that does not mean that such measures are essentially useless or rather counterproductive. They can contribute to mitigating the overall emission reduction costs by correcting market failures regarding the choice of vehicle fuel economy. Moreover, they can still have an indirect positive effect on overall global emissions: Through reducing the demand for fossil motor fuels, sector-specific instruments contribute to decreasing allowance prices in the emission permit market. This lessens the economic pressure on stationary CO2 sources in the energy and industry sector, implying an attenuation of leakage tendencies in allowance price sensitive industries.

Preferential Treatment of Alternative Fuel Vehicles

In order to lessen the dependence on oil imports and to promote biofuels, vehicle emission/fuel economy regulations can be designed as a means to incentivize the production of cars that can combust alternative fuels, primarily fuels with higher biogenic shares (e.g., E85) but also natural gas based fuels. When calculating a manufacturer's specific average emissions, those cars that can run on alternative fuels would be attributed low emission values, for instance by considering non-petroleum-based fuels free of net CO2 emissions. Selling these cars would then bring down the manufacturers' official average specific emissions. The manufacturers gain the opportunity to increase the fuel consumption of their conventional vehicle fleet while still complying with the standard. Manufacturers can either produce more emission intensive upper-class vehicles or implement less costly fuel saving technologies in their residual fleet. Average CO2 emissions will rise unless the CO2 savings resulting from the use of alternative fuels outweigh the effect of higher specific fuel consumption. As alternative fuels are not free of GHG emissions, a net reduction of specific CO2 emissions can result only—if at all—in case that the granted bonus is small.[12]

Yet, it is generally questionable whether such a calculation method resembles the reality, particularly in the case of Flexible Fuel Vehicles (FFV) that can use either conventional fossil-based or alternative fuels. Depending on the price and availability of the alternative fuels, FFV may mainly rely on conventional fuels. So far, the U.S. regulation does not premise the availability of FFV credits on actual use of alternative fuels; consequently, the magnitude of the substitution of biofuels for conventional fuels is uncertain. In consequence, it is very likely that this regulatory approach will end up worsening the actual on-road GHG emission performance of the fleet. This holds particularly true recalling the uncertain climate impacts of certain biofuels; it is even contentious whether they yield any net GHG savings due to indirect climate effects associated with their production (e.g., NOX emissions, land use change). Besides environmental considerations, concerns regarding their ethical sustainability—due to competition with the cultivation of food crops—remain. Finally it has to be mentioned that the use of biomass in stationary combustion plants, substituting coal for instance, is economically more efficient and yields greater net CO2 savings.

Multiple Crediting of Electric and Fuel Cell Based Vehicles

Vehicle emission/fuel economy regulations may be also used in order to promote the commercialization of battery electric vehicles (BEV), plug-in hybrids (PHEV), and fuel cell based vehicles (FCV), by providing additional credits for such advanced technologies. These advanced technology credits are often in the form of a multiplier that is applied to the number of vehicles sold, such that each eligible vehicle counts as more than one vehicle in the official compliance calculation of a manufacturer's fleet average emissions.

While strengthening incentives for bringing zero (tailpipe) emission vehicles in the market, multiple crediting of electricity based cars creates similar problems as the preferential treatment of vehicles combusting alternative fuels. The production of such vehicles gains attractiveness for manufacturers since it allows reducing the efforts to improve the fuel efficiency of their conventional cars. Even without multiple crediting considering electricity based vehicles for standard compliance as zero emission vehicles will worsen the average emission efficiency of the fleet—as long as the emission standard is a binding constraint—due to lower efficiency of the remaining conventional vehicles, unless the electricity is entirely generated from additional renewables.[13] Multiple crediting even aggravates the problem as it further relieves the pressure to reduce the specific emissions of conventional cars. Thus, manufacturers may be tempted to produce a certain number of "alibi" zero emission vehicles in order to avoid considerable changes in their conventional fleet, but without gaining broad consumer acceptance or paving the way to sustainable marketability of advanced vehicles. The problem of worsening average fuel economy of the fleet even gains relevance bearing in mind that electric and fuel cell vehicles will—due to their limited range—presumably be used mainly for shorter trips while cars with conventional drive trains will remain dominant for purposes implying higher mileages.

