Including road transport in the EU-ETS – An alternative for the future?

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Disclosure statement

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The report is the outcome of independent work by the Centre for European Economic Research (ZEW GmbH), Mannheim. Any opinions expressed in this report are those of the authors unless explicitly otherwise stated.

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Executive Summary

Background

This report addresses the regulation of CO_2 emissions of passenger cars and light commercial vehicles (LCV) after 2020. Current targets are set at 95 g/km for passenger cars and 147 g/km for LCVs in 2020. It has been proposed by the European Parliament, that the targets should be set to 68-78 g/km in 2025 for passenger cars. However, concern has been raised that such targets would not be technology neutral and that the cost of producing cars that satisfy the standards would exceed the consumers' willingness to pay for the fuel efficiency improvement (IKA, 2014; NFF, 2014). Moreover, it is unlikely, that the standards alone would be sufficient to achieve the long term targets for emission reduction in road transport. This report addresses inclusion of the road transport sector in the EU Emissions Trading System (ETS) as an alternative or a complementary policy measure.

Feasibility

In the conclusions from the council meeting of 23/24 October 2014 the EU Council has noted that under existing legislation member states can opt to include transport in the EU ETS. In terms of practical feasibility, regulating upstream, i.e. fuel providers seems the most sensible option. The number of entities is limited, and most fuel providers already have experience with the EU ETS through refinery activities. Costs are likely to be passed on to consumers along the fuel chain, which suggests that auctioning allowances to avoid windfall gains would be preferable as an allocation mechanism. Road transport could be included in the existing ETS (open) or in a (semi-)closed separate ETS. The former is more cost-efficient than the latter option, but the latter option would be more likely to lead to reductions within the transport sector and mitigate any possible distributional impact on the sectors covered in the existing ETS.

Interaction with existing regulation

Including the road transport sector in the EU ETS is compatible with and reinforces existing policies. In practice, it is likely to act as a small carbon tax on fuel and as such raises the fuel price for end consumers. By increasing the cost of driving the potential rebound effects from improved fuel economy in cars can be reduced. While the effect on fuel prices may not be large enough to provide sufficient incentives for innovation in fuel economy in the auto industry, the use of carbon dependent vehicle taxes in many EU countries also raises consumer demand for fuel economy improvements. Revenues from an auctioning of emission allowances could be used to support uptake or R&D in alternative fuel vehicles or other emission reducing technologies. In the presence of an ETS regulating the CO_2 emissions from road transport, however, CO_2-based vehicle taxes, subsidies, and standards will have no effect on the overall emissions, which are then determined by the cap.

Innovation incentives and path dependencies

The dynamic efficiency of regulating private transport through the ETS has been called into question due to the limited effect on the allowance price and the availability of alternative abatement options in other sectors. However, the existing research gives little cause for concern with regard to the innovation incentives provided by the ETS. Nevertheless there are additional market failures and path dependencies in the development and adoption of alternative technologies in transport, which warrant policy measures to complement the ETS. Such additional policy measures include subsidies for R&D and infrastructure investments to overcome externalities that may otherwise inhibit future technological change.

Advantages

The advantages of including road transport in the EU ETS are several. By sending a price signal, the ETS simultaneously incentivizes adjustment of carbon-emitting activities along all margins of substitution: Fuel carbon intensity, fuel economy in cars, driving behavior and demand for vehicle miles travelled. The ETS guarantees no emissions above the cap, is technology neutral, and is a cost-efficient instrument because abatement occurs in the sectors that face the lowest marginal abatement cost. Moreover, the abatement cost is revealed by the allowance price so policy makers can observe the cost of the policy implemented directly. The marginal abatement costs for road transport are widely held to be higher than the marginal abatement costs faced in many other sectors covered by the EU ETS. This implies that including the road transport sector in the EU ETS would increase the cost efficiency of EU climate policy although abatement may take place in other sectors of the economy under ETS rather than in road transport.

Concerns of distributional effects

The effect on the EU Allowance (EUA) price of including road transport depends on the cap set and on the steepness of the enlarged ETS marginal abatement cost curve. It is likely that the inclusion would lead to an increase in the EUA price, although recent analysis suggests that such an increase could be very moderate to negligible (Flachsland et al., 2011). Should the EUA price increase, this could impact other sectors in the ETS adversely and potentially lead to carbon leakage as firms move out of the EU. So far there is little evidence of adverse effects on industry in the existing ETS despite previous EUA prices significantly above current levels (Martin et al., 2014). This suggests that an EUA price increase would have to be considerable to induce leakage effects. In addition allowance allocation mechanisms can vary by sector to protect more competition exposed sectors as is done in the existing ETS. The obligation to hold EUAs corresponding to the CO_2 emissions from the sector implies a transfer from the road transport sector to the sectors where abatement occurs if the road transport sector is obliged to acquire allowances in an auction.

Introduction

The European Union (EU) has ambitious targets for reducing its emissions of greenhouse gas (GHG) by 80 to 95 % compared to 1990 by the year 2050. The transportation sector currently accounts for approximately one fifth of the CO_2 emissions of the EU-28 according to the European Environmental Agency. The EU White Paper on transportation states the objective, that GHG emissions from the transportation sector should be reduced by 60 % by 2050 compared to 1990. From 1995 to 2010 the emissions from road transportation grew by 23 %. At the EU level one of the key policy tools for achieving CO_2 emissions reductions in road transport is the implementation of emission performance standards for passenger cars and light commercial vehicles (LCV) responsible for approximately 15 % of the CO_2 emissions in the EU.

The mandatory emission performance standards for new passenger cars were introduced in EC/443/2009 to reduce CO_2 emissions. This regulation set a target of an average of 130 g CO_2/km for new cars sold by 2015. In 2011 with EC/510/2011 similar regulation was introduced for light commercial vehicles setting a first target to 175 g CO_2/km for 2017. In both cases, recent numbers provided by the European Environment Agency indicate that the targets have been met before the deadline. In early 2014, the targets for the period up to 2020 were set to 95 g CO_2/km for passenger cars and 147 g CO_2/km for LCVs. The European Parliament has suggested maintaining a constant downward trend and setting the targets to 68-78 g CO_2/km for 2025 in a 2014 report (EPRS, 2014).

However, regulation through emission standards has a number of drawbacks. It only affects new cars and therefore is slow to reduce fleet emissions, as it provides no incentives for behavioral adjustment of the user of the vehicle. An important consideration is that the cost of the regulation is unobservable to the regulator and the general public. Additional production and innovation costs eventually result in higher prices of cars, but policymakers do not observe how the costs of improving fuel economy rise with the stringency of the standards. Additional problems are associated with measurement of emissions through performance tests and potential distortions in the technology used to produce better test performance rather than reduce real world emissions.

Long term goals are important to provide a stable policy environment and incentives for innovation in the regulated sector. The European Parliament and the European Council have asked the Commission to review the current regulation concerning emission performance standards until the end of 2015 and submit proposals for amendments and appropriate targets for emission performance standards for passenger cars and light commercial vehicles after 2020. Given the drawbacks of using emission performance standards discussed briefly above, the present report focuses on alternative or complementary policy option for the CO_2 regulation of passenger cars and LCV in the European Union, namely, the inclusion of road transport in the EU Emissions Trading System (ETS).

The advantages of including the transportation sector in the EU ETS are many. An ETS equalizes abatement costs across sectors and ensures that the emissions abatement takes place where they are the cheapest. As abatement costs for individual sectors are imperfectly observed by regulators, this implies that abatement may take place in sectors and ways that are unexpected to the regulator (Convery et al., 2008). However, by setting a cap and issuing allowances for emissions corresponding to the cap the ETS ensures that the emission reduction target is achieved. The cost of achieving the target are revealed through the price of emissions allowances and in principle allow a policy response if the costs become too high or too low relative to society's marginal valuation of emission reductions. In effect, the ETS puts a price on CO_2 emissions, which will provide incentives to reduce emissions across the economy.

In the following, the report discusses specific design issues for including road transport into the EU ETS. The focus is on passenger cars and light duty vehicles, and freight will not be touched upon. The report will focus on five issues. In Chapter 1, the details of the current regulation scheme are laid out. In Chapter 2, it is discussed whether to incorporate the road sector directly into the existing EU ETS or to create a separate ETS for the road transport sector and link it through gateways to the remaining ETS. A gateway solution has been implemented for the recent inclusion of aviation into the ETS. The chapter discusses efficiency gains, distributional impacts between sectors, and effects on incentives for innovation in the transport sector. In Chapter 3, the question of whether upstream, midstream or downstream regulation is most cost-efficient will be briefly discussed. This chapter focuses on the advantages and disadvantages of making fuel providers, car manufacturers, or consumers the regulated entity. Chapter 4 focuses on how emission allowances should be allocated among the parties in the road transport sector and takes a look at how the cap should be set. Finally, Chapter 5 discusses overlaps and interactions with existing regulation of relevance to the road transport sector. The conclusion summarizes the discussion with recommendations for policy makers.

The main criteria underlying the discussion of each design feature concern cost-effectiveness of the regulation, efficacy in terms of emission reductions and innovation incentives, as well as distributional issues (between sectors, within sectors and with regard to entrants versus incumbents).

Chapter 1: Current EU regulation of passenger cars and light-commercial vehicles

A brief history of EU standards

In 1995 the European Commission adopted a strategy for reducing the CO_2 emissions of cars which was based on three pillars: a voluntary agreement with the car industry, improving consumer information, and promoting fuel efficient cars by fiscal measures. In 1998 the first voluntary commitment was made by the European Automobile Manufacturer's Association (ACEA) to reduce average emissions from new cars sold to 140 g CO_2/km by 2008. This commitment was followed in 1999 by similar commitments on the parts of the Japanese Automobile Manufacturers' Association and the Korean Automobile Manufacturers' Association with 2009 as the target year. The measurement of average CO_2 emission of the new car fleet in the EU was initiated following a decision in the European Parliament and of the European Council in 2000 to monitor progress. In 2007, the Commission concluded, that although progress had been made towards the voluntary commitment target, this progress was not fast enough to achieve the Community target of 120 g CO_2/km in 2012. As a result, the EU regulation on emission standards for passenger cars was introduced in 2009 setting a target of 130 g CO_2/km to be phased in between 2012 and 2015. This regulation was continued with a new target set to be phased in between 2020 and 2021 of 95 g CO_2/km. Similarly, for light commercial vehicles, a mandatory emission standard was introduced in 2011 with a target of 175 g CO_2/km to be phased in by 2017 and 147 g CO_2/km by 2020. The main aim of the regulation is to provide incentives for the car industry to invest in new technologies (EC 443/2009).

Design of the existing regulation

There are a number of features in the existing regulation to increase flexibility in compliance with the emission standards. Among other things these features aim to achieve an equal burden sharing among manufacturers. The most important features are outlined below as described in regulation (EC 443/2009) with amendments from 2013 (EU 397/2013) and 2014 (EU 333/2014). Further details can be found in those documents.

Limit value curve

The standards regulate the new car fleet average, but the emissions of the individual model may deviate from the standard according to the so-called limit value curve. The limit value curve relates the CO_2 emissions target to the mass of the vehicle (expressed in kgs). The primary reason for introducing this curve into the regulation is to achieve a more equal burden sharing among manufacturers. Heavier vehicles tend to have higher emissions and the limit value curve is designed in such a way that heavier cars are allowed higher emissions than lighter cars, while ensuring that the overall fleet average target is met. Specifically, an equation for the limit value curve is specified in Annex 1 to the regulation. The limit value curve is a linear function of the deviation of vehicle mass, M, from a baseline mass, M_0. It has the formula:

$$Specific\ emissions\ of\ CO_2 = 130 + a \times (M - M_0)$$

The slope parameter and the baseline mass are determined in the regulation.[1]

Supercredits

For new passenger cars that have specific emissions of less than 50 g CO_2/km (low-emitting cars), car manufacturers receive so-called “Super-Credits”, which allow these cars to be weighted more heavily in the calculation of the fleet average emissions. In 2012 and 2013, each new car emitting less than 50 g CO_2/km was counted as 3.5 cars. This weighting decreased to 2.5 cars in 2014, 1.5 cars in 2015, and will be 1 car in 2016. For the 95 g CO_2/km target, low-emitting cars will be weighted as 2 cars in 2020, 1.67 cars in 2021, 1.33 cars in 2022, and 1 car from 2023 onwards.

Pooling

A further incentive for manufacturers is the ability to form pools with other car manufacturers in order to achieve the emission targets over the average pooled fleet of new cars sold. Only information on average emissions of CO_2, specific emissions targets, and the total number of registered vehicles may be

[1] The slope parameter takes on the value a = 0.0457 in the period until 2020. After 2020, the slope parameter declines to a = 0.0333. The baseline mass is set at the average mass of new passenger cars in the three preceding calendar years. For the first period until 2015, M_0 = 1372.0.

exchanged to prevent issues of collusion between manufacturers and such agreements may relate to a maximum of 5 calendar years. Two types of pools exist: Open pools are open to any manufacturer wishing to take part subject to the conditions laid out in the regulations. Closed pools consist of manufacturers who are in some way connected, e.g. through voting rights or the right to appoint board members, etc. In practice, only closed pools are currently in use.

Eco-innovations

"Eco-Innovations" provide an additional incentive for car manufacturers to lower the emissions of their new car fleets. These measures allow for a reduction of up to 7 g CO_2/km per year in the fleet average emission standard target for car manufacturers. The measures must be independently verified and may not be mandatory under other laws.

Penalties

Car manufacturers face penalties for non-compliance with the targets as measured according to the level of excess emissions above the fleet average target. For passenger cars the penalty is €5 for the first g/km, €15 for the second g/km, €25 for the third g/km, and €95 for all subsequent g/km above the target for 2012-15. The penalty will be €95 for every excess g/km from 2019 onwards. The penalty is multiplied by the total number of new vehicles from the manufacturer in question registered in that year.

