Including heavy duty road transport CO_2 emissions in the European Union Emissions Trading Scheme

An assessment of feasibility, costs and emissions for Finland

Jim Antturi, Samuli Puroila and Markku Ollikainen

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FOREWORD

In 2014, the EU Commission raised the question whether the CO_2 emissions from heavy duty vehicle transportation, or road transportation as a whole, should be included in the European Union Emissions Trading Scheme, EU ETS. To anticipate Finland's response to the future Commission's request for the EU member states' statements on the topic, this report examines how this inclusion could be carried out and considers the possible impacts of this kind of arrangement in Finland.

The Finnish Transport Safety Agency Trafi commissioned Dr. Markku Ollikainen, Professor of Environmental and Resource Economics of the Helsinki University, and his students Mr. Jim Antturi and Mr. Samuli Puroila, to conduct this study.

A couple of project meetings were arranged during the study period. The following experts contributed to these meetings as well: Ms. Maria Rautavirta and Ms. Saara Jääskeläinen from the Ministry of Transport and Communications, and Mr. Marko Sillanpää, Mr. Erik Asplund, Mr. Keijo Kuikka and Mr. Juhani Puurunen from the Finnish Transport Safety Agency.

Helsinki, 28 February 2015

Dr. Anita Mäkinen
Chief Adviser, person in charge for project in Trafi
Finnish Transport Safety Agency Trafi

ALKUSANAT

EUn komissio harkitsi vuonna 2014 tieliikenteen raskaiden ajoneuvojen kasvihuonekaasupäästöjen sisällyttämistä EU:n päästökauppasopimuksen. Ennakoiden EU-komission jäsenvaltioille kohdistettua lausuntopyyntöä asiassa, tässä työssä selvitetään, mitä tieliikenteen sisällyttäminen päästökauppaan käytännössä tarkoittaisi ja arvioidaan, mitkä olisivat komission ehdotuksen mukaisen menettelyn vaikutukset Suomessa.

Selvityksen toteuttivat Trafin toimeksiannosta Helsingin yliopiston taloustieteen laitoksen tutkijat. Hankkeen vastuullisena johtajana toimi ympäristöekonomian professori Markku Ollikainen. Muut raportin kirjoittajat ovat Jim Antturi ja Samuli Puroila.

Hankkeen aikana pidettiin muutama projektikokous, joihin osallistuivat edellä mainittujen lisäksi Maria Rautavirta ja Saara Jääskeläinen liikenne- ja viestintäministeriöstä sekä Marko Sillanpää, Erik Asplund, Keijo Kuikka ja Juhani Puurunen Trafista.

Helsingissä, 28. helmikuuta 2015

FT Anita Mäkinen
Johtava asiantuntija, hankeen vastuuhenkilö Trafissa
Liikenteen turvallisuusvirasto Trafi

FÖRORD

EU kommissionen övervägde år 2014 huruvida växthusgasutsläpp från tunga transportfordon eller vägtransporter borde inkluderas i systemet för handel med utsläppsrätter inom EU, ETS. För att förutse Finlands svar för EU kommisionens kommande begäran på uttalandet till EU medlemstaterna i den här frågan, studeras i denna rapport vad den tunga trafikens inkludering i EU ETS innebär i praktiken, och dess möjliga effekter i Finland utvärderas.

Rapporten genomfördes av forskare från avdelningen för ekonomi vid Helsingfors Universitet på uppdrag av Trafiksäkerhetsverket Trafi. Markku Ollikainen, professor i miljöekonomi verkade som ansvarig ledare för projektet. Hans två studerande Jim Antturi och Samuli Puroila är de övriga författarna för raporten.

Under projektet arrangerades några möten där experterna Maria Rautavirta och Saara Jääskeläinen från kommunikationsministeriet samt Marko Sillanpää, Erik Asplund, Keijo Kuikka och Juhani Puurunen från Trafiksäkerhetsverket Trafi deltog.

Helsingfors, den 28 februari 2015

FD Anita Mäkinen
Ledande sakkunnig, ansvarig för projektet i Trafi
Trafiksäkerhetsverket Trafi

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ABSTRACT

Recently, the question has been raised whether or not heavy duty vehicle transportation or road transportation as whole should be included in the EU ETS. In this report we examine how this inclusion could be made, how strong incentives emissions trading would provide to reduce transport emissions and, finally, how high the costs would be for HDV transport. Transport can be included in the EU ETS either via upstream agents, producers and suppliers of transport fuels, or via downstream agents, HDV operators. The downstream solution is simply infeasible. There are more than a million micro HDV firms and this would cause very high transaction costs. Furthermore, monitoring and enforcement would be extremely difficult causing the risk of fraud and undermining credibility of the whole EU ETS. In contrast, upstream agents can be included rather easily in the EU ETS and this would strengthen the demand for emission allowances and increase allowance price. The impact of emissions trading would show up as a marginal increase in fuel tax not only for HDV operators but also for light duty transport. Using the Finnish transport data, we demonstrate that even under rather high emission allowance price, fuel prices increase very little. Therefore, price incentives remain weak. Given the inelastic demand for fuels in Finland, the impact of upstream emissions trading on HDV and light duty transport emissions remains small. Actually, this impact is much smaller than the reduction produced by the current policy package for transport.