The ceteris paribus effect, i.e., before potential corrective interventions, on economy wide overall CO2 emissions strongly depends on the integration of transport with emission trading policies. In case of a comprehensive emission trading scheme, i.e., including motor fuels, being in place, worsened vehicle efficiency does not increase overall emissions beyond the cap since higher transport emission will be offset by increased abatement in other emitting sectors. Yet, the correction of asserted failures in the vehicle market can be foiled through multiple crediting, leading to a suboptimal allocation of emission abatement efforts. If the emission trading scheme captures stationary sources only, the rise in specific fuel consumption of conventional vehicles induced by multiple crediting of electricity based vehicles implies increasing aggregate CO2 emissions; additional upstream[14] emissions of BEV, PHEV, and FCV are covered and do not have an impact on overall emissions. The worst results occur in the absence of any cap-and-trade scheme; the worsened efficiency of the fleet will then be reflected almost entirely by a respective increase in overall CO2 emissions.

Comparing the U.S. and the European Approach

Both the European Union and the United States recently made rulemaking efforts to control transport's contribution to GHG emissions by limiting the specific CO2 emissions/fuel consumption of passenger vehicles.[15] Still, the European Union and the United States chose different ways to regulate their vehicle markets. In light of the previous considerations, the current European approach to limit CO2 emissions from passenger cars as well as the upcoming U.S. regulation will be briefly assessed. It needs to be mentioned here that manufacturers selling light duty vehicles in the U.S. market will have to comply with a twofold regulation in the future: The National Highway Traffic Safety Administration will continue to administer the CAFE (Corporate Average Fuel Economy) regulations, while new GHG standards will be under the jurisdiction of the Environment Protection Agency (EPA); however, both regulations should be widely harmonized.[16]

It is obvious that for heterogeneous markets such as the European and the U.S. vehicle market uniform standards lead to excessive costs. Thus, the regulators will employ attribute-based standards in both markets. The use of attribute-based standards promises to enhance the cost efficiency of the regulation by harmonizing the reduction targets across manufacturers. On the other hand, using vehicle attributes as reference parameter to differentiate emission targets can impose an important distortion of the manufacturers' abatement decisions. With regard to the reference parameter, the United States and the EU have made different choices. The European standards will be differentiated according to the vehicle weight, while the U.S. standards are based on the vehicles' footprint (track width x wheel base). As weight reduction is an effective and relatively cost efficient means of emission abatement, the distortion implicit to weight-based standards is likely to create a significant source of economic efficiency losses. Using the vehicle's footprint as reference parameter will presumably lead to less costly distortions of the allocation decision between different abatement options. Footprint-based regulation is likely to be less vulnerable to adjustments in the design of the vehicles in order to attenuate the required emission reduction—due to technical reasons and for lack of consumer acceptance. Furthermore, the footprint is a good empirical indicator for a vehicle's specific CO2 emissions/fuel consumption, but it has a weaker direct impact on its emissions/fuel economy than metrics like weight.

The upcoming U.S. regulation will provide maximum compliance flexibility to manufacturers by allowing banking, borrowing, averaging across cars and light trucks, as well as credit trading across manufacturers. The European legislation allows manufacturers to form a pool that can jointly meet their targets. Although this added flexibility helps reducing the overall costs of complying with the regulation, the question remains whether it would not be more consequent and more efficient to implement an explicit transparent market for tradable credits.

With regard to alternative fuel vehicles and electricity based vehicles the U.S. regulation grants relatively generous provisions. For instance, dedicated alternative fuel vehicles, i.e., vehicles that can solely run on alternative vehicles, are as yet considered for CAFE compliance with a six fold higher MPG value than their value actually measured in the test procedure. For flex-fuel vehicles (mainly running on E85), however, the preferential treatment will phase out until 2019 under the new regulations; for dedicated alternative fuel vehicles credits remain available. Electric and hydrogen vehicles will probably receive multiple credits in the context of vehicle emission/fuel economy regulations compliance. These provisions privileging vehicles that use alternative fuels or alternative drive trains will likely worsen the actually achieved efficiency of the light duty fleet and may also lead to increased oil consumption. But they will not affect the amount of overall GHG emissions if a comprehensive cap-and-trade scheme, including stationary sources as well as motor fuels, such as incorporated in the Waxman-Markey bill, will finally be passed by Congress.