Small manufacturers

To avoid overburdening manufacturers with only a small number of sales in the European market, the EU has allowed smaller manufacturers relaxed conditions with regard to emission standards. Manufacturers selling less than 1,000 cars per year in the EU are exempt from the legislation. Those selling between 1,000 and 10,000 cars per year who do not wish to form a pool may propose an individual reduction target to be approved by the EU Commission. Manufacturers selling up to 300,000 cars per year are able to apply for a target fixed at a 25% reduction in emissions compared to 2007 levels for the period 2012 to 2019. This fixed target increases to a 45% reduction compared to 2007 levels from 2020 onwards.

Advantages and disadvantages of emission standards

The use of emission performance standards has a number of advantages and disadvantages. The emission performance standard directly provides incentives in the transport sector for car manufacturers to innovate and to implement technologies to reduce fuel consumption. The standards also have a series of disadvantages for regulation of CO_2 emissions in transportation. The foremost of these is that the costs of goal attainment with standards are unobservable to regulators. Another important issue is that the instrument is directed at the purchase decision of new cars only, and does not give incentive to reduce the use of the vehicle after purchase.

Innovation stimulation

Since 2008, CO_2 emissions have declined by approximately 4 % annually for passenger cars. Figure 1 shows the evolution in liters of fuel per 100 km for a subset of EU countries together with the EU-28 average. Despite this apparent success, it is hard to say how large a share of the decline is due to the standards. Standards are not the only regulation to target CO_2 emissions of new cars (see also Chapter 5 for an overview of existing regulation). In particular CO_2-based national registration taxes have been introduced in several EU countries in the years preceding 2010. In addition fuel taxes also provide incentives to purchase a car with lower fuel consumption.

An important dimension to providing incentives for innovation is that such incentives should be technology neutral. Until now this seems to have been the case for standards in the sense that conventional internal combustion engine (ICE) vehicles as well as hybrid and electric vehicles have been able to reach the target (see Figure 2). Whether a tightening of the standards beyond 2020 will still be economically viable for manufacturers of conventional vehicles is currently under discussion.

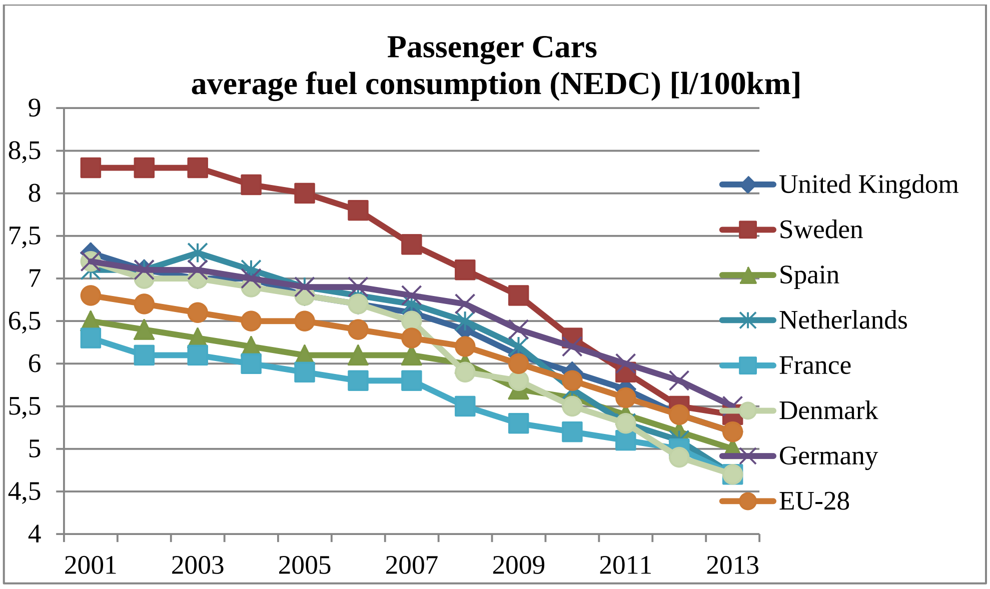

Figure 1: Evolution in average fuel consumption of passenger cars in the EU, 2001-2013, based on the New European Driving Cycle (NEDC) tests. Source: www.eupocketbook.theicct.org.

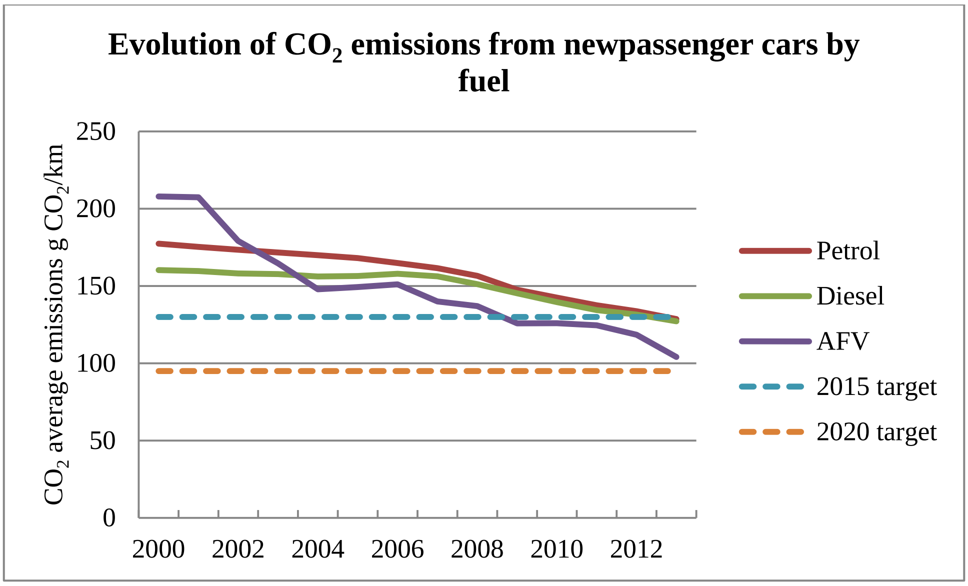

Figure 2: Evolution of CO_2 emissions from new passenger cars by fuel type. AFV is Alternative Fuel Vehicle. Source: Monitoring of CO_2 emissions from passenger cars – Regulation 443/2009 provided by European Environment Agency (EEA).

The cost of emission standards

The effect of the increasingly stringent environmental regulation and standards on the price of vehicles is hard to distinguish from the overall developments in the car market. Varma et al. (2011) analyze this issue in a report for the European Commission. They find through a series of hedonic price regressions that the impact of improved fuel economy on the price is mixed. In particular, it turns out to be difficult to isolate the effect of variation in fuel economy on the vehicle price as fuel economy is correlated with other attributes such as weight, size of the car, and engine power. In a series of stakeholder interviews with several manufacturers, Varma et al. (2011) found that those factors most important to vehicle prices and cost pass-through to consumers were environmental standards (i.e. Euro standards and emission standards), market conditions (taxation of vehicles etc., consumer purchasing power) and competition. For cost pass-through to consumers, competition and market conditions were considered among the interviewed stakeholders to play the most important role in addition to the extent to which additional features of a car could be considered to bring added value to consumers.

As for future regulation, concern has been raised that a future tightening of the goals to 68-78 g CO_2/km will no longer be economically viable. In a report discussing the future regulation of light duty vehicles a series of model simulations is carried out to analyze the future costs of producing vehicles satisfying the proposed emission performance standards beyond 2020. The analyses indicate that the costs exceed the consumer willingness-to-pay for fuel efficiency as determined by their user cost savings over the vehicle's life time. Furthermore, in particular car manufacturers serving the market for larger passenger cars could be adversely affected by the regulation unless the performance standard is made to depend on e.g. weight as the current standard does. The model used for these calculations is sensitive to assumptions concerning the evolution of economic viability and market penetration of hybrid and electric vehicles (IKA, 2014).

Distortion of manufacturer incentives

Car manufacturers have a number of different opportunities to reduce CO_2 emissions from new vehicles. The use of a mass-based limit value function is intended to redistribute the burden of reductions among manufacturers so as not to punish manufacturers of heavy vehicles disproportionately. However, it also distorts manufacturers' choice of abatement technology. One option manufacturers have is to reduce weight of the vehicle, but with the mass-based limit value curve such a strategy would at the same time increase the stringency of the target. The impact assessment pertaining to the emission standards for passenger cars and light commercial vehicles specifically assesses this point and finds that the estimated additional costs imposed on manufacturers by the legislation increase by about 3 %. The increase in costs depends on the cost of the light-weighting technology and may be higher if the cost is lower than the relatively high costs assumed in the report (European Commission, 2012a). A related issue is that increasing mass would lead to less stringent targets. This could provide an incentive for manufacturers to increase weight rather than reduce emissions depending on which measure is cheaper. Recent research by Ito and Sallee (2014) for the Japanese car market has found evidence of such unintended consequences of attribute based regulation as manufacturers bunch at weight thresholds where the stringency of the emission standard shifts discontinuously. Bunching at weight thresholds can also be observed in Europe (see Figure 3) where such discrete thresholds are implicit in the measurement of emission performance. Increasing weight to achieve a less stringent target not only reduces the effectiveness of the regulation for the goals it was meant to achieve but can also have serious side effects such as increased fatalities from car accidents due to the larger damage caused by heavier vehicles.

Monitoring compliance

Monitoring compliance with the target depends on a standardized test cycle for new cars (New European Driving Cycle, NEDC). Evaluations have criticized these tests for not accurately capturing real-life emissions. A recent report from the ICCT shows that the discrepancy between real life emissions and the emissions measured through the NEDC test currently in use for type approval have been increasing over time from 11 % in 2001 to 25 % in 2011 (ICCT, 2013). The test cycle allows a variety of energy-consuming options to be turned off for the duration of the test (e.g. air condition). Moreover vehicles are divided into inertia classes based on weight to avoid having to calculate emissions for every model. This has resulted in some incentive to manipulate weight to achieve more desirable test results as is evidenced by bunching around inertia class thresholds as can be seen in Figure 3 (Mock, 2011).

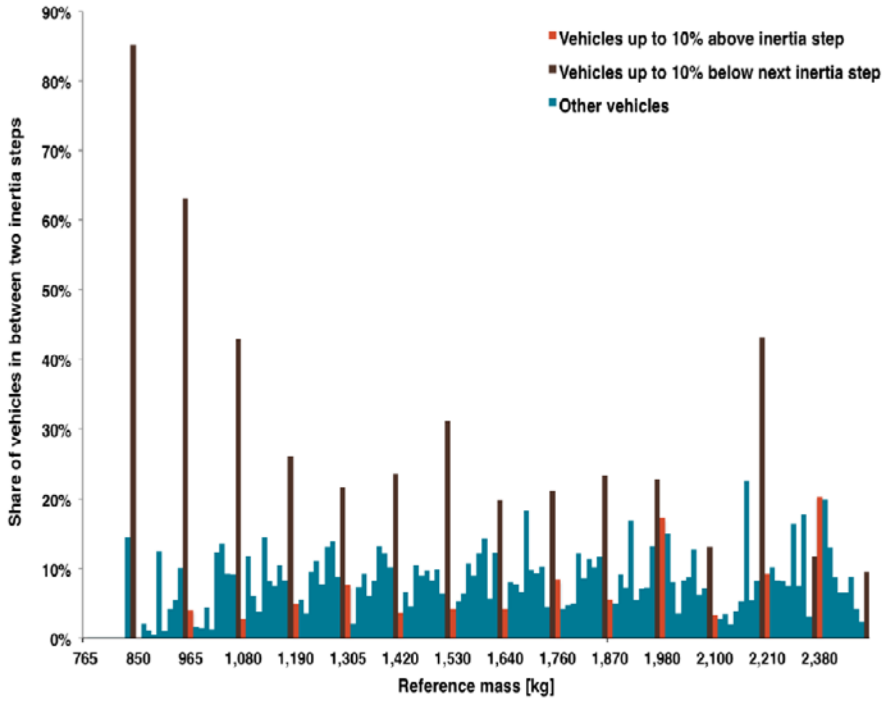

Figure 3: Distribution of new passenger car registrations by reference mass in EU-27 (2010) - Binned into 10 categories for each inertia class. Source: Figure 2, Mock (2011).

These issues suggests that the laboratory driving cycle test poorly reproduces conditions and real driving behavior, and vehicles which perform best in these tests do not necessarily perform best in real life. Taken together these issues imply that the actual size of the emission reduction is also uncertain as it depends on the quantity of new vehicles sold, their performance in real life, and the use of the vehicle (vehicle distance travelled).

Determinants of emissions

The actual emissions of the car fleet depend on the composition of the entire car fleet including used cars. It has been shown for the US that the use of fuel economy standards has led to what is referred to as “used car leakage:” higher costs of new cars results in postponed scrapping of older vehicles. The magnitude of this effect has been found in the order of 13–16 % reduction of the expected fuel savings (Jacobsen and van Benthem, 2015). The price of fuel including taxes also plays a role as do registration and annual circulation taxes. The main determinant however, is how much the car is used and how. There is substantial heterogeneity across consumers in annual distances travelled and also driving behavior (speed, stop and go, etc.) play a role in determining emissions. The emission standards provide no incentive to change driving behavior in order to reduce CO_2 emissions. On the contrary, as the emission performance standard improves the fuel efficiency of the vehicle it makes driving cheaper for the owner. This results in what is known as the "rebound effect" as drivers respond to the lower cost of driving by driving more (see Box 1). Such rebound effects have empirically been found to set off the efficiency gains by more than 50 % in the transport sector (Frondel et al., 2008).