TIIVISTELMÄ

Tavaraliikenteen, tai vaihtoehtoisesti koko tieliikennesektorin, liittämistä EU:n päästöoikeuskauppaan on ehdotettu keinona vähentää liikenteen päästöjä. Tässä raportissa selvitämme, miten tämä voitaisiin toteuttaa, kuinka voimakkaasti päästöoikeusmekanismi kannustaisi vähentämään liikenteen päästöjä ja kuinka suuret olisivat raskaan liikenteen kohtaamat kustannukset. Liikenne voidaan liittää päästöoikeuskauppaan keskitetysti, kohdentamalla kauppavelvollisuus polttoaineen jalostajille tai jakelijoille, tai hajautetusti, jolloin kaupan alaisina toimijoina olisivat raskaan liikenteen kuljetusyritykset. Hajautettu ratkaisu on kuitenkaan ole toteuttamiskelpoinen: Euroopassa on yli miljoona pientä kuljetusyritystä, joiden liittäminen päästöoikeuskauppaan aiheuttaisi valtavat transaktiokustannukset. Lisäksi näiden yritysten valvonta olisi hyvin haastavaa, jonka seurauksena koko kauppajärjestelmän uskottavuus joutuisi koetukselle. Polttoaineen jalostajat tai jakelijat olisi sen sijaan varsin helppo liittää päästöoikeuskauppaan. Tämän seurauksena päästöoikeuksien kysyntä lisääntyisi ja hinta nousisi. Päästöoikeuden hinta vaikuttaisi sekä raskaan liikenteen toimijoihin että yksityisautoilijoihin samalla tavoin kuin polttoaineveron korotus. Suomen liikennetilastoihin perustuen osoitamme, että tämä vaikutus on varsin pieni, vaikka päästöoikeuden hinta olisi verrattain korkea. Näin ollen myös kannustin päästöjen vähentämiseksi on pieni. Ottaen vielä huomioon polttoaineiden joustamattoman kysynnän voidaan todeta, että liikenteen liittämisellä päästöoikeuskauppaan olisi keskitetyn ratkaisun tapauksessakin vain vähäisiä vaikutuksia liikenteen päästöihin. Nykyiset ilmastopoliittiset toimenpiteet ovat liikenteen osalta tehokkaampia päästöjen vähentämisessä kuin liikenteen liittäminen päästöoikeuskauppaan.

SAMMANFATTNING

Frågan har nyligen ställts om inte tunga transportfordon eller vägtransporter skulle inkluderas i systemet för handel med utsläppsrätter inom EU, ETS. I denna rapport undersöker vi hur denna inkludering kunde göras, hur starka incentiv handel med utsläppsrätter skulle utgöra för att reducera transportutsläpp och slutligen, hur höga dessa kostnader skulle vara för transporter med tunga transportfordon. Transporter kan inkluderas i ETS antingen via uppströmsagenter, producenter och leverantörer av transportbränsle, eller via agenter medströms, operatörer för tunga transportfordon. Alternativet medströms går dock inte att tillämpa. Det finns mer än en miljon mikrooperatörer för tunga transportfordon och vilket innebär mycket höga transaktionskostnader. Vidare vore uppföljning och genomdrivande extremt svårt med risk för bedrägerier och underminering av trovärdigheten för hela i systemet för handel med utsläppsrätter inom EU, ETS. I motsats till detta kunde uppströmsagenter relativt lätt inkluderas i ETS och detta skulle stärka efterfrågan för utsläppsrätter och höja priset på utsläppsrätter. Inverkan av handeln med utsläppsrätter skulle visa sig som en marginell ökning i bränsleskatter inte bara för operatörer för tunga transportfordon men också för lätta transportfordon. Genom att använda finskt transport data visar vi att priset på bränsle stiger relativt lite även för ganska höga priser för utsläppsrätter. Prisincentiven förblir därför svaga. Eftersom efterfrågan på bränsle i Finland är oelastiskt kommer inverkan av handeln med utsläppsrätter uppströms på tung och lätt fordonstrafik att förbli liten. I själva verket är denna inverkan att var betydligt mindre än den minskning som den nuvarande politiken för transporter medfört.

1 Introduction

Climate policies entail continuous reduction of greenhouse gas emissions from all sources, including transport. Roughly a half of the emissions in the EU are controlled within the European Emissions Trading Scheme (EU ETS) since 2005. Installations in the power production sector and multiple processing industries belong to the EU ETS. It is a single Europe-wide market in which all installations can freely trade with emission allowances. The total amount of allowances is determined by the cap set on emissions and over time tightened by the EU Commission.