The European climate policy framework would be more vulnerable to the negative impacts of missing the fuel efficiency targets set by the regulation, because emissions from the combustion of motor fuels are not captured by the EU ETS. Yet, the EU passenger car regulations, coming into effect in 2012, comprise multiple accounting for vehicles that emit less than 50 g CO2 per kilometer, but they will expire already in 2015; furthermore, the EU rules provide only negligible credits for alternative fuel vehicles.

Summing up, both the U.S. and the EU approaches reveal structural deficiencies. The economic efficiency of the European vehicle emission standards suffers particularly from choosing weight as the standard determining attribute. This leads to suboptimal abatement decisions and excessive overall compliance cost as a viable lever for emission reductions loses—regulation induced—some of its attractiveness (due to the tightening of the standard subsequent to weight reductions). Moreover, safety may be affected adversely since it hampers weight convergence across vehicles.[17]

The upcoming new U.S. regulation will remedy several weaknesses of the old CAFE standards. Using the vehicle footprint as reference parameter entails relatively small distortions and the flexibilities provided by credit trading will considerably increase the efficiency. A crucial flaw remains, however. Different standards for cars and light duty trucks (LDT) imply a certain market distortion toward—more fuel consuming—LDT and bias the sales mix. The different treatment of cars and trucks has led in the past, despite constant CAFE standards within each segment, to decreasing combined MPG values as the market share of LDT rose. A major asset of the prospective U.S. climate policy is the probable inclusion of motor fuels into the cap-and-trade emission trading scheme. This internalization of the climate externalities into the fuel price will have an effect on the actual driving behavior of motorists, while emission standards only affect the vehicle characteristics.[18] Nevertheless, one has to acknowledge that fuel taxes levels are significantly higher in the EU, thereby more than offsetting the lacking mark-up for emission allowances; hence, the impact of fuel price signals on actual driving patterns is still higher in Europe than in the United States. Yet, an explicit climate component in the fuel price—as represented by such a emission allowance mark-up—could enhance transparency and potentially increase awareness of climate issues.

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NOTES

1 In the EU, transport emissions have significantly increased, while most other sectors in the EU reduced their emissions since 1990. In the United States, both transport emissions as well as those from other sectors increased over the recent years; thus, transport's share of overall emissions remained relatively stable.

2 While the National Highway Traffic Safety Administration (NHTSA) will administer the CAFE (Corporate Average Fuel Economy) regulations, the new GHG standards will be under the jurisdiction of the Environment Protection Agency (EPA).

3 Taking into account the specific CO2 emission intensities of diesel and gasoline fuel, it is easily possible to formulate fuel efficiency targets in terms of CO2 emissions per kilometer.

4 See e.g., Greene, D. L. et al. (2005): Feebates, rebates, and gas guzzler taxes – A study of incentives for increased fuel economy, in Energy Policy, Vol. 33, p. 757-775; Greene, D. L. et al. (2005): Corrigendum to 'Feebates, rebates, and gas guzzler taxes – A study of incentives for increased fuel economy', in Energy Policy, Vol. 33, p. 1901-1902.

5 See e.g., Turrentine, T. S. / Kurani, K.S. (2007): Car Buyers and Fuel Economy?, in: Energy Policy, Vol. 35, p. 1213-1223; Kempton, W. / Layne, L. (1994): The Consumer's Energy Analysis Environment, in: Energy Policy, Vol. 22, p. 857-866; Moxnes, E. (2004): Estimating Consumer Utility of Energy Efficiency Standards for Refrigerators, in: Journal of Economic Psychology, Vol. 25, p. 707-724; Atonides G. / Wunderink S. R. (2001): Subjective time preference and willingness to pay for an energy saving durable good, in: Zeitschrift für Sozialpsychologie, Vol. 32, p. 133-141; Kooreman, P. (1995): Individual Discounting and the Purchase of Durables with Random Lifetimes, in: Economic Letters, Vol. 48, p. 29-32.