Box 1: The Rebound Effect

The EU Energy Efficiency Directive (EU, 2012) establishes a framework to increase energy efficiency with the aim of reducing primary energy consumption across Europe by 20 % by 2020. However, the effectiveness of this strategy depends crucially on how energy users and suppliers react when energy efficiency improves. The so-called "rebound effect" may significantly reduce the expected benefits of efficiency improvements and consequently societal capacity to move towards a carbon-neutral, climate-proof and adaptive economy. The study of this phenomenon goes back thirty years ago and builds on the foundations laid by Jevons (1865), the work of Khazzoom (1980, 1987) and Lovins (1988) which has stimulated current scientific research. In the transport sector, direct rebound effects occur when an increase in the efficiency in the physical use of fuel (e.g. increases in km/liter) reduces the price of the energy service delivered (e.g. kilometers). This can incentivize increases in the demand of energy services. Rebound effects can be composed by a range of secondary and economy-wide effects as prices, incomes; demand and supply in multiple markets change as a result (Turner, 2013). Secondary effects occurs when service demand increases followed by relaxing household budget constraints given a decrease in the effective price of the service in the presence of improvement in energy efficiency (Koesler, 2013). Yu et al. (2013) is a current example of empirical research on secondary rebound effects. They found evidence that couples with monetary saving due to improvements in energy efficiency would use this monetary savings to increase their travel demand. Regarding economy-wide rebound effects, they arise when changes in quantities and prices at the macro level are a consequence of spillover effects of the initial changes in energy efficiency in one sector (Turner, 2013). Eventually, neglecting rebound can lead not only to unreliable estimates of energy saving but also to the incorrect design of energy efficiency policies.

Box 1: The Rebound Effect (cont.)

Measuring the direct rebounds in the transport sector has been an active area of research in the last years. Using a panel data that depicts driving behavior in Germany, Frondel et al. (2008) obtained estimates of the rebound which is in the range of 57 % and 67 %. On the heterogeneity of the rebound, Frondel et al. (2012) found that drivers in the low vehicle mileage categories can experience larger rebound effects. They argued that drivers with low automobile mobility will have larger responses to reduction in the relative fuel cost than drivers with high demand for individual transportation. In regards to the dynamics of the rebound effect, Small and Van Dender (2007) found that in the USA, the rebound has fallen in the period 1997-2001. They argued that the rebound will continue decreasing because increases in real income will make drivers less sensitive to changes in fuel prices. They estimated a rebound effect of 4.5 % and 22.2 % for the short and long run.

While designing policies to counteract the rebound effect requires an accurate measure of the rebound, there is in the literature a large variation in this estimate. Gillingham (2014) found that estimates for the direct rebound effect are generally in the range of 0 to 50 %. Examples from current research show that in Germany the rebound in the transport sector can be around 60 % (Frondel et al., 2012) while for Sweden, a rebound of 3 % was estimated (Whitehead et al., 2015). While these large variations in the rebound size can be attributed to methodological and country differences, there is at the bottom of this debate a lack of consensus of basic concepts of energy efficiency and energy use which are crucial in measuring the rebound (Turner, 2013).

Summary and conclusion

There is some indication that the introduction of standards has played a role in improving the fuel efficiency of cars in Europe. The standards have been designed in a way that aims to increase flexibility in achieving the target through the use of limit value curves, super-credits and eco-innovations. Nevertheless regulation through standards has a number of drawbacks. Firstly, the standards address only the new car market segment and they provide no incentive for used car owners or for changing driving behavior. Secondly, the measurement of performance as well as the design of the standard to relate emission performance to weight gives cause to distortions in vehicle design. These distortions may have further unintended consequences, e.g. as cars become heavier, injuries caused by accidents become more serious. Thirdly, since the standards improve fuel economy of a car it becomes cheaper to use the car. This leads to what is known as the “rebound effect” where savings in fuel economy are counteracted through increased driving. Such rebound effects can substantially reduce the abatement that was intended by the introduction of the standards in the first place. Finally, the standards are costly for firms to implement, yet the cost is unobservable to regulators implying that the cost-efficiency of the regulation is unmeasured. Studies of a future tightening of the emission standards suggest that the costs of improving fuel economy further may be higher than consumers’ willingness to pay for the improvements. In addition, it is uncertain whether such future standards would continue to be technology neutral.

Chapter 2: Inclusion in the open ETS or a closed ETS for road transport

The EU introduced its emissions trading scheme in 2005 thereby becoming the first multinational cap-and-trade scheme for greenhouse gasses. The EU ETS remains the largest carbon market and covers Iceland, Lichtenstein and Norway in addition to 28 EU member states. More than 11,000 power stations and other installations are currently covered by the ETS. The latest addition to the scheme is aviation, which entered the EU ETS in 2012.[2] The EU ETS is currently in its third phase running from 2013 to 2020. It covers approximately 45 % of the EU's greenhouse gas emissions. Sectors currently not covered by the ETS include buildings (e.g. heating), agriculture, and road and maritime transport. In recent years the EU ETS has been much criticized due to the currently low allowance price and the accumulated surplus of allowances in the market. In its report on the state of the carbon market from 2012 the Commission discusses different options for improving the functioning of the EU ETS and reducing the number of surplus allowances accumulated during the financial crisis (European Commission, 2012b). Among the options discussed is an expansion of the ETS to cover sectors currently outside the carbon market. In the conclusions from the council meeting of 23/24 October 2014 the EU Council has noted that under existing legislation member states can opt to include transport in the ETS (European Council, 2014). Such an expansion requires consideration of each of the design features of the enlarged EU ETS.

The emission allowances issued are traded on a market and the cap determines their scarcity and hence their price. Each allowance permits the holder to emit one ton of CO_2 equivalent. Installations under the ETS must surrender sufficient allowances for the previous year to cover their emissions or face heavy fines. The current cap for fixed installations is reduced by 1.74 % every year in order to reduce emissions by 21 % in 2020 compared to 2005. For avia-

[2] Following international controversy with regard to the original directive 2008/101/EC, the scheme was amended to cover domestic and internal flights within Europe, yet not flights to or from third countries until 2016.

tion the target is a 5 % reduction by 2020 compared to the average annual level of emissions in the years 2004-2006.

Since the launch in 2005 several rules have been changed to make the system more effective. In the early days of the ETS almost all allowances were given for free to the regulated entities. This means of allocation is known as "grandfathering". In the later phases of the ETS a growing share of allowances has been auctioned. In 2013 approximately 40 % of allowances were auctioned and the share is set to rise further in coming years. For the aviation sector benchmarking has been used for the initial allocation of allowances, although 15 % of allowances will be auctioned over the period 2013-2020. In addition to purchasing allowances on auction or from each other (over-the-counter transaction), companies can make use of credits from e.g. the Clean Development Mechanism (CDM) or Joint Implementation (JI) mechanism established in the Kyoto Protocol.

The impact of an ETS in terms of cost-effectiveness, distributional effects and efficacy depends on its design. The market must be large enough for regular trading to take place, and single traders should not hold considerable market power such that the carbon market can be used strategically. Likewise the more sectors an ETS covers the more potential abatement opportunities exist within the carbon market. As an ETS ensures that abatement takes place where the cost is lowest, this implies that some sectors may not experience much reduction in their emissions. The damages from CO_2 emissions do not depend on the source of the CO_2, therefore there is no reason why emission reductions should necessarily occur in specific sectors.[3] Including new sectors can affect the price of emissions allowances depending on how the expansion is designed. In this chapter advantages and disadvantages of a full integration of road transport into the ETS are discussed versus a more limited integration or the setting up of a separate ETS where only emissions from road transport are traded. In this regard it is useful to distinguish between static efficiency and dynamic efficiency. Static efficiency refers to the allocation of resources at

[3] The EU White Paper on Transportation does have specific targets for emission reductions in the transportation sector. Such targets may not be achieved if transportation is integrated in the EU ETS.

a point in time whereas dynamic efficiency is concerned with the long term developments. The latter puts more emphasis on considerations of incentives for innovation and adoption of new technologies. The dynamic effects of regulation will be considered in the final section of this chapter.

The closed road transport ETS

Creating an ETS in parallel to the existing EU ETS focusing solely on road transport would ensure that emission reductions set as a cap for the system are achieved within the road transport sector. In addition a separate ETS for road transport could take into account any legal or organizational issues specific to that sector, which may be less easily accounted for in full integration. Regulation through an ETS is more flexible than standards as the emission reductions may occur through the use of other abatement measures than improving fuel efficiency. Potentially, the price on carbon emissions in the transport sector would provide incentives to reduce driving, reduce the carbon content of fuel, and influence purchase of relatively fuel efficient vehicles (both used and new). The exact impact may depend on the choice of regulated entity, which is the subject of Chapter 3. A disadvantage to this approach would be that the abatement measures used are likely to be more costly than abatement measures available in the sectors covered by the existing EU ETS. Prohibiting the use of these cheaper abatement measures to achieve the needed emission reductions for the economy as a whole would imply a higher overall cost of GHG emission reduction than in an integrated system. While the cost of achieving the target set for road transport would likely be lower with the possibility of trading emission allowances than the cost of using emission standards, the closed system overall is less efficient than a system which allows for more integration with the full EU ETS and in consequence has more abatement opportunities available.

A closed transportation ETS also runs the risk of strategic considerations affecting trading in emission allowances due to the limited number of actors in the market. The magnitude of this risk depends on who the regulated entity is. If car manufacturers are regulated (e.g. required to hold emission allowances corresponding to the estimated emissions of their sold vehicles), the structure of the market with few large players could imply that some actors have an interest in driving the price of emissions allowances up. The more participants there are in a market the lower is the risk of such strategic behavior.

Improving efficiency through a gateway

When aviation was included into the EU ETS there were concerns of how this might be accomplished while taking into account that aviation was not covered by the Kyoto Protocol. As such emission reductions in aviation could not contribute to complying with the targets set out in the Kyoto Protocol. For this reason, a separate, but linked ETS was set up for aviation in which trade occurs between operators and owners of aircraft, but with a gateway to the full EU ETS. The gateway provides the opportunity for operators in the aviation sector to purchase allowances in the EU ETS, but allowances from aviation emission reductions cannot be used by industries in the EU ETS to cover their emissions (Directive 2008/101/EC).

The effect of having a semi-open system implies that the price of emission allowances cannot deviate too much between the two systems. For example, if the price of allowances within the aviation sector roses much above the price of an EU allowance from the EU ETS, aviation operators have an incentive to purchase allowances in the EU ETS until prices are equalized. In this way abatement costs across sectors in the two ETS are equalized and emission reductions have been achieved at less expense than in the fully closed system.[4] At the same time, the gateway insulates the EU ETS from periods in which the price of an allowance in the aviation sector is much lower than the price in the EU ETS. In this case, as no allowances can flow out of the aviation sector, a price difference can be maintained.

A gateway may be useful in the early stages of expanding an ETS if the impact of the expansion on allowance prices is very uncertain (for instance if there is very little knowledge about an appropriate cap after the inclusion of a new sector) in the sense that it could prevent a price collapse. Alternatively, if a sector experiences much larger fluctuations in activity through the business

[4] By essentially putting an upper limit on the allowance price a gateway also reduces potential windfall gains when allowances are allocated for free as is the case for the majority of allowances in the aviation sector. For more on windfall gains please see Chapter 4.

cycle than the other sectors a semi-integrated system can limit the impact of these fluctuations on other sectors by limiting the impact on the quota price.

If no limits are put on trade through the gateway, i.e. if all allowances are tradeable in both markets, then it is in effect a fully integrated ETS with one carbon price. In this sense it is possible to set different caps for the different ETS, but since the allowances can be traded freely between them, there is no control over where abatement occurs and in practice it would function as an integrated ETS with a cap equal to the sum of the caps set for each scheme.

Full integration

Full integration of road transport into the existing EU ETS has significant advantages. The institutional base is already available as a working system with reporting mechanisms and trading institutions. Enlarging the coverage of the existing ETS also offers several economic advantages for its operation. Firstly, a correspondingly enlarged EU ETS has a larger number of abatement options and thus can improve cost efficiency of mitigation. Secondly, it is expected that larger schemes have lower volatility of trading and hence certificate prices. This is due to the fact that individual trading activities only have a small impact on the market price and liquidity due to the greater volume of trades in a single large trading scheme.

While the cap set for the integrated EU ETS would guarantee that no more emissions take place than those for which allowances exist, it could be the case that none or only very little of the abatement takes place in the road transport sector. The allocation of abatement efforts across sectors depends on the relative marginal abatement costs. The cheapest abatement opportunities will be realized before the more expensive alternatives are taken up. This is exactly the point of using an ETS. When it comes to GHG emissions it should not play a role which sector reduces emissions as the damage caused by one additional ton of emitted CO_2 equivalent is the same regardless where it came from. Burden sharing among sectors is easily achieved in an ETS by ensuring that no sector covered by the regime avoids paying the market price for its emissions. The market price in this sense is determined by the marginal abatement cost curve and the cap for the integrated system.

Impact on allowance price and distributional concerns

The inclusion of road transport into the EU ETS with a single common cap could redistribute resources between sectors by reducing compliance costs for climate policy goals for the road sector while raising compliance costs for other sectors. Sectors such as manufacturing are already covered by the EU ETS and are exposed to competition in the global market. For such sectors a substantial increase in allowance prices could have a negative impact on their international competitiveness and might lead to carbon leakage as carbon-intensive production relocates outside the EU ETS area. Whether the inclusion of road transport into the ETS will have a large impact on the allowance price and hence potentially on the global competitiveness of other sectors depends on the setting of the cap and the marginal abatement cost curve for the enlarged EU ETS.