So far, the emitting sectors not belonging to the EU ETS, such as transport, have been subject to national climate policies via EU's burden sharing between the Member States. Recently, a question has been raised whether the heavy duty transportation only or road transportation as whole should be included in the EU ETS. Double motives for this suggestion can be found. They are, first, to regulate the growing emissions from the transport sector and, second, to increase demand for emission allowances (EUAs) in the European Union Emissions Trading Scheme.

According to the *Strategy for Reducing Heavy-Duty Vehicles' Fuel Consumption and CO_2 emissions* by the European Commission (2014a), road transport, including heavy duty vehicles (HDVs), has increased its relative share of CO_2 emissions within the EU. The report's impact assessment (2014b) lists three options for controlling the emissions from HDVs. One option is to include road transport as whole to the EU ETS. The two other options are to improve knowledge, comparability and accountability of HDV CO_2 emissions; and to introduce legislation setting mandatory HDV CO_2 emission ceilings.

The *Report on the state of the carbon market* by the European Commission (2012) discusses alternative methods to strengthen demand for allowances and increase allowance price in the EU ETS. Expanding the EU ETS to new sectors is mentioned as one of the six alternative structural methods to correct the emissions allowance market. Even though the report does not name any sector, transport and heating of households are two obvious candidates. Finally, the recent resolution of the European Council on climate targets for 2030 emphasizes that Member States can opt to include transport sector within the framework of the ETS.

None of the papers mentioned above discusses in detail how transport could be included in the EU ETS. Further, they do not assess what this would imply on costs and emissions in the transport sector. It is mentioned, however, that the inclusion of transport in the EU ETS would cover CO_2 emissions from transport and most likely the agents subject to emissions trading would be the suppliers of transport fuels (the European Commission 2014b, 23). Whether this or some alternative model would work is, therefore, a very important question. In this study we scrutinize alternative ways of including transport in the EU ETS from Finland's point of view. More specifically, we pose and answer to the following questions. In what ways the transport sector could be included in the EU ETS? Would emissions trading provide incentives to reduce emissions in the transport sector to match the needs of climate policies and, for instance, the goals set by the European Council for 2030? Finally, how much emission allowance price would increase transport sector's costs?

There are actually many alternative ways to include transport in the EU ETS. Following the impact assessment (the European Commission 2014b), we discuss both upstream and downstream approaches for this inclusion. We provide first a qualitative assessment of alternative approaches and then choose the best candidate for quantitative analysis. We assess the impact of EUA price on transport fuels under alternative assumptions concerning EUA prices. Drawing on these predictions, we then let the Finnish transport sector to adjust to new transport fuel prices, estimate changes in fuel consumption and emissions. We, finally, compare the achieved reductions to the reduction requirement set by national climate policies to achieve the reduction target for 2020 and 2030. [1]

If allowances are auctioned to the included agents, the revenue from auctions can be given to member states according to selected distribution rules. In the case of transport, auction revenue resembles fuel taxes that are currently an important source of budget revenue to most member states. More importantly, if fuel producers, suppliers or HDV operators are included in the EU ETS, fuel consumption would be subject to double emission taxation (fuel tax and emission allowance price). There are examples of double taxation in the EU ETS, for instance in Finland

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[1] Finland's current policy package to curb transport-based emissions is defined in the renewed *Finnish Climate Policy Programme for the Ministry of Transport and Communications' administrative branch* which lists six methods to control emissions from transport: 1) promoting alternative fuels, 2) renewing passenger car fleet, 3) improving energy efficiency of transport, 4) channeling the growing volume of transportation in cities into more environmentally friendly transport modes, 5) endorsing the change toward information society, and 6) applying financial instruments (Jääskeläinen 2014).

(taxation of heating and combined heating and power, CHP, plants) and United Kingdom (domestic firms belonging to the EU ETS). But surely discussion on the use double instruments would be necessary. Also, member states may respond to double instrument by revising their fuel tax systems. We briefly comment on these aspects throughout our discussion.

2 Alternative ways to include transport in the EU ETS: A qualitative assessment

The European Union implemented its cap-and-trade scheme for CO_2 emissions in 2005. The current trading period (2013-2020) is the third in the history of the EU ETS.[2] During this period, the installations in the power sector must buy allowances in auctions, while installations in sectors under carbon leakage risk are given most of the allowances for free. Currently, the EU ETS suffers from oversupply of allowances and a low EUA price merely thanks to three factors: economic recession, large supply of CERs and ERUs to the EU ETS, and the impacts of renewable targets (European Commission 2014c; Aatola, Marjamaa, Ollikainen & Ollikka 2013.)

Commercial aviation was included in the EU ETS in 2012. It is currently the only form of transportation directly linked to the EU ETS. Aviation has its own emissions cap, based on the industry's historical emissions, and own allowances that cannot be sold outside aviation, while aviation firms are allowed to buy freely the ordinary EUAs. Each year 83% of the allowances available are allocated based on grandfathering, 15% auctioned and 2% placed in a reserve, from where they can be released (European Commission 2014d). For years 2014-2016 the airlines operating only within the European Economic Area are the complying parties but EU Commission originally wants to expand trading to all flights arriving to or departing from the EU.