6 See Greene, D. L. / German, J. / Delucchi, M. A. (2009): Fuel Economy: The Case for Market Failure, in: Sperling, D. / Cannon, J. S. (eds.), Reducing Climate Impacts in the Transportation Sector, Springer, p. 1-25.

7 See Espey, M., and S. Nair. (2005): Automobile Fuel Economy: What Is it Worth?, in: Contemporary Economic Policy, Vol. 23, p. 317-323; Verboven, F. (1999): Implicit Interest Rates in Consumer Durables Purchasing Decisions – Evidence from Automobiles, Antwerp, [http://www.econ.kuleuven.be/public/NDBAD83/Frank/Papers/Verboven,%201998.pdf].

8 For each car whose emissions are below its specific standard, credits are generated according to the difference between its actual emissions and the standard. These credits are tradable and manufacturers exceeding the standard can buy them to comply with the regulation. Such a scheme of tradable emission standards would be classified as a baseline-and-credit scheme. This approach grants maximum flexibility to the manufacturers and is in line with the principle of consumer sovereignty, because all kinds of cars remain in the market as long as their emissions are offset by the purchase of reduction credits.

9 The extent of cost reductions attainable through the introduction of credit trading depends on how well the credit markets works (e.g., market power abuse) and whether the manufacturer-specific emission targets are based on certain vehicle attributes in a manner distorting the manufacturer's abatement decision. The latter problem could be prevented if the manufacturer-specific standards are based on past values and not current values of the reference attribute.

10 H.R. 2454, American Clean Energy and Security Act of 2009.

11 However, if we assume the existence of the aforementioned market failures, the additional purchase costs for fuel efficient vehicles may be more than outweighed by the resulting fuel savings. Then, tightening of the vehicle emission/fuel economy standards would pay off also for consumers (car buyers).

12 For the adverse effects of preferential treatment of alternative fuel vehicles see also Liu, Y. / Helfand, G. E. (2009): The Alternative Motor Fuels Act, alternative-fuel vehicles, and greenhouse gas emissions, in: Transportation Research Part A, Vol. 43, p. 755-764; Rubin, J. / Leiby, P. (2000): An analysis of alternative fuel credit provisions of US automotive fuel economy standards, in: Energy Policy, Vol. 13, p. 589-601.

13 Electricity based vehicles are true zero emission vehicles only if the energy to charge the batteries or to produce hydrogen stems from renewable sources and if this energy sources could not alternatively substitute fossil energy sources used for other purposes. Put another way, electric based vehicles are net carbon free only if the potential for additional renewables expansion they provide through vehicle-to-grid services (V2G) and controlled charging equals/exceeds the additional electricity demand resulting from their operation.

14 I.e., emissions related to the generation of electricity or the production of hydrogen.

15 Although vehicle emission standards can ensure emission reductions, they do not allow for a precise control—neither of absolute emission reductions nor of the actual on-road emissions per kilometer—due to several uncertainties regarding the number of vehicles, specific mileages per vehicle, driving behavior, etc.

16 The currently proposed rule can be found under http://edocket.access.gpo.gov/2009/pdf/E9-22516.pdf. The European legislation is available under http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2009:140:0001:0015:EN:PDF.

17 In multi-vehicle collisions the crush space and the disparity in the masses of the colliding vehicles crucially determine injury risks. Thus, a tendency towards weight convergence could potentially reduce the fatality rate of collisions between heavy vehicles (e.g., light trucks, SUV) and light cars. (See Gayer, T. (2004)): The fatality risks of sport utility vehicles, vans, and pickups relative to cars, in: Journal of Risk and Uncertainty, Vol. 28, p. 103-133) Weight-based standards, however, penalize weight reductions by subsequent tightening of the specific standard.

18 Higher vehicle fuel economy will even rather encourage additional driving due to the lower specific fuel consumption costs ("rebound" effect).

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