Flachsland et al. (2011) illustrate the effect of integrating road transport into the EU ETS in a stylized graph repeated here in Figure 4. The horizontal axis depicts the total volume of abatement in both transport and the existing ETS as implied by the reduction target or cap. From the left hand side, the marginal abatement cost curve (MACC) of the existing ETS is shown to be rising from left to right as abatement volume in the ETS sectors increases (ETS MACC). From the right hand side, the MACC for transport is illustrated rising from right to left as abatement within the transport sector increases. The point on the horizontal axes marked by Q_{set} shows the allowance price in two separate emission trading schemes where the existing ETS and the transport sector have to reduce emissions corresponding to the distance from the origin to Q_{set}. This distribution of required abatement efforts results in the allowance prices P_{ETS} and P_{trans} in the ETS and the transport sector respectively. Due to the steeper MACC in the transport sector, the allowance price in the isolated transport emissions trading scheme is higher than the allowance price in the ETS. The intersection of the two curves at *(Q^*, P^*)* illustrates the distribution of abatement efforts in the integrated ETS. Here, P^* is the emission allowance price in the integrated system. It is slightly higher than in the isolated ETS, but lower in the isolated transport emissions trading scheme. The figure thus illustrates the effect of integrating the two systems and how it depends on the relative steepness of the respective marginal abatement cost curves and the total quantity of abatement necessary. The extent to which an expansion of the ETS to also include road transport would lead to higher prices depends on the steepness of the actual MACC. While there is some uncertainty as to the steepness of the actual MACC a series of modeling exercises have been carried out with different assumptions to shed light on how the EU allowance price might be affected.

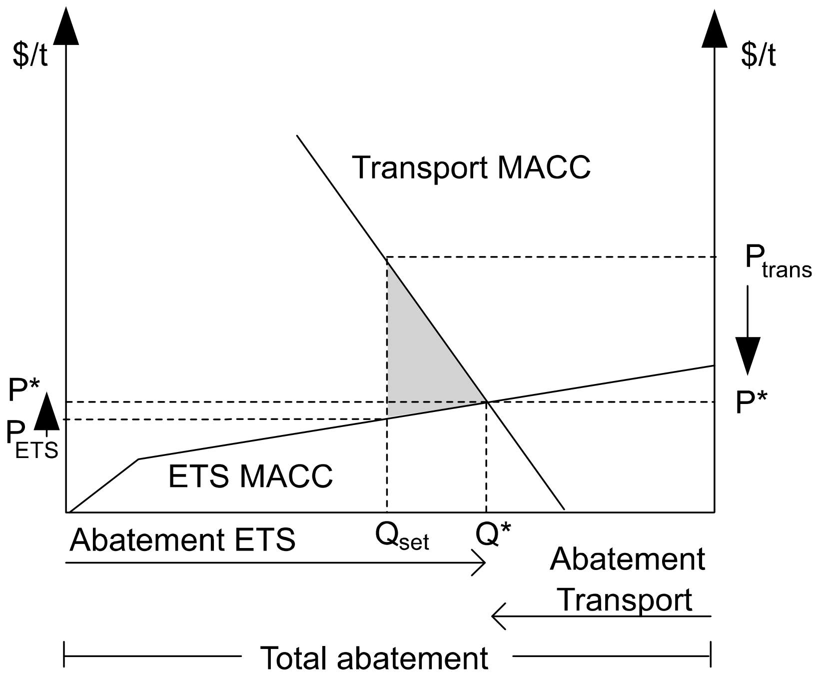

Figure 4: Allowance price effects of including transport. Source: Figure 5 in Flachsland et al. (2011).

Several studies directly or indirectly concern the marginal abatement cost curve for the (road) transport sector. The general sentiment is that the marginal abatement cost curve for the road transport sector is steeper than for the remaining EU ETS. Blom et al. (2007) construct a marginal abatement cost curve for the transport sector including maritime transport and aviation and find it to be significantly steeper for reductions above 180 Mtons. While the report from Cambridge Econometrics (2014) does not explicitly depict a marginal abatement cost curve, the results of their analysis indicate only limited reductions in the road transport sector of 1-3 % for allowance prices between 10 and 20 €/ton CO_2. Their calculations of what the EU ETS price would have to be for CO_2 emission reductions of 23 % to occur in the road transport sector exceed 200 €/ton CO_2 suggesting a relatively steep marginal abatement cost curve. Heinrichs et al. (2014) also find that emission reduction in the road transport sector declines following inclusion in the EU ETS which implies that cheaper abatement options are available in other sectors. However, indications of a steep marginal abatement cost curve for road transport or the result that abatement primarily occurs in other sectors does not imply that allowance prices would rise steeply with the inclusion of road transport into the ETS, although it does strongly suggest that the cost-effectiveness of the regulation for CO_2 reduction would be improved.

Flachsland et al. (2011) use four different marginal abatement cost curves (Blom et al., 2007; McKinsey, 2009; Enerdata-POLES; AIM/Enduse). They find basically no increase in EUA price after transport inclusion in their standard scenario which analyses a 20 % reduction of emissions by 2020. Their findings are due to three factors: 1) The extensive use of credits from CDM/JI projects, 2) the volume of abatement opportunities in road sector, and 3) the relatively low reduction target for transport (7 % below 2005 levels). As a result, they estimate that more abatement will take place in the transport sector and less in the ETS after integration. The study is a little outdated as current targets are more ambitious than those analyzed by Flachsland et al. (2011). The most recent analysis has been carried out by Paltsev et al. (2015). In a CGE modeling exercise, Paltsev et al. (2015) first assess the volume of overall emission reductions under emission standards once the rebound effect and leakage to other sectors of the economy have been taken into account. They find relatively small emission reductions of 65 million tons of CO_2 in 2020 through the use of standards for private cars compared to total emissions of 3,100–3,400 million tons of CO_2 in 2020-25 for the ETS as a whole. When incorporating the road sector in the ETS the reductions for private cars is lower at 18 million tons of CO_2 in 2020. The fact that less reduction takes place for private cars illustrates that the cost-effective allocation of abatement efforts induces reductions in other sectors under the ETS. Quantifying the welfare gain from using the ETS rather than emission standards, Paltsev et al. (2015) find the consumption loss from achieving the same carbon reductions under an ETS regime to be an order of magnitude smaller than under the emission standard regime.[5] In addition to studying the current 2021 target, Paltsev et al. (2015) also assess the impact of the targets after 2021 of 68-78 g CO_2/km proposed by the European Parliament. The cost of achieving the same emission reduction as with standards but using only the ETS is found to be € 24-63 billion/year lower in 2025 depending on the stringency of the emission standard. Similar cost savings arise when comparing a scenario based on only the ETS to a scenario combining the extended ETS with emission standards.

The implied EU allowance price and sectoral emission reductions from the different scenarios were generously provided to us by Paltsev et al. A substantial increase in EU allowance prices can be observed over time as the cap is tightened. The price in the model is approximately 4 €/ton CO_2 in 2015.[6] Assuming a cap on total emissions at 3,123 million tons of CO_2 in 2025, the scenario with ETS and emission standards fixed at the 2021 target yield an EU allowance price of 17 €/ton of CO_2 in 2025. The scenario without emission standards has a higher price at 21 €/ton of CO_2 in 2025 roughly corresponding to three times the current EU allowance price. Comparing the resulting distribution of emission reductions across sectors in the two scenarios with the ETS, it is clear that the scenario with emission standards has substantially larger reductions in private transport, where emissions decline by almost 20 % compared to 2010 levels corresponding to 14 % of the overall reductions in EU emissions from 2010 to 2025. In the ETS only scenario, emission reductions in private transport are reduced to 4 % of 2010 levels, which corresponds to only 3 % of overall EU emission reductions. If converted to an increase in the fuel price, an EU allowance price of 21 €/ton would add about 0.05-0.06 €/L to the fuel price, which is not likely to reduce driving substantially.[7] In the ETS only

[5] The setup studied in Paltsev et al. (2015) looks at an ETS covering the whole EU economy and not just the sectors presently covered by the ETS. This implies that sectors such as agriculture and transportation (private and non-private) are also covered by the ETS.

[6] The EU allowance cost in early April 2015 is somewhat higher at approximately 7 €/ton CO_2. This discrepancy is due to the incorporation of all sectors into the ETS which raises efficiency and lowers the price of allowances due to the availability of cheaper abatement options in sectors currently excluded from the ETS.

[7] Calculated based on a CO_2 content of 2,360 g/L and 2,690 g/L for gasoline and diesel respectively.

scenario, the reductions that do not occur in private transportation instead occur especially in the electricity sector (increase in share of reductions from 40 to 45 % of overall reductions compared to the scenario with ETS and standards) and in the energy-intensive sector (30 to 32 % of overall reductions compared to the scenario with ETS and standards). Manufacturing slightly increases its share of the overall reductions by 0.5 percentage point from 0.3 to 0.8 % of all reductions. In the following we turn to the evidence of carbon leakage or loss of competitiveness of domestic EU firms due to the ETS.

Carbon leakage and effects on competition

So far there is limited concrete evidence of adverse effects on industry in the existing EU ETS despite previous EUA prices significantly above current levels. A recent survey by Martin et al. (2014) discusses the available empirical evidence from ex post assessments of the EU ETS. While the literature is still quite limited, it is growing fast. The survey covers quantitative studies based on macro and micro data as well as qualitative analyses and case studies. The different studies focus on both environmental impacts but also on effects on competitiveness and other indicators of economic performance (turnover, employment, etc.). The main conclusion is that there is little evidence of substantial detrimental impact on firm performance and competitiveness that can be causally ascribed to regulation under the ETS. There is also some heterogeneity in findings though, for instance similar studies for Germany (Petrick and Wagner, 2014) and France (Wagner et al., 2014) using administrative firm data find no adverse effects on performance in Germany, whereas in France significant negative employment effects were determined. In both cases, the analysis relies on matching firms under the ETS to similar firms not in the ETS. The validity of the findings depends on the quality of the match although several robustness checks are carried out in each case to lend support to the identification strategy. Furthermore, it should be noted, that studies so far mainly study the impact on firm performance beyond that of rising electricity costs. There is evidence that electricity producers are able to pass through the costs of emission allowances to end users, which could affect firms both inside and outside the ETS negatively compared to international competitors. More research is needed in this area to determine the total impact of the ETS on firm performance.

To some extent the use of different allowance allocation mechanisms, i.e. "grandfathering" allowances to exposed sectors and auctioning them to less exposed sectors, can alleviate the regulatory pressure on competition exposed sectors. Currently, the ETS uses such a mix of allocation methods although the share of auctioned allowances is expected to increase over time (see Chapter 4 for more on allocation mechanisms).

Innovation incentives and dynamic efficiency

The most recent research by Flachsland et al. (2011) and Paltsev et al. (2015) suggest that the impact of including road transport into the ETS on the EU allowance price would be limited in the short term, but that the gains from a static efficiency point of view could be substantial. In light of these findings, the question has been raised whether a relatively low short term EU allowance price will provide sufficient incentives for innovation and adoption of new technologies to ensure that the relevant technologies are available for deployment when needed. This question concerns the *dynamic efficiency* of an enlargement of the EU ETS to include road. There is a general impression that emission standards have contributed to improving the fuel efficiency of the vehicle, which leads some actors to surmise that a further tightening of these standards could maintain such an effect in the future. This section discusses the innovation incentives provided by different policy tools with an emphasis on comparing the performance of standards and an emissions trading scheme.

Before going into this comparison, Parry et al. (2003) raise an important issue in the debate on innovation incentives from environmental regulation. They compare the welfare gains from innovation to the welfare gains to be had by correcting the pollution externality. In a relatively simple setup, they show that the Pigouvian welfare gains from correcting the pollution externality are often much larger than the gains from innovation for reasonable parameter settings. Innovation dominates in terms of welfare gains only when the speed with which innovation reduces abatement costs substantially is high (50 % reduction in 10 years) and the optimal initial abatement level is relatively low. While their analysis is based on a stylized setup with optimal policy choices for both innovation and abatement, it is still worth keeping in mind that the welfare gains to be had with the use of conventional technology once the appropriate (static) incentives for pollution control are in place may significantly outweigh the gains of waiting for the development of cheaper abatement methods.

Innovation incentives of policy tools

Research has suggested that standards can be an effective way of encouraging innovation activities (see Clerides and Zachariadis, 2008). However, it is not clear that fuel standards are better than other policy options at stimulating innovation (Anderson et al., 2011). Standards may have a negative effect on technology diffusion in the total car fleet. By driving up the price of new vehicles, standards are likely to induce households to postpone scrapping an older vehicle. There is evidence that the use of increasingly stringent standards in other industries has led to prolonged use of old, less inefficient capital stock thus slowing down diffusion of new technology and keeping pollution levels higher than they might otherwise have been (Jaffe et al., 2002). Furthermore, standards also encourage innovation in very specific dimensions. In the absence of standards such innovation activity may be redirected into other areas of technology that car manufacturers deem promising and customers demand such as the autonomous vehicle, improved safety measures, etc.

There is a large theoretical literature on the dynamic efficiency of different regulatory measures. Most theoretical studies provide a clear-cut picture of a higher impact of market-based instruments such as cap and trade systems or an emission tax on innovations – also in the long-run, see Downing and White (1986) or Milliman and Prince (1989). Magat (1978) concludes that also command-and-control regulations can provide incentives for continuous innovation if, and only if, regulated firms are growing or if the standards do not remain constant over time. Jaffe and Stavins (1995, p. 45) nicely summarize the existing theoretical literature on this issue as follows: "Theoretical economic analyses have generally supported the notion that market-based approaches provide the most effective *long-term* incentives for invention, innovation, and diffusion." They also provide empirical evidence in favor of this view for the case of energy efficiency technologies in buildings. Another study by Kerr and Newell (2003) also support this view based on data for lead-reducing technologies. A more recent survey by Requate (2005) emphasizes that the exact ranking of different policy tools for innovation incentives is generally context dependent. Montero (2002) compares emission standards to auctioned or grandfathered tradeable emission permits in varying market settings. He finds that emission standards can potentially outperform permits in terms of innovation incentives under imperfect competition. Emission standards regulate the individual firm without spillover effects whereas permits have both a direct and a strategic effect in such a market. The direct effect is to lower the compliance cost which works to increase innovation activities. The strategic effect in contrast can work in the opposite direction under imperfect competition, as the reduced demand for permits following innovation by one firm would result in a lower permit price for the competing firm thus reducing its compliance cost. Such an effect would be more likely to be observed in an ETS limited to the road transport sector, whereas the strategic effect of road transport innovations in a larger, integrated ETS would be likely to be small.