Aviation sector provides an example of a possible solution for HDV traffic and we discuss this briefly in the following sections. Before going in detailed discussion it is worth notifying how two key features of emissions trading programs, the single market property and choice of production technology, are related to transport sector.

[2] At present, the EU ETS covers approximately 45 % of greenhouse gas emissions in the EU. The main sectors included in the scheme are: power and heat generation; energy intensive industries, such as oil refining, production of steel, iron, aluminum, other metals, cement, lime, pulp, paper, cardboard, acids and organic chemicals. In addition to CO_2 emissions, the EU ETS regulates nitrous oxide and perfluorocarbon emissions. In trading the emissions are translated to CO2-equivalent emissions.

2.1 Key features of emissions trading as related to the transport sector

Emissions from transport in general and HDV transport in particular are a function of a variety of variables. In the short run the stock of vehicles is fixed implying that transport emissions depend on transport operators' logistic systems, and fuel consumption and composition between bio and fossil components. In the long run also the stock of vehicles can be changed, infrastructures improved and car manufacturers can reduce unit emissions of vehicles. This suggests that reducing transport emissions is best made by a coordinated interplay between several agents in the economy; none alone masters emissions. This feature has important implications when considering the role of transport sector in an emissions trading scheme.

In an emissions trading scheme a transportation firm can reduce its emissions in the short run by optimizing its logistic arrangements and reducing the consumption of transport fuels. In the long run the firm can buy new vehicles, which have lower unit emissions. However, if the choice of including transport sector in the EU ETS means abandoning tightening regulation of emissions from vehicle technology, the means of the transport sector to reduce emissions remain limited, which leads over time with the tightening emission cap to high costs. The contrast to other installations in the EU ETS is striking. They can change their technologies or fuel mixes in the production plants to facilitate lower emissions. But transporting firms must take for granted the unit emissions of vehicles, which do not decrease in the absence of separate regulation. Hence, transport firms would be economically vulnerable in the EU ETS.

Emissions trading takes place in a single market for all installations in different sectors included in the trading. Therefore, if transport sector is included in the trading system it is not guaranteed that emission reductions would take place in the transport sector. In fact, emission reductions are likely to take place in other sectors, because the marginal abatement costs are lower in many other sectors compared to the transport sector. Hence, over time emissions from transport sector do not decrease at a pace, which could be achieved in the presence of policies targeting technology improvements. If vehicle technology is not environmentally regulated transport sector can in the long run only pay EUA prices without any chance to adjust apart from closing down firms or charging high prices from processing industry. The solution is hardly cost-efficient.

The European Commission (2014b) discusses *upstream* and *downstream* ways of including transport in the EU ETS. *Upstream* solution refers to an idea that upper-end players are required to participate in emissions trading. Fuel producers or suppliers are the key upper-end players, who could be set responsible for complying with the EU ETS. *Downstream* solution, in contrast, refers to options, where HDV transport operators are included in the EU ETS. While not mentioned in the report, one additional possibility for downstream inclusion is to include transport in the EU ETS via its own cap and allowances in a similar fashion as aviation. In this case the responsible agents would, again, be HDV transport operators. We next assess both upstream and downstream solutions.

2.2 Upstream approaches to including transport in the EU ETS

In the upstream solution a fuel producer or a fuel supplier must buy an amount of EAUs that reflects the CO_2 content of transport fuels they have sold out. The impacts of emissions trading would then be passed through to HDV operators and light duty vehicles in the fuel price. Hence, upstream solutions cannot distinguish between HDV and other transport. It would incentivize the HDV sector to reduce CO_2 emissions only via higher fuel prices. Thus, emissions trading works like a tax on transport fuels. The producers and suppliers in turn, can avoid buying EUAs only by increasing the bio-component in the transport fuels. This however, requires a rather high EUA price, as biofuels are still expensive.

Turning the attention to HDV transport, the European Commission (2014b, 29) rightly acknowledges that including road transport in the EU ETS: ”…would provide a limited incentive to invest in technical measures to improve vehicle technologies and would most likely not trigger any sizeable reduced HDV fuel consumption in view of low fuel use price elasticities”. Looking from the angle of the EU ETS, an upstream solution would be technically easy and administratively fairly light. Demand for EUAs would increase, which would increase upward pressure on EUA price, while emissions reductions would take place in sectors which have lower abatement costs.

Academic research has focused on upstream emissions trading solutions for controlling transport emissions. In general, the literature emphasizes the positive role of price incentives but worries the risk that transport-specific measures may not enter the market. [3] Drawing on

[3] Winkelman, Hargrave and Vanderlan (2000) identify and discuss the possibility of fuel producers, processors or carriers being the complying industry in the emissions trading market. They note that this inclusion would

this literature and applying it to the Finnish circumstances, our assessment of the upstream solution is as follows.

Transport. Upstream solution would entail an increase in fuel prices and thus in the cost of HDV operators and all other transport as well. Higher transport costs would be passed along to the processing industry that is dependent on road transport. In Finland the share of road transport is 90% in transportation of manufactured goods. Despite increased fuel price, incentives to reduce emissions would be rather limited in the short run, as the demand for fuels is very inelastic (according to Dahl 2012 only -0.05% in Finland). In the long run emissions reduction by HDV operators would depend on how well vehicle technology evolves towards lower emissions; but this would require other type of regulation. If producers wish to avoid EUA costs by increasing the share of biofuels, some reduction in emissions would automatically take place but this requires high EAU price. In the absence of improvements in vehicle technology or an increase in the bio-component of transport fuels, tightening the cap on emissions would only increase HDV operators' costs and emission reductions would take place in other sectors. Hence, emissions trading system as an upstream solution would not invite all cost-effective methods to reduce transport emissions. The time horizon plays an important role. Traffic would benefit from a modest need to reduce its emissions in the short run but the situation would change crucially in the long run. The tightening of the emission cap is expected to yield gradually a carbon free electricity system and after that larger reductions in other sectors. If this happens then transport would become the main polluting sector in the EU ETS. Tightening the cap would then mean that transport sector would face dramatically increasing costs, as it would not have other means to reduce emissions than lower its fuel consumption.

EU ETS. Inclusion of transport via fuel producers or suppliers in the EU ETS without changing the cap would increase demand for EUAs (roughly 5%) and increase the price of EUA. The number of participating entities would not increase much and the verification and monitoring issues would be easy to handle. Therefore, also administrative burden for the EU would be light. There is no doubt that this solution would strengthen the functioning of the EU ETS

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result in higher retail fuel prices in proportion to the price of the emission permit. This could create an incentive for using more biofuels and in long term consumers could switch to cleaner vehicles. A warning on cost-efficiency lost is given by Millard-Ball (2008), who points out that inclusion in the emissions trading scheme would lead to missing out some cost-effective methods of reducing emissions from transport. Also, Santos et al. (2010) argue that emissions trading would most likely undermine the introduction of alternative measures to reduce emissions below the cap level.

in a very easy way. Furthermore, revenue from auctions could be distributed to member states in the same manner as is currently done in the EU ETS.

Qualification: including vehicle manufactures in the EU ETS

An alternative upstream solution discussed in the literature would be to involve vehicle manufacturers in the EU ETS. Since vehicle manufacturers produce carbon intensive products, the manufacturers could be required to hold a certain amount of pollution permits attributed to the new vehicles sold. In this case the costs of buying EUAs would be passed to vehicle buyers. This increase in car prices may lead to an older fleet of cars. Whether ageing of the fleet implies reduced or increased emissions, is unclear and depends on the life cycle impacts. In this design, a small number of vehicle manufacturers would fit well to the EU ETS and expectedly transaction and administrative costs would be low. However, uncertainties concerning the future emissions of vehicles make this solution less viable. Not only because forecasting future emissions is problematic, but also because the EU ETS is based on current emissions. (Santos et al. 2010.) Furthermore, at least in the case of low EUA prices, this choice may decrease technological development towards cleaner vehicle technology, as manufacturers could produce more vehicles with high fuel consumption.

2.3 Downstream approaches to including transport in the EU ETS

Involving HDV operators directly may be the only option to solely include commercial transportation from the road transport sector in the EU ETS. In this system, HDV operators are required to report their fuel consumption-based CO_2 emissions and to buy EUAs to match these emissions. In this system fuel prices would not change because HDV operators would pay for EUAs to the emissions trading market. Based on the EUA price level, the operators would take all available profitable actions to reduce their emissions so as to avoid EUA costs. Furthermore, HDV operators would pass the costs of transportation to the processing industry, as in the upstream case. Should the demand for fuels decrease marginally, there would be a slight reduction in fuel prices. The European Commission (2014b) notifies that most of the 1 million HDV transport operators in the EU are micro-enterprises. Under such program they all are obliged to obtain emission permits based on their fuel consumption. Commission stresses, however, that most likely instead of investing in cleaner vehicles, the HDV operators would likely become buyers of permits.

Academic research has also discussed downstream solutions for transport. To highlight our key findings, EUA price is seen to have a more constructive role compared to upstream solutions, where it works like a tax. Increasing actors in the emissions trading scheme is good but only if transaction costs do not increase. There are also many specific questions concerning the design of the trading system, among others geographical and durational issues.[4] Drawing on this literature and applying it to the Finnish circumstances, our assessment of the downstream solution is as follows.

Transport. Downstream system guides reduction of operator's emissions efficiently, as it includes in principle all relevant emission reduction measures available to HDV operators. But, again, separate regulation of vehicle technology is needed to facilitate emission reductions in the long run. In the short run, as the Commission stresses, the HDV operators would likely become just buyers of permits and processing industry would encounter higher costs. Reduction in emissions is further decreased by the evident risk of fraud, which is created by the possibility of underreporting fuel consumption (for instance, using agents not belonging to the EU ETS to buy fuel). The EU ETS's annual verification system would further increase costs of HDV operators. As like with aviation, the geographic coverage of the emissions resulting from road transportation should be carefully considered. Even though a majority of the fuel consumed in the EU is bought within the Union, there is an incentive for private car owners as well as HDV businesses to buy fuel from non-EU countries. This is a possible problem for many border countries in the EU, and it would constitute carbon leakage. For Finland trans-border trade of fuels already exists, as fuel is very much cheaper in Russia.