The recent history of the EU ETS and the current allowance price has provided some cause for concern as the allowance price has dropped far below the levels originally anticipated when the ETS was introduced. Despite the current state of affairs, empirical evidence suggests that the ETS has been effective in reducing emissions especially in its second phase (Petrick and Wagner, 2014). In the modeling framework described above, the EU allowance prices are expected to rise substantially in the future. But even in the first two phases of the EU ETS when the allowance future prices were relative low and there were concerns about over-allocation of permits (Ellerman and Buchner, 2007; Anderson and Di Maria, 2011), the EU ETS has significantly contributed to innovation in the field of low-carbon technologies (Calel and Dechezleprêtre, forthcoming). These findings corroborate an earlier study by Martin et al. (2012), which finds that firms that expect to experience a reduction in freely allocated permits innovate significantly more. Martin et al. relate this finding to the free allocation mechanisms in the EU ETS for highly trade-intensive and carbon-intensive firms. They conclude that free allocation as used in the first two phases of EU ETS is likely to have led to fewer innovation activities related to climate-friendly innovations. However, the impact of such future price increases and an announced future tightening of the cap on current innovation activities depends crucially on the credibility of the policy and the policy makers' ability to commit to the future policy goals. Helfland and Wolverton (2011) discuss uncertainty about future regulation as one factor that could potentially inhibit car manufacturers' supply of fuel efficient vehicles. Evidence of commitment to the ETS is already present as the third phase of the EU ETS (2013-2020) is characterized by a higher amount of allowances auctioned and, more importantly, a European cap without National Allocation Plans as in the first phases. Moreover, the EU has announced that the cap will be reduced by 1.74 % per year, which sends a clear signal to the economy of an increasingly stringent climate policy. These goals as well as the EU 2020 goals and beyond should help reduce uncertainty about future policy stringency which is important for the decision to innovate or not and how much to spend to new, less-polluting technologies. Removing excess emission allowances by reducing the available allowances or enlarging the ETS without adding additional allowances could further strengthen the credibility of the ETS as a climate policy tool.

The current overallocation of emission allowances emphasizes an important issue for setting long term goals, namely that the regulator's reaction to innovation and adoption of new technology play an important role (Requate, 2005). This is particularly the case when the stringency of the policy instrument is fixed long in advance as when setting a reduction path for the EU ETS cap. Innovation and technology adoption beyond the levels expected by the policy makers can then result in lower permit prices reducing incentives for firms to invest in pollution reducing technology. The same point applies to accurately incorporating or adjusting policy to the level of economic activity and growth (see also Chapter 4 on setting the cap).

Existing incentives for clean innovation in the absence of standards

Competition in the car manufacturing industry is fierce and representatives of the industry have long been found among the global top spenders on research and development (R&D). Car manufacturers have a strong incentive to innovate to the extent that they want to keep and increase their market shares (IKA, 2014). In the absence of regulation mandating certain technology innovations, the main concern for car manufacturers deciding which R&D investments to make is the extent to which consumers are willing to pay for resulting product improvements.

To the extent that fuel efficiency improvements amortize through lower user costs of driving consumers should be willing to pay for fuel economy improvements. However, the observation that seemingly profitable investments do not take place at the expected rate has been made repeatedly in the context of energy efficiency. This has given rise to the notion of an energy efficiency paradox or energy efficiency gap. One explanation that has been put forward is that consumers are myopic and fail to take future cost savings fully into account when making their purchase decision. That is, the consumer willingness to pay for improvements in fuel efficiency is not high enough to cover the additional costs of producing fuel efficient vehicles. Evidence of the extent to which consumers are myopic when it comes to fuel economy is mixed however (Greene, 2010; Allcott and Wozny, 2015; Knittel et al., 2013). Even if myopic decision-making plays a role in vehicle choice, standards are not the best way of addressing the issue. An alternative policy could be to place a tax on the vehicle at the time of purchase or registration, which reflects the fuel efficiency of the vehicle. Such a tax could be a means to increase the saliency of fuel efficiency at the time of vehicle choice, though the potential effects of prolonging vehicle lifetime applies in this case as in the case of standards. A better policy option would be to use an annual circulation tax, which would make ownership of an inefficient vehicle less desirable regardless of its age and thus also affect used cars directly. Several EU countries already have such vehicle taxes in place as will be discussed further in Chapter 6. Similarly, taxes on fuel are present in all EU countries and increase the cost of driving. These taxes provide additional incentives for households to invest in a more fuel-efficient car.

In a paper specifically addressing innovation activities in the car industry, Aghion et al. (forthcoming) study the relationship between fuel prices and patenting activity in technology related to the internal combustion engine ("dirty" in their terminology) versus technology related to alternative fuels such as electric vehicles or hybrids ("clean" in their terminology). They find that clean innovation is stimulated by increases in fuel prices and dirty innovation is depressed. For clean innovation to overtake dirty innovation an increase of 40 % in the fuel price compared to 2005 levels would be needed.[8]

[8] An important caveat of their model is that it does not take account of the actual emissions reductions caused by the technologies developed. For instance, electric vehicles could be dirtier than a conventional vehicle depending on the source of the electricity with which it is charged.

Path dependencies and additional market failures

Acemoglu et al. (2012) find that a market-based regulation such as a tax or cap-and-trade systems increase the costs of operating a dirty technology, e.g. a fuel combustion technology. The regulation leads to innovation in the dirty technology and can also stimulate innovation in other areas (clean technologies) such as electric engines. Their point is, however, that a path dependency in a certain, say dirty, technology would make previous investments in a dirty technology "sunk costs" if the firm switches to the clean technology. This implies that a market-based regulation can improve innovation in the dirty technology at the costs of innovation in the clean one in the presence of path dependency. Aghion et al. (forthcoming) find evidence of such path dependency and in addition of spatial spillovers in innovation activities, which reinforce such path dependencies. The presence of these path dependencies would suggest that early inducement to innovate in clean technologies is important. Acemoglu et al. (2012) therefore call for a policy mix including the market-based regulation to punish current emissions and a R&D subsidy to promote innovation in different technologies including the clean one.

Researchers active in the field of environmental innovation frequently call for such a policy mix (see e.g. Fischer and Newell, 2008). Next to pollution as one source of a market failure (a negative externality), innovation activities create another externality, the knowledge spillover. As innovators cannot fully protect their intellectual property against the use by others (imitators), they cannot enjoy the full future returns from their R&D expenditures. As a result, their incentive to invest in R&D is lower than socially optimal. Or to use the words of Popp et al. (2010, p. 877): "Pollution creates a negative externality, and so the invisible hand of the market allows too much of it. Technology creates positive externalities, and so the invisible hand of the market produces too little of it."

For the deployment of new technologies in transportation there is an additional externality, which causes a certain path dependency. This is the so-called network externality. Alternative fuel vehicles such as electric vehicles require charging capacity in a network corresponding to the road network. The construction of such a network requires substantial infrastructure investments, which may not take place as long as it is unclear which technology will come out on top to dominate the future transport market. This type of externality is common with technologies that exhibit increasing returns to scale as the number of users increases (see, e.g., Arthur, 1989). The missing infrastructure in turn inhibits the development of such technologies (conventional fuel lock-in). Therefore a case can be made for subsidies for deployment and construction of alternative technologies, although such subsidies should be made widely available rather than focus on a specific technology. In cases where there is increasing returns to the number of users of a technology, the prevailing technology may easily be determined by chance, such as the presence of a subsidy scheme limited to a certain technology which speeds up the deployment of that technology. Due to the externality there is no guarantee that the prevailing technology is the superior one, and history contains several examples where alternative technologies may have been more efficient than the ones that have come to dominate the market (Arthur, 1989). Such effects are exacerbated when there is learning by doing such that improvements in the efficiency of a technology also increase with use.

Overall the presence of these additional externalities provides ample justification for the use of additional policy instruments in the shape of subsidies for R&D and deployment to improve environmental performance of future private transport. In each case however, it is clear, that standards are not the most efficient means of internalizing the externalities. Each externality should have its own policy tool taking into account the interactions of externalities and policy tools in order to determine the optimal regulation design. Pricing CO_2 emissions as done in an ETS does not conflict with the presence of additional policy tools to stimulate innovation and adoption, but the expected impact of these policies should be taken into account in setting the cap reduction path so as to avoid unintentionally weakening the ETS over time.

Summary and conclusion

Incorporating the road transport sector into an ETS is feasible and likely to generate large efficiency gains through the increased abatement options. The largest efficiency gains are likely to be had from incorporation into the existing EU ETS rather than a separate ETS for road transport. Ex ante analysis based on modeling exercises suggests, that the welfare gains from using the ETS rather than emission standards are likely to be substantial. Regulating private transport through the ETS would lead to less reduction in private transportation emissions than emission standards, though the short term effect on the EU allowance price is likely to be small. Reductions in emissions would instead occur in electricity production and energy intensive sectors. In the longer run as the EU allowance price increases there may be concern about leakage effects and loss of competitiveness in the EU. Current evidence from the EU ETS does not give strong indications of detrimental impact on competitiveness of European firms, though there is some heterogeneity in findings. Additionally, there has been little research on the effect of rising electricity costs due to the ETS on European firm performance. As research in this area expands in the coming years, such long term effects can be better assessed.

The dynamic efficiency of regulating private transport through the ETS has been called into question due to the limited effect on the allowance price and the availability of alternative abatement options in other sectors. However, the existing research gives little cause for concern with regard to the innovation incentives provided by the ETS. Nevertheless there are additional market failures and path dependencies in the development and adoption of alternative technologies in transport, which warrant policy measures to complement the ETS. Such additional policy measures include subsidies for R&D and infrastructure investments to overcome externalities that may otherwise inhibit future technological change. It should be kept in mind that the static efficiency gains from correcting the CO_2 externality and improving existing technology may be much larger than the gains from the development and deployment of brand new alternative technologies. As such there is a clear cut case for addressing both the static inefficiency by regulating CO_2 and stimulating innovation taking all existing policies and their interactions into account.

Chapter 3: Regulated entity: Upstream, midstream or downstream regulation

Regulating the road transport sector at any level along the fuel chain creates the same macroeconomic incentives, in the form of a price effect that increases the marginal cost of driving, for the actors involved (Ewringmann et al., 2005). The important caveat to this result is that all abatement options must be incentivized, all emissions along the fuel chain in the road transport sector must be accounted for, and the transaction costs must be passed through to consumers (Flachsland et al., 2011). This chapter discusses at which point along the fuel chain transaction costs are minimized, but also touches upon possible difficulties with incentivizing abatement options along the fuel chain.

The fuel chain is divided into three levels: downstream, midstream, and upstream, which represent consumers of fuel, car manufacturers, and fuel suppliers, respectively. It is assumed throughout that the additional costs incurred by actors further up the fuel chain are fully passed through to consumers at the downstream level.

Downstream regulation

Consumers are responsible for the CO_2 emissions from personal car fuel consumption through the use of their vehicles. Regulating the actual consumption related emissions of CO_2 at the source incentivizes adjustments in behavior and in consumer demand for vehicles and carbon content of fuels. It therefore does provide incentives for entities further up the fuel chain to abate as consumers presumably have a willingness to pay to reduce their carbon emissions related to driving. Flachsland et al. (2011) point out however, that the transaction costs involved in regulating such a large number of units are non-trivial. Regulation of the road transport sector at the consumer level (downstream) would involve over 243 million passenger cars and over 512 million potential car users in the EU (NFF, 2014). In addition, consumers are highly dispersed (Brunner et al., 2009) and mobile (Raux and Marlot, 2005), both of which contribute to the relatively high transaction costs involved in regulating the road transport sector at the downstream level. Flachsland et al. (2011) go as far as to say that the level of transaction costs prohibits downstream regulation.

The transaction costs involved in regulating consumers in the road transport sector include the cost of implementing and administrating the EU ETS trading infrastructure, and the cost of information campaigns (Raux and Marlot, 2005). Decomposing transaction costs into these components provides a detailed picture of where the specific costs arise.

The cost of implementing the trading infrastructure of the EU ETS contributes significantly to the transaction costs of regulation at the consumer level. Raux and Marlot (2005) suggest a system for trading where consumers are equipped with chip cards loaded with a specific number of CO_2 permits. These can then be used at the point of fuel purchase to surrender the required amount of CO_2 permits. In addition, the trading of permits could be possible using ATMs at gasoline stations or banks, as well as over the internet. Desbarats (2009) proposes a similar system where carbon credits for the fuel combusted by the consumer will be deducted at the point of purchase. Such a design would imply frequent trade but with very small trade volumes. Jochem (2009) estimates that the cost of implementing a system as described above would cost around €140 million in Germany alone.

Administration costs must be added to the pure implementation costs and include the monitoring, verification, and reporting of emissions, which, in the case of downstream regulation, would apply to over 243 million entities (NFF, 2014). As most of these are relatively small emitters, in some cases requiring less than one EUA per year, increased efficiency gains through trading larger volumes of EUAs at an upstream level are foregone (UK Department for Transport, n.d.). The cost of managing the permit exchange market further adds to the above administration costs (Raux and Marlot, 2005).