EU ETS. Including more than one million small participants in the EU ETS would be very challenging and costly. The EU ETS covers currently 12 000 bigger installations and thus the nature of the whole trading system would change. Transaction costs would be high not only for HDV operators but also for the EU. Finding a sufficient number of accredited verifiers would be challenging at least in the short run. The annual verification costs would increase the

[4] Raux and Marlot (2005) point out that the market for emission allowances becomes more liquid relative to upstream solutions. Thus, in theory, involving private car-owners in an emissions trading scheme would substantially increase the amount of players in emissions trading, and more importantly, affect efficiently on peoples' decision making. Yet the advantage of having more participants in emissions trading is also the main argument against downstream solutions: more participants mean higher transaction costs. Winkelman et al. (2000) also believes that a strict downstream program could lead to strong public opposition. Santos et al. (2010) stress that not only is the allocation of allowances important when planning a cap-and-trade scheme for road transportation but the regulator should also take into account the many details of the while designing the system. They include geographic area, time scale, interaction with other schemes and taxes, credibility of continuity, long-term marginal abatement costs, costs and benefits.

cost structure of small HDV firms. The risk of fraud is more than evident and created by the possibility of underreporting fuel consumption. Thus far the EU ETS has been a rather compliant and uncorrupted system, now this good reputation would be at risk. Possibility of introducing fraud into the EU ETS by downstream solution has not received much attention, so far. What said is about auction revenue in the previous section holds true in this case, too.

Qualification: a separate trading program for HDV transport

How would the hypothetical case, where HDV transport had its own allowances and cap, relate to the assessment above? Naturally, by adjusting the cap, the EU could control the overall emissions from transport. Otherwise, much of our above analysis would be valid for this case. Most importantly, the risk of fraud would continue to be present in a similar way as above implying that the cap might not be actually met. The costs for HDV operators would increase if vehicle technology does not improve and bio-component of transport fuels increase. Furthermore, the problem of having a large number of participants and high transaction costs would remain and seriously question the feasibility of separate trading. Finally, to reduce the (too) large number of participants, only larger operators could be included in trading. In this case, transaction costs would be lower but also greater amount of emissions would be outside the system. Furthermore, this would not eliminate the fraud risk.

2.4 Conclusions of qualitative analysis

We summarize our qualitative findings as follows.

First, upstream solutions would be easy to implement and they would undeniably strengthen the demand for and price of EUA. This solution would cover all transport, not only HDV operators. The upstream inclusion of transport in the EU ETS shows up as an increase in the fuel tax. Therefore, it provides similar incentives to HDV operators to reduce their emissions as fuel tax. In the short run, HDV operators pay EUA costs in higher fuel prices, and given inelastic demand, adjust their emissions only marginally. In the long run, the reduction of emissions depends on how vehicle technology evolves but inclusion of transport in the EU ETS does not promote it. Reduction in transport emissions is by no means guaranteed and, as a matter of fact, once the electricity sector becomes carbon free, transport as the main polluting sector in the EU ETS would encounter high costs, because of its low ability to reduce emissions.

Second, downstream solutions would cover solely HDV operators and leave light duty vehicles out of the system. It provides better incentives to reduce emissions compared to upstream solution, because now EUA price does not show up as a tax but instead as a cost item that could be avoided by taking appropriate measures to reduce emissions. Unfortunately, the list of weaknesses of downstream solutions is rather long. Like in upstream solutions, inelastic demand reduces emission reduction potential, while vehicle technology towards lower emission remains beyond the control of emissions trading. Downstream solutions are not necessarily beneficial for the functioning of the EU ETS, as they result in high transaction costs and administrative burden and the obvious risk of fraud.

Third, reducing transport emissions provides a hard challenge to the regulator. Responding to the rather large reduction requirements of national climate policies clearly requires progress in vehicle technology, fuel consumption and composition as well as in other variables, such as choosing relevant infrastructures. In the presence of multiple targets, economics suggests applying the so-called Tinbergen Rule: the society should use at least as many instruments as it has targets. A carefully designed policy package is the best policy option. Inclusion of transport in the EU ETS as the sole policy measure is inferior to a well-designed policy package.

Based on our qualitative assessment we rule out downstream solutions to include HDV transport sector in the EU ETS as infeasible. Therefore, in the next section we focus on the quantitative impacts of upstream solutions, which are technically easy to implement, albeit its impacts cover whole transport, not only HDV operators. We assess both costs and emissions under upstream solutions.

3 Assessing costs and emissions under upstream trading

Irrespective of whether the complying industry is fuel producers or suppliers, an upstream trading would cause similar impacts on fuel prices, fuel consumption and CO_2 emissions. We assume that no additional emissions allowances are allocated if transport sector is included in the EU ETS. The impacts of this inclusion on fuel costs and emissions depend much on the expected EUA price. We let the price to vary from the current 7 euros to 30 euros in order to cover the expected range of EUA price. We focus on both the heavy duty road transport and road transport sector as a whole in Finland.

3.1 Transport emissions and impact of EUA prices on fuel prices

Domestic transport causes around one fifth (12.7 Mt) of the total greenhouse gas emissions (roughly 61 Mt) in Finland (Statistics Finland 2014). In 2012 road transport was responsible for around 90% of transport emissions with its share of 11.4 million tonnes of CO_2 equivalent greenhouse gas emissions (VTT LIPASTO). The same year, HDV transport emitted around 2.8 million tonnes of CO_2e.

While emissions from transport vary with economic fluctuations, they are expected to decline steadily over time. Table 1 provides the baseline prediction for CO_2 emissions for HDV and other road transport in Finland from the present up to 2030, which is the most recent focus on EU's climate policy.

Table 1. CO_2 emissions from road transport in Finland (tonnes) (source: VTT Lipasto)

Year	HVD transport	Road transport (without HDV)	Entire road transport sector
2015	3 018 217	8 790 828	11 809 045
2016	2 996 443	8 735 806	11 732 249
2017	2 969 762	8 661 758	11 631 520
2018	2 907 070	8 470 954	11 378 024
2019	2 841 547	8 279 826	11 121 373
2020	2 807 670	8 195 346	11 003 016
2021	2 796 478	8 200 602	10 997 080
2022	2 786 263	8 199 262	10 985 525
2023	2 773 001	8 194 468	10 967 469
2024	2 761 823	8 185 341	10 947 164
2025	2 751 106	8 180 927	10 932 033
2026	2 738 718	8 155 444	10 894 162
2027	2 728 379	8 120 821	10 849 200
2028	2 717 622	8 067 183	10 784 805
2029	2 709 843	8 033 382	10 743 225
2030	2 701 571	7 998 763	10 700 334

The downward trend of emissions in table 1 is due to EU's climate policy implemented by national measures in the member states.

Transport emissions are directly linked to fuel consumption, and therefore, the main method for reducing emissions is to reduce the consumption of fossil fuels. Technological development of motor vehicles plays a major role in reducing emissions, and CO_2 -based taxation of vehicles encourages customers to purchase and transport companies to manufacture fuel-efficient vehicles. In addition, the share of biofuels in Finland will nearly double from 8% in year 2015 to 15% in year 2020. This will reduce fossil emissions from transport since emissions from biofuels are not considered as net greenhouse gas emissions.

A liter of fuel emits a certain amount of carbon dioxide. For a liter of diesel CO_2 emissions are 2660 g/l and for gasoline they are 2350 g/l. Employing these numbers, we can solve how much EUA price would increase fuel prices. However, since not all of the CO_2 in motor fuels is accountable in the ETS, the price of EUA falls only upon the share of fuel that is refined from fossil oil. Table 2 shows how much the European Union Emissions Trading Scheme would increase the prices of diesel and gasoline under different EUA prices. The share of biofuels has been taken into account with the amount determined for year 2016 in Finland.

Table 2. Impact of EUA prices on fuel prices in year 2016 (€/l)

EUA price	Diesel	Gasoline
7 €	0.017 €	0.014 €
10 €	0.024 €	0.020 €
15 €	0.036 €	0.031 €
25 €	0.060 €	0.051 €
30 €	0.072 €	0.061 €

Overall, the impact of EUA prices on fuels costs is rather small, only a few cents, and in most cases could not be distinguished in the ordinary daily variation of fuel prices. Both diesel and gasoline are heavily taxed in Finland and taxes provide a good yardstick to evaluate the EUA price impacts. One component of the excise duty on fuel is a CO_2 based tax component that aims at reducing fossil fuel consumption and transport related CO_2 emissions. For fossil diesel this tax is currently 0.1861 €/l and for gasoline 0.1625 €/l. The amount of the tax is different for fossil fuels and biofuels but comparing these figures with the EUA price effects presented in table 2 shows that the CO_2 based tax seems to be a more significant climate policy tool.

3.2 Expected costs to transport sector

In an emissions trading scheme the participating agents have to pay allowance price for every unit of CO_2 emitted. By adjusting their operations the agents have an opportunity to reduce their emissions. Should no adjustment occur, the agents would pay for emissions according to their business-as-usual behavior. We provide cost estimates for both cases. We assume first that transport does not adjust at all to the increased fuel prices caused by emissions trading, and then relax this assumption by using price elasticities to guide their fuel consumption.

The costs for transport under no-adjustment with different EUA prices under the baseline prediction for emissions in year 2016 are presented in table 3. The annual cost burden varies from 21 million to 90 million euros depending on the assumed EUA price. These costs can be compared to outlays used for transport fuels to obtain a better perspective for the assessment of the figures. For example, HDV transport in Finland consumed more than 1100 million liters of diesel in 2013 worth roughly 1400 million euros (VAT not included). The annual costs would thus represent a share of 1.5% – 6.4% depending on EUA price.