The third major component of overall transaction costs for regulation at the consumer level is the cost of informing consumers about the EU ETS and how the exchange mechanism functions. Raux and Marlot (2005) acknowledge that the cost of information campaigns cannot be ignored and Abrell (2010) suggests that this cost alone is sufficient reason not to regulate the road transport sector at the downstream level.

Midstream regulation

At the midstream level, car manufacturers represent a significantly smaller pool of regulated entities (36 brands) compared to consumers (NFF, 2014). As such, the transaction costs of regulation at this level (midstream) are lower than at the consumer level. In particular, the cost of implementing EU ETS trading infrastructure and information campaigns as described by Raux and Marlot (2005) for downstream regulation is significantly reduced. However, it is less clear how to implement an ETS at this level and simultaneously provide incentives for fuel suppliers and consumers to abate. Difficulties in incentivizing abatement further along the fuel chain make this option less likely to be cost-effective in practice.

Accounting for the level of CO_2 emissions that require coverage at the car manufacturer level is a major factor in the calculation of the administration costs involved with regulating the road transport sector at this level. The literature advocates an approach where car manufacturers have to surrender sufficient EUAs at the time of sale to cover the lifetime emissions of new cars (Desbarats, 2009). The UK Department for Transport (n.d.) suggests that these estimates should be calculated by multiplying tailpipe gCO_2/km (grams of CO_2 emitted per kilometer travelled) by the projected lifetime distance travelled for each car. Abrell (2010) finds that covering lifetime emissions for cars is in line with the EU ETS carbon accounting, which makes it preferable to trading specific emission rights for gCO_2/km among car manufacturers alone.

Flachsland et al. (2011) argue that defining uniform emission factors for heterogeneous cars and fuels is cumbersome and inefficient. They also raise the issue that the trading infrastructure of the EU ETS would require modification, for example, multi-year trading periods, to allow car manufacturers to surrender allowances for car emissions several years into the future. Abrell (2010) likewise points out the fact that current EU ETS trading periods may be too short compared to the average car life cycle, which would necessitate a change in the EU ETS trading period setup.

NFF (2014) adds that changes in the carbon content of fuel and, therefore, actual future tailpipe emissions, cannot be reliably forecast. This suggests that in practice, it may be difficult with a midstream design to incentivize fuel providers to lower the carbon content of their fuel. Similarly, regulation of lifetime expected emissions of a vehicle does not take heterogeneity of consumers into account. Therefore it would be difficult in practice to give consumers incentive to reduce driving or drive more efficiently if car manufacturers are the regulated entity.

Upstream regulation

Fuel suppliers are responsible for the sale of fuel to passenger car users via service stations. According to the ADAC (2013), there are over 14,000 service stations in Germany alone. However, a few large companies cover the majority of the market with 6 brands accounting for almost 75 % of the market in Germany.[9] Similarly in the UK, regulating fuel producers covers 99 % of the market with just 20 firms (UK Department for Transport, n.d.). The large fuel producers are typically vertically integrated and cover everything from drilling for oil to selling fuel to consumers. Regulating at the fuel supplier or producer level concerns a much smaller number of regulated entities than regulating at the consumer level. An added advantage derives from the fact that fuel is already taxed in all EU countries (see also Chapter 5). UK Department for Transport (n.d.) emphasize that the point at the supply chain at which these fuel taxes are collected provides an excellent basis for regulation of carbon content and additional administrative costs would be low. As fuel sales are already recorded for tax purposes, these records could provide the basis for monitoring CO_2 emissions as well as for initial allocation of allowances unless auctioning is used. In a fully integrated ETS, for example, fuel producers would then need to hold EUAs to cover the total amount of CO_2 emissions resulting from the fuel they sell. As many fuel producers are already covered by the EU ETS due to oil refinery activities, they are already familiar with the functioning of the system.

Depending on whether road transport is integrated completely into the existing ETS or whether a separate road transport ETS is established, the small number of actors in the upstream fuel supplier market may give cause for concern about strategic trading. The basic idea would be that firms could hold excess carbon allowances in order raise the allowance price and put competi-

[9] Aral, Shell, Jet, Total, Esso and bft according to Statista (2015).

tors under pressure. A gateway similar to the one implemented for aviation could mitigate such issues, whereas full integration into the existing ETS would likely make such concerns redundant due to the larger number of market participants.

In terms of incentivizing abatement along the fuel chain regulating fuel suppliers is also attractive. Fuel producers have two options for responding to inclusion into the ETS. They can lower the carbon content of their fuels and they can pass on the cost of emissions allowances to consumers through higher fuel prices. An increase in fuel prices experienced by passing on allowance costs to consumers is unlikely to be very high, but of course would depend on the effect on the allowance price of including road transport into the ETS. Taking the carbon content of a liter of gasoline or diesel delivers a carbon-related fee of approximately 0.025 Euro/l for an allowance price of 10 €. Current fuel taxes are at least an order of magnitude larger in all EU countries as shown in Chapter 5.

Summary and conclusion

When choosing which entity to regulate there are generally two factors, which should be considered. Firstly, the ability of the regulated entity to incentivize actors further along the fuel chain (e.g. by cost pass through) is important to ensure that all abatement options are incentivized. Secondly, transaction costs including administration and monitoring costs play a role. In order to minimize transaction costs, it has been suggested to a) choose the point of regulation that has the lowest number of entities and b) if possible to choose a regulated entity where the necessary administrative infrastructure is already in place. In this sense, regulation at the upstream level of the fuel refinery has been widely proposed as the most appropriate candidate. An additional consideration is that the limited number of entities at this level of the fuel chain may result in strategic trading if a separate ETS is set up for road transport. In an enlarged ETS integrating road transport with other regulated sectors the trading volume of fuel suppliers would not be sufficient to manipulate the market.

Chapter 4: Cap setting and allocation mechanism

Two important design features of the ETS concern setting of the cap and how the allowances are initially allocated to market participants. The setting of the cap determines the stringency of the environmental policy and the emission reductions attained through the ETS. The allowance allocation mechanism has implications mainly for distribution of the scarcity rents that the cap creates and can be designed with the aim to reduce impacts on global competitiveness. In this chapter we briefly touch upon each of these issues and how they relate to an expansion of the EU ETS to cover the road transport sector.

Setting the cap

Setting the cap has important implications for achieving environmental goals and sending the right signals for innovation and adoption of new technologies. During Phase I of the EU ETS the emission permits were issued for 2080 $MtCO_2$, while the actual emissions were around 2020 $MtCO_2$. This mismatch prompted a dramatic fall in the allowance prices (Brunner et al., 2009). Alternatively, setting the cap too tight may increase the EU allowance price to levels at which competitiveness of European firms is seriously affected. Additionally, efficient regulation of the CO_2 externality requires that the marginal abatement cost is equalized across sectors. Since not all sectors are currently covered by the EU ETS, adjustments to the cap and the distribution of abatement efforts across sectors should keep the criterion of equal marginal abatement costs in mind (Böhringer et al., 2009).

The EU ETS covers around 50 % of EU CO_2 emissions and approximately 45 % of total EU GHG emissions in Phase III (2013-2020). Light-duty vehicles account for around 15 % of the total EU CO_2 emissions. There are separate emission reduction goals defined for both the existing ETS and the transportation sector. As a result an overall cap and reduction path to achieve these goals can be calculated. The calculation of a new cap for the integrated system could follow the principle illustrated in Figure 3 in Chapter 2, where the integration of two systems is displayed.

Reduction paths for the cap

Setting the cap and its adjustment is a dynamic process that depends on the inclusion or exclusion of sectors, countries, entities, economic growth, emissions and stringency of the economy-wide cap. In phase III of the ETS the cap will be adjusted downwards by an annual rate of 1.74 % of the average total emissions in the period 2008-2012 to reach emission levels 21 % below 2005 emission levels in 2020.[10] However, this rate could be increased to consider a reduction up to 30 % below emission levels if other developed countries commit to similar goals. To reach the target of a reduction of emissions of 43 % below 2005 levels by 2030 the reduction rate would need to increase to 2.2 % after 2020. In setting the reduction rate it is important to incorporate expected growth rates in the economy and interactions with other policies as well as the rate of technological change as discussed in Chapter 2.

Reform of the EU ETS

The European Commission is currently working on amendments to Phase III of the EU ETS and a reform of the ETS for the 4th phase, which begins in 2021. It has been estimated that the financial crisis and the recession that followed have resulted in excess allowances in the order of 2.1 billion tons by the end of 2013. This excess supply is likely to affect the allowance market well into the future. In response to the abundant supply the Commission has proposed to introduce “backloading” of allowances to postpone auctioning of 900 million allowances until 2019-2020 (EU 176/2014). An additional measure has been proposed for Phase IV of the ETS in the form of a “Market Stability Reserve” (European Commission, 2014). Such a reserve will automatically remove allowances from the market in case of oversupply as measured by allowances in circulation in the market, and release allowances if the allowance price rises markedly over a 6 month period indicating excess demand. The reserve should work to reduce the impact of demand shocks such as the recent crisis on market stability.

[10] In absolute terms this corresponds to a reduction in the number of emission allowances of 38 million tons every year until 2020.

Allocation mechanism

Once the cap has been set, allowances can be issued equalizing the total number of permits to the cap. The allocation mechanism has an impact on the distributional effects of including the transport sector into the EU ETS. Who receives the scarcity rent created by capping emissions will be established by defining whether permits are sold (e.g. through auction) or allocated for free (Brunner et al., 2009). Note also that the considerations involved in choosing an allocation mechanism are concerned with the risk of carbon leakage, the effects on early movers (i.e. entities with above average environmental performance), the possibility of windfall profits for regulated entities, and the potential need to garner revenue for redistribution or other policy instruments such as subsidies. There are basically four options for allocation of emission allowances to the road transport sector upon inclusion into the EU ETS. The first two options assume that some new emission allowances are allocated for free upon expansion of the EU ETS. The third and fourth options require emission allowances to be bought on the market. They could be auctioned by the authorities directly or the authorities could opt not to allocate any additional allowances for road transport essentially leaving the cap as it is, and requiring the road transport sector to purchase existing allowances from other regulated installations.

Free allocation

Grandfathering

With the allocation mechanism known as “grandfathering” emission allowances are allocated for free in proportion to past emission levels. In this scheme a one-off allocation can be fixed for the current emission levels or there can be regular updates based on new emission data. One of the main drawbacks of this allocation mechanism is that it may not provide much incentive to reduce emissions. Depending on how the baseline is adjusted over time, this may encourage agents to invest in dirty technologies or not to invest at all in order to keep their emission levels high and get more free allowances. Grandfathering allowances also runs the risk of punishing early movers in terms of environmental technology whose emissions are relatively low within a sector. Since they would be awarded a lower number of allowances based on their past emissions than less efficient competitors they would not be able to benefit from their investments. Grandfathering can also lead to an increased lobbying of powerful groups to get more allocations for free.

Benchmarking

When allowances are allocated for free, but based on a benchmarking scheme, there is more incentive to reduce emissions. Depending on how the benchmark is determined, early movers can retain an advantage of their investments. Benchmarking requires data to determine what an appropriate benchmark is, which may in some cases be difficult to obtain.

General concerns about free allocation

One of the main problems with free allocation mechanism is that they may present barriers to market entry or exit. For instance, if allowances are allocated for free to incumbents while entrants need to pay for them, this may discourage entry and reduce competition. Moreover, in order to keep allowances and profit from their monetary value, agents may delay shutting down inefficient plants. For this reason, additional allowances are typically set aside for new entrants.

A major lesson learned from the early stages of the EU ETS was that some recipients of grandfathered allowances were able to pass on the opportunity cost of the allowances to final consumers. This led to windfall gains for the regulated entity and was especially observed in the power sector (Ellerman et al., 2010; Woerdman et al., 2009). As demand for electricity is rather inelastic and immobile, the price of electricity increased to reflect the emission allowance price, despite utilities not having paid for their allowances in the first place. Cars also need to refuel where they are used suggesting that windfall gains might be large if allowances are given away for free to this sector.

Auctioning

According to Brunner et al. (2009), auctioning offers several advantages over free allocation. It follows a polluter-pays principle that can lead to more efficient investment decisions. In addition, the revenue generated by auctioning can be used by governments to outweigh the regressive effect generated when income is transferred from poorer households (i.e. drivers with high income shares of fuel expenditure) to higher income groups (i.e. shareholders) via pass-through of the cost of the allowances. While in free allocation there is an incentive for sellers to keep permit prices high, in this scheme all are buyers so there is an inverse incentive to keep prices low which can be achieved by investing in clean technologies. It is recommended to carry out small and frequent auctions to limit the market power of large bidders that can also affect competition.

No new allocation for the road transport sector

If no new allowances are allocated upon expansion of the EU ETS to cover road transport, then the regulated entities in the road transport sector will be required to purchase allowances from the existing ETS. Including the sector without increasing allowances could potentially remove a large share of the current excess supply of allowances. In this case the transport sector would literally be paying for emission reductions in other sectors by purchasing allowances from them directly. In terms of distributional impacts within the ETS, this is a question of whether the price of allowances would increase enough to impact on global competitiveness of other ETS sectors once excess allowances are taken by the transport sector. Potential windfall gains would not accrue to fuel suppliers since they would be required to purchase allowances in the market.

Additional allocation for new entrants in the ETS

There is a New Entrants Reserve (NER) that contains allowances for new installations or airlines, as well as expansion (under certain conditions) of existing installations and airlines after 2013. The rationale behind the NER is based on principles of equity and securing competition in the markets affected. The NER holds allowances amounting to 5 % of the cap (for aviation 3 % of the cap). The allocations from the reserve to new entrants should mirror the allocations to corresponding existing installations. Road transport would not need to be treated differently than other sectors under the ETS in this respect.

In phase III of the ETS, 300 million allowances from the NER have been set aside to finance a demonstration and testing scheme for renewable and carbon capture and storage technologies. Unused allowances from the NER are in principle surrendered to the member states for auctioning.

Summary and conclusion

Setting a cap by matching issued emission permits and actual emissions can send the right signals for innovation and adoption of new technologies. Nevertheless, deviations from it can create artificial variation in allowance prices if the cap is set too loose, and have direct effects on firm competition if it is set too tight. Expected growth rates in the economy, potential effect of environmental regulation on economic growth and the rate of technological change are also important elements to consider when setting the cap and its adjustment. Regarding allowance allocation, free allocation can discourage investment in innovation and may lead to windfall gains. Auctioning is best suited for the inclusion of the transport sector in to the ETS because it not only overcomes drawbacks from free allocation but also generates revenues that can be recycled. Moreover, if no new allowances are allocated upon expansion of the ETS to include emissions from road transport, additional reforms to the ETS to remove allowances from the market due to possible oversupply may not be needed. Road transport will increase the allowance demand and assist in stabilizing the allowance price. The resulting price level and its effect on competitiveness are concerns to be considered when designing the road transport inclusion into the ETS.

Chapter 5: Overlap and interaction with other regulation

Environmental policies aim to correct market failures by internalizing externalities and providing incentives for taking all effects of activities into account. In some cases, multiple externalities and market failures exist simultaneously. When this is the case, a single instrument is rarely sufficient to address all issues and produce a well-functioning efficient market. Therefore complementary policies are introduced to address each of the market failures in turn.

Carbon emissions are not the only environmental impact of road transport. Policy measures to address other environmental issues such as non-GHG emissions or noise pollution are also implemented. There may be (unintended) interactions between these policy measures that require careful consideration when designing regulation. In the case of road transport, a multitude of instruments are currently in use at the national and international level. For the transition towards a low carbon economy the implementation of new technology is of crucial importance in lowering the costs. Innovation and deployment of new technology are both associated with externalities. This chapter provides an overview of the most important regulations in place with an impact on environmental effects of road transport and discusses their interactions.

Existing regulation of transportation carbon emissions at the EU level

An overview of the existing regulation at the European level to reduce CO_2 emissions but also air pollution is found in Table 1. Regarding regulation for fuel suppliers, the Fuel Quality Directive 98/70/EC aims to reduce the GHG intensity of fuels by up to 10 % by the end of 2020 compared to 2010 levels (European Council, 1998). In this case, the legislation applies to fuel producers and suppliers who have to ensure that the targets set out in the Directive are met. The latest amendment to this Directive came into force on the 5th of June 2009. This Directive applies to gasoline, diesel, and biofuels used in road transport. The GHG intensity of fuel takes account of the life-cycle emissions, which include emissions from extraction, processing, distribution, and consumption of fuel. The 10 % reduction target is composed of a mandatory 6 % reduction in the carbon intensity of fuels by 2020 and two additional indicative

2 % targets. The first of these 2 % targets may be achieved in either of the following ways: Firstly, through reductions in the GHG intensity of the supply of energy for use in any type of road vehicle. Secondly, through the use of any technology that is able to reduce life cycle GHG emissions per unit of energy from fuel. The second additional 2 % target may be attained through the use of credits from the Clean Development Mechanism of the Kyoto Protocol.

The Directive 1999/94/EC on CO_2 emissions and fuel economy labels for new cars was designed to create awareness in customers on fuel consumption and CO_2 emissions of new vehicles. The legislation requires that a label be attached or displayed near the car at the point of sale providing information on the fuel economy and CO_2 emissions of the car. Furthermore, an annual guide on fuel economy and CO_2 emissions from cars in consultation with manufacturers must be provided free of charge at the point of sale. Finally, all promotional material must contain the fuel consumption and CO_2 emissions information for the car model to which it applies. The Directive 2006/40/EC, as part of the EU's climate action strategy, aims to reduce the emissions of fluorinated greenhouse gases (GHG) in the mobile air-conditioning systems fitted to passenger cars (European Council, 2006). The goal will be achieved by incrementally banning fluorinated GHGs with high global warming potential (GWP). From 2009, manufacturers have been unable to use mobile air-conditioning units in new cars which contain gases with a high GWP of over 150 leaking more than 40g per year for single evaporator systems or 60g per year for dual evaporator systems. From 2017, a total ban on the use of fluorinated GHGs with a GWP over 150 in mobile air-conditioning systems will be implemented and all new cars equipped with mobile air-conditioning units designed to contain gases with a GWP over 150 cannot be registered, sold or used in the EU.

Table 1: An overview of existing EU legislation of environmental externalities from road transport

Legislation	**Subject matter**	**Regulated entity**	**Goal (interpretation from preamble)**
Regulation EC/443/2009	CO_2 emission standards for new passenger	Passenger car manufacturers	Reduce CO_2 emissions in road transport sector from new passenger cars by

	cars		establishing fleet average CO_2 emissions performance requirements of 130 g CO_2/km by 2015 and 95 g CO_2/km by 2021
Regulation EC/510/2011	CO_2 emission standards for new light commercial vehicles	Commercial vehicle manufacturers	Reduce CO_2 emissions in road transport sector from new light commercial vehicles by establishing fleet average CO_2 emissions performance requirements of 175 g CO_2/km by 2017 and 147 g CO_2/km by 2020
Regulation EC/715/2007	Euro 5 and Euro 6 emissions standards (Non GHG emissions)	Private car and commercial vehicle manufacturers	Improve air quality by reducing emissions of CO, NO_x, hydrocarbons, non-methane hydrocarbons, and particulate matter (all in mg/km) from light passenger and commercial vehicles
Directive 1999/94/EC	CO_2 emissions and fuel economy labels for new cars	Private car manufacturers and retailers	Allow consumers to make informed decisions on CO_2 emissions and fuel economy when purchasing new cars
Directive 98/70/EC	Fuel quality directive to reduce the GHG intensity of fuels used in vehicles by up	Fuel producers and suppliers	Reduce the life cycle emissions of GHG and air pollutants (by reducing sulphur content of fuels in ppm)

	to 10 % by 2020		
Directive 2006/40/EC	Mobile air conditioning systems	Vehicle manufacturers	Reduce the emission of hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride from mobile air conditioning units
Directive 2003/96/EC	Energy Taxation	Final consumers	Setting a minimum rate tax for energy products, previously limited to mineral oils, to all energy products including coal, natural gas and electricity.

The Energy Taxation Directive sets the rules across Member States on what must be taxed and when exceptions can be allowed. It established minimum rates based on the energy volume consumed; EU members are free to set their own rates on top of the minimum one. Taxes on fuel prices can have different motivations from reducing CO_2 emissions. Raising revenue as a main goal and persuading customers to purchase cleaner technologies as a second one are the main reasons for using this instrument in the EU (European Commission, 2011). Examples where taxes are mainly revenue driven are the USA where fuel taxes are used to create funds for maintenance and extension of highways (see Pirog, 2009). Because taxes on fuel prices are taxes on driving, they are not designed to tackle only reductions on CO_2 emissions but also other pollutants such as NOx, PM and VOCs. In the EU, the current recommendations to amend the tax directive is an example of the acknowledgment that further efforts are needed to improve the efficiency of this instrument to reach environmental targets. It is argued that increasing the use of taxes in order to decarbonize non-ETS sectors could be an alternative (European Commission, 2011). However, inclusion of road transportation into the ETS can work to the same effect. Figure 5 shows the size of taxes on fuel prices across EU Member States.

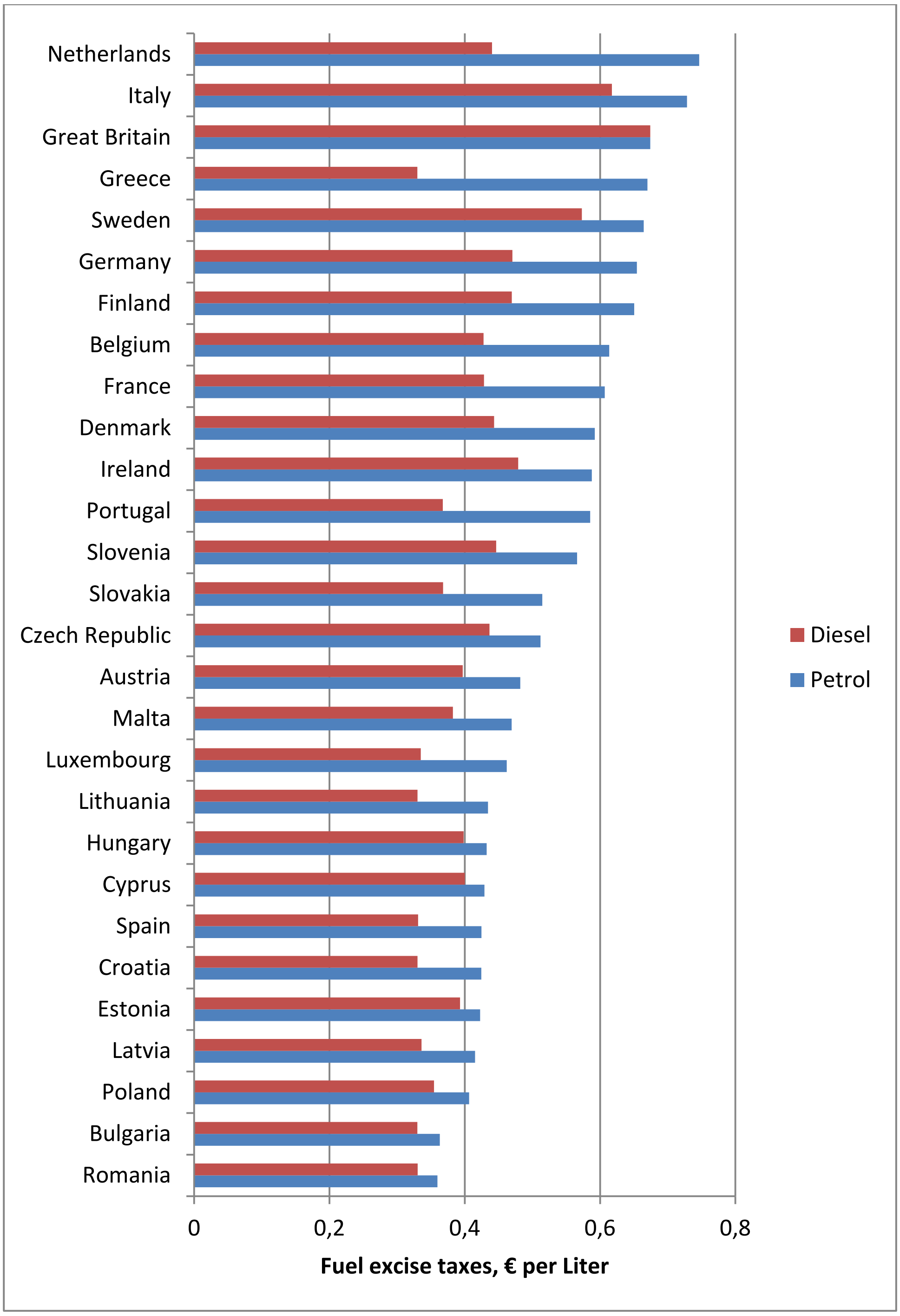

Figure 5: Road fuel excise duties. Source: European Environment Agency

At the national level

The environmental regulations at the national level differ among member states. The following section mainly focuses on Germany (Table 2). There is a tax in Germany on fuel price; this is influenced by the taxes levied on each liter of fuel purchased. Apart from the 19 % value-added tax (Mehrwertsteuer), taxes on mineral oil and its stockpiling are included in the price. German law has provided for the implementation of "environmental zones" (Umweltzonen) in order to decrease the level of air pollution in these areas (35. BImSchV, 2006). One of the measures used to achieve this is the issuance of stickers for passenger cars displaying air polluting characteristics in four categories. These stickers, in order of high to low air polluting characteristics, are red, yellow or green. No stickers are issued for cars with worse air polluting attributes than those issued with red stickers.

Table 2: An overview of existing German legislation of environmental externalities from road transport

KraftStG 2002	Tax for passenger cars	Private car users	
EnergieStG 2006	Tax on use of mineral oil	Fuel consumers	Reduce the use of mineral oil and increase the efficiency of its use
ErdölBevG 2012	Fee for mineral oil stockpiling	Fuel consumers	Create a stockpile of mineral oil to combat sudden supply shocks
BImSchV 2006	Environmental zones and stickers for air pollution	Private car users	Improve air quality by limiting access of cars to certain areas depending on their specific air pollutant emissions

CO_2 taxation on vehicle registration and/or ownership is a very well stablished practice in the EU. The current structure of the tax design that incorporates a CO_2 element into the vehicle registration tax was proposed in 2005. The main argument was that carbon taxes on vehicle registration and ownership needed to be harmonized across EU members and avoid double taxation when vehicles were moved from one country to another within the EU (European Commission, 2005). There is a huge variation on how the tax is implemented across Member States of the EU. These taxes range from zero (e.g. Bulgaria, Czech Republic, Slovakia) to different values. For instance, in Austria this tax is levied upon the first registration of the vehicle, electric vehicles are exempted and there is a penalty of €20 for each g/km emitted in excess of 250 g/km.

In order to increase the demand for alternative vehicles some European countries (e.g. Italy, UK) have granted subsidies for the purchase of these vehicles. These grants are set according to the emission of the vehicle. In the case of company cars; the grants are conditioned to scrap one vehicle with more than ten years. An interesting example that is frequently cited in the literature is the French feebate (e.g. D'Haultfoeuille et al., 2014 and Tovar, 2011). Under a bonus-malus system, when CO_2 emissions are 90 g/km or less, a premium is granted for the purchase of a new car. The maximum premium is €6,300 (20 g/km or less). In addition when a car of at least 15 years old is scrapped and the new car purchased emits maximum 90 g/km, an extra bonus of €200 is granted. There is also a malus which is payable when the purchased car exceeds 130 g/km of CO_2 emissions. Economists, however, generally criticize subsidies as free-rider effects are likely to take place and tax money has to be spent that could provide larger benefits in other areas.

The environmental taxes on vehicle ownership in Germany are determined on the basis of engine size and the emissions per kilometer (KraftStG, 2002). The exact calculation of the tax takes place with a number of steps. First, the Euro standard to which the vehicle's engine conforms is determined. Second, the engine type (gasoline or diesel) is identified. Third, the level of tax based on engine size and date of first registration is calculated. Finally, the number of g CO_2/km that the specific emissions of the vehicle are above the exemption limit is used to calculate the final tax level. For an overview of CO_2 emissions on vehicles, see the summary with an overview from the European Automobile Manufacturers' Association (ACEA).[11]

The need for additional regulation

The European Union has committed itself to halve the existing conventional fuel cars by 2030 in urban areas and phase them out by 2050 in cities[12]. The electrification of road transportation will be one of the key elements in the European roadmap to reduce its CO_2 emissions. It is argued that in order to succeed with the introduction of electrical cars, certain barriers need to be overcome, namely: 1) high purchase cost, 2) slow spreading of infrastructure for recharging, 3) consumer acceptance, and 4) relative evolution compared with other alternative technologies. In order to overcome these barriers, government policies will play an important role (Perdiguero and Jiménez, 2012). To tackle point one, there are programs of subsidies for the purchase and research and development in some European countries[13]. However, a bigger effort is needed if the goal of the road electrification is to be achieved. In this regard Achtnicht et al. (2012) show that the ability to expand the availability of alternative fuel stations is crucial to increase the demand for non-conventional vehicles. Recharging time is another potential problem which depends on the battery size and the recharging technology. Charging a car with a driving distance of 150 km using modern charging stations could take around 30 minutes while using a normal plug will take up to 8 hours (Koetse et al., 2014). The low ratio of km driven to recharging time and the low number of recharging stations can prompt a fear of getting stranded particularly in drivers of electric vehicles. This is what has been called “range anxiety” by Chaudhary (2014) and this, according to that author, has been the main barrier for the adoption of these vehicles. Moreover, the grid capacity can also be another important issue. In this sense, Perujo and Ciuffo (2010) argue that increasing the number

[11] Available at http://www.acea.be/publications/article/overview-of-co2-based-motor-vehicle-taxes-in-the-eu

[12] White Paper available at http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=COM:2011:0144:FIN:en:PDF

[13] For instance, in the UK there are grants available for the purchase of electric vehicles of up to 5000 British Pounds (see Hirte and Tscharaktschiew, 2013)

of electric vehicles can create considerable pressure on the power supply and would require further investments.

Many studies that analyze the environmental impact of electric vehicles s focus only on the vehicle-use phase when different technologies in transportation are compared. Hawkins et al. (2012) found that EVs powered by the current European electricity mix can contribute to reduce certain pollutants such as CO_2 emissions; however, the production of these vehicles represents also an environmental burden. Techniques such as life cycle assessments (LCA) can be used to compare the amount of emissions and other pollutants generated in the production and use of conventional and alternative vehicles. In this line, Thiel et al. (2010) show a comparison of CO_2 emissions from vehicles that run on different fuels using a well-to-wheel (WtW) procedure which is a specific type of LCA. They show that in Europe, in 2010 new gasoline vehicles emitted around 160 g CO_2 per km while 60 g per km corresponded to electric vehicles. Nordelöf et al. (2014) show that this value for the European electricity mix can be between 60 and 70 g/km while for coal fired based power generation; these values can be between 139 and 175 g/km. Therefore, the fuel that is used to generate the power used by EVs will play a crucial role in its mitigation capacities. Using data on the USA, Graff et al. (2014) show that heterogeneity in the generation mix is not the only factor that can reduce the potential reduction of CO_2 emissions from increasing electric vehicles. Shifting load profiles during daily charging periods could also increase CO_2 emissions. It is possible that charging an electric vehicle can produce more pollutants than conventional cars depending on when the care is charged. Given the considerable efforts to increase the number of electric vehicles it has been proposed to focus on plug-in hybrid electric vehicle (PHEV) as a short run strategy and elecric vehicles for the medium or long run (Thiel et al., 2010). Kihm and Trommer (2014) point out that supporting the market penetration of PHEV can help to reach suburban areas around big cities. In addition, Smokers et al. (2010) suggest that legal and financial incentives are needed to ensure that electric vehicles are powered with renewable energy sources and the integration to the network needs to be done with smart grid developments.

In the long run a number of possibilities that can help to increase the number of electric vehicles exist. Designing a more integrated system of renewable and conventional power generation, use of smart metering and dynamic pricing for consumers encouraging recharging during off-peak periods, and implementation of real time monitoring of electricity consumption (see Grünig et al., 2011). In the short and medium run, technological advances in conventional automobile components such as tires, cooling technologies and lightings which are not generally considered in fuel efficiency test could save a significant share of the energy used in road vehicles (IEA, 2007). However, the real challenge is to achieve prices that are still attractive for vehicle consumers after these improvements have occurred (NPC, 2012). There is still room for designing measures that encourage drivers to use their vehicles in a more efficient way. These measures include: having tires inflated to the right pressure and replacing the clogged air filter on regular basis which could save around 10 % in energy use (World Energy Council, 2013).

According to Fullerton et al. (2008), the use of a multi-instrument approach can improve the effectiveness of policy instruments. Regarding the supply side, Mock et al. (2014) argue that instruments aimed to induce manufacturers to develop new technologies need to be complemented with policies to induce drivers to adopt more efficient technologies. Possible strategy to increase firm technological levels can be done through what is called "directed technological change" (Acemoglu et al., 2012). Under this framework, the government encourages improvements in clean technologies through research subsidies up to the point where these technologies are advanced and then flows of investment will occur without governmental intervention. To implement this process several policies can be implemented. Barro and Sala-i-Martin (2004) argue that greater availability of human capital reduce the social cost of adopting advanced technologies in a country. That is, investing in human capital can increase the return of technological adoption. The Horizon 2020 program in which 65,000 researchers will be funded, the development of European Research Area measures, and the current proposal to give EU governments more flexibility to grant subsidies for industries to research and develop new technologies are concrete examples of policies to increase human capital. Barro and Sala-i-Martin also point out the importance of honoring intellectual property rights across international borders to incentivize technological developments in leading economies. In this line, the newly established "Unitary patent package" will reduce the administrative cost of patenting and will protect development within the EU.

Knittel (2013) claims that learning by doing spillovers can lead to market failures when developing alternative technologies in the transport sector. Therefore, this is an issue that requires an effective policy framework. Policies such as tax credits and capital cost rebates were found to have an impact on the production of experience derived knowledge in wind power generation. Nemet (2012) argue that firms in this sector can benefit from waiting to learn from other firm knowledge derived from investment and consequently these policies can correct this market imperfection.

Network effects (e.g. ensuring that a network of charging stations exists for electric vehicles) can also play an important role for the decision to adopt a new technology (Achtnicht et al., 2012). Failure to take such effects into account and address them through policy could slow down deployment significantly. Establishing an EU-wide minimum coverage of refueling infrastructure for technologies with high acceptability, harmonized standards for the main alternative fuels and alignment of policy, funding (public and private) and taxation in the to improve alternative fuel infrastructure are the main objectives for policy design on this issue (European Union, 2011); however, it is unclear which specific mechanism could be used.

Summary and conclusion

The Directives on CO_2 emission and fuel economy standards along with the Energy Tax directive are the main pillars in the EU effort to regulate a market that has a multiplicity of market failures. Possible learning by doing spillovers in the car manufacturing industry and unavailability of feasible non-conventional technologies create the need for further policy instruments to stimulate innovation and to address other environmental externalities associated with road transport. The inclusion of the road transport sector into the ETS needs to be coordinated with and complemented by the existing regulation. While policies such as standards can steer the vehicle supply towards the production of more efficient vehicles, similar results can be achieved through feebates and taxes on CO_2 emissions by inducing demand for cleaner technologies. In the short run, including private transportation into the ETS could incentivizes consumers to reduce the demand for kilometers driven while in the long run, it could create the incentives for the car industry to innovate and make technologies such as electric cars a feasible option for the current market. Reducing the social cost of adopting new technologies still requires further support. Policies such as public investment in human capital can reduced the social cost while policies such as tax credits and capital cost rebates could help to overcome market failures prompted by learning by doing spillovers.

Conclusion

The transportation sector is responsible for some 20 % of the EU's CO_2 emissions, where road transport is the predominant contributor, with growing emissions in the past ten to twenty years. Accordingly, this sector features prominently in the climate policy of the EU and its member states. With the aim of reducing CO_2 emissions in road transport, binding emission performance standards for new passenger cars and LCV were introduced in 2009 and 2011 at the EU level. Although this regulation may have helped to improve the fuel efficiency of new vehicles sold in Europe, it has been increasingly criticized for several inherent drawbacks. A general concern and well-known result from economic theory is that emission standards usually fail to meet the environmental target at minimum cost (i.e. to be cost-effective). This is basically due to the fact that virtually all car manufacturers have to fulfill the prescribed standard, no matter what their marginal abatement costs are, while other abatement options remain unaddressed. The standards focus only on the new car fleet, but provide no incentive for used car drivers to change their driving behavior. To make matters worse, drivers of new, fuel-efficient cars are incentivized to use their car for more and longer trips, as driving becomes relatively cheaper, reducing the expected environmental benefit of the fuel efficiency improvement (known as the rebound effect). There is also some empirical evidence that car manufacturers have adapted to the standard as it is currently designed by making their car models heavier, which may lead to other unintended consequences such as more serious injuries in car accidents.

Recently, the European Commission has been asked by the European Parliament and the European Council to review the emission performance standards for passenger cars and LCV in place and to propose how these should be amended for the period after 2020. Against this background, the important question arose whether there are other, better alternatives available to regulate the CO_2 emissions of road transport. This report discussed the policy option of regulating the sector's CO_2 emissions within a cap-and-trade system, in particular the inclusion of road transport in the existing EU ETS.

Compared to emission performance standards, including road transport in the EU ETS has a number of advantages. First and foremost, in a cap-and-trade system the marginal abatement costs are equalized within and across the regulated sectors, resulting in overall cost efficiency. By setting the cap the total amount of emissions allowed in the system is constrained, creating a scarcity and market price of (tradeable) emission allowances, and thus incentivizing emissions reductions. Entities with abatement costs below the allowance price will undertake the abatement activities and sell surplus allowances, while entities with higher abatement costs will buy additional allowances instead of implementing costly abatement measures. This trade is beneficiary for both entities and ensures that the emissions abatement takes place where it is cheapest. The larger the ETS and the more sectors included, the more abatement options are available and the higher the efficiency and welfare gains. Although it would be feasible to construct a separate ETS for road transport only - perhaps amended with a gateway to the existing ETS - the most cost-efficient means of regulation would therefore be to integrate the road transport sector fully into the existing ETS. Recent analysis as cited in this report has shown that the potential savings from regulating the road transport sector in the ETS rather than through standards are large.

Of course, the trade mechanism implies that the actual emission reductions may vary significantly across the regulated sectors. If private transport is included in the EU ETS, then it can be assumed that this sector will be a net buyer of allowances, while more emission reductions are expected to occur in electricity production and energy intensive sectors. However, in terms of climate change mitigation the only thing that matters is achieving the overall CO_2 emission reduction target, not the specific source of reduction. And that is ensured by the cap – the other big advantage of a cap-and-trade system.

When including the road transport sector in the EU ETS, regulation at the upstream level of the fuel suppliers seems to be most appropriate. Fuel suppliers are able to pass through costs and thus incentivize actors along the whole fuel value chain to undertake abatement efforts. The transaction costs associated with the ETS (e.g., monitoring and reporting) are minimized at the upstream level, since the number of fuel suppliers is limited and most of them are already experienced with the EU ETS through their refinery activities. Strategic trading behavior to manipulate the EUA market is most unlikely to occur due to the mere size of the market.

In order to avoid windfall gains and not to adversely affect previous abatement efforts, emission allowances should be allocated through auctioning, instead of any form of free allocation. Auctioning also generates revenues that can be used to reduce distortionary taxes elsewhere in the economy. The increased demand for EUAs by the entities from the road transport sector will stabilize the market price. Given the current oversupply of EUAs the short term price effects are likely to be small, while the long term effects will depend on how the cap of the integrated ETS is adjusted. Most EU ETS stakeholders would welcome a higher allowance price that provides stronger incentives for CO_2 abatement and innovation of clean technologies. However, an increased EUA price may raise concerns about reduced competitiveness of Europe's economy and carbon leakage effects. To date, competitiveness concerns are not supported by current empirical evidence from the EU ETS, but further research in this area is needed.

In summary, the inclusion of road transport in the EU ETS is a feasible and promising way to address the climate externalities of car driving in the future. Unlike the emission performance standards, the cap-and-trade approach ensures to achieve a given overall emission reduction target at minimum cost. The market price of tradeable emission allowances provides technology-neutral incentives for abatement activities within the regulated sectors. Fuel suppliers are likely to pass through costs to car drivers by raising fuel prices, strengthening incentives for fuel-efficient cars and driving. Nevertheless, in the presence of other externalities and path dependencies in the road transport sector, further policy measures may be required to complement an integrated EU ETS. Subsidies for R&D activities and the expansion of fueling infrastructure, for example, may help to overcome R&D spillovers and network externalities, fostering technological change. When thinking about such vehicle technology policies, however, policymakers should take possible interactions with an integrated EU ETS into consideration, e.g. adjusting the cap reduction path accordingly.

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