Table 3. Annual costs for transport from EU ETS under no-adjustment (year 2016)

EUA price	HDV transport	Road transport without HDV	Entire road transport sector
7 €	20 980 000 €	61 150 000 €	82 130 000 €
10 €	29 960 000 €	87 360 000 €	117 320 000 €
15 €	44 950 000 €	131 040 000 €	175 980 000 €
25 €	74 910 000 €	218 400 000 €	293 310 000 €
30 €	89 890 000 €	262 070 000 €	351 970 000 €

Note that figures in table 3 represent at the same time the upper limit to the auction revenue obtainable to the Finnish government if transport is included in the EU ETS. For comparison, the Finnish government collects currently 2568 million euros via fuel taxation. For the chosen range of EUA prices, auction revenue would represent only 0.8–3.5% of this revenue. This indicates that the role of the auction revenue from transport in the emissions trading market is small. Actually, it would change only marginally the currently existing price incentive mechanism.

How transport would adjust to the rising fuel prices under the EU ETS can be examined by using estimates of price elasticities. Price elasticity of demand indicates how much the consumption of fuel changes when prices rise. It describes agents' behavior in one figure containing implicitly all concrete measures that reduce demand for fuels. Literature offers a large number of numerical estimations for this elasticity. It is sensible to separate HDV transport from other modes of road transport because of its different characteristics. We study both HDV and the rest of road transport with two different options. For heavy duty in Finland, a study by Dahl (2012) provides elasticity of -0.05. De Jong et al. (2010) supply a long term elasticity that is generally applicable to transport in whole Europe and end up with a value of -0.3. For road transport in general, Goodwin et al. (2004) offer a short-term elasticity of -0.25 and long-term elasticity of -0.64 based on a literature review covering a large number of studies on some European and OECD countries and the US (review contains no studies on elasticities in Finland).

All reported price elasticities are small. So, it is warranted to say that fuel demand is inelastic with respect to fuel price. Using these elasticities we calculated how the Finnish road transport sector would adjust to rising fuel prices and how this would change the costs the EU ETS adds to transport. The results can be seen in table 4.

Table 4. Annual costs for transport from the EU ETS under adjustment

EUA price	HDV transport elasticity -0.05	HDV transport elasticity -0.3	Road transport (without HDV) elasticity -0.25	Road transport (without HDV) elasticity -0.64
7 €	20 960 000 €	20 890 000 €	60 980 000 €	60 720 000 €
10 €	29 930 000 €	29 780 000 €	87 010 000 €	86 480 000 €
15 €	44 880 000 €	44 540 000 €	130 270 000 €	129 060 000 €
25 €	74 720 000 €	73 780 000 €	216 250 000 €	212 910 000 €
30 €	89 620 000 €	88 270 000 €	258 990 000 €	254 170 000 €

By comparing the costs presented in tables 3 and 4, only a minor difference can be found. The price increasing effect of emissions trading on transport fuels does not encourage transport sector to introduce any major measures in reducing fuel consumption. This means that instead of taking any specific measures, transport would more likely buy allowances to cover its emissions. Transport's position as a buyer in emissions trading market reflects the fact that unless vehicle technology changes, optimizing logistic and other operator-specific variables provides very limited chances to reduce emissions.

3.3 Expected impacts on emissions from transport sector

As the changes in the Finnish transport sector behavior turned out to be modest, the reduction of emissions can also be expected to be moderate. Table 5 presents changes in emissions calculated using the same elasticities as above in table 4.

Table 5. Annual reduction in CO_2 emissions (tonnes)

EUA price	HDV transport elasticity -0.05	HDV transport elasticity -0.3	Road transport (without HDV) elasticity -0.25	Road transport (without HDV) elasticity -0.64
7 €	-2 000	-12 500	-24 000	-61 500
10 €	-3 000	-18 000	-34 000	-88 000
15 €	-4 500	-27 000	-51 500	-132 000
25 €	-7 500	-45 000	-86 000	-219 500
30 €	-9 000	-54 000	-103 000	-263 500

Table 5 shows that the reductions in the HDV transport related CO_2 emissions are small but also indicates that the size of elasticity plays an important role. The best way of interpreting the results in table 5 is to relate them to the baseline evolvement of emissions (incorporating 2020 climate target for transport) reported in table 1, and to the climate policy needs for 2030.

From table 1, the baseline reductions for the HDV transport are on average 40 000 tonnes annually during the first five years up to 2020. Road transport without HDV follows the same pattern: annual average reduction in baseline scenario is 120 000 tonnes up to 2020. Reduction requirement reflecting the climate policy needs for 2030 are still undefined in Finland (and other member states) but they will be more stringent than for 2020, as the EU needs to reduce emissions at least by 40% by year 2030. In transport the base year is 2005, and assuming 40% reduction for transport (which may be an underestimation) by 2030, the annual emissions are roughly 7 million tonnes. The baseline estimation presented in table 1 predicts the 2030 emissions to be around 10.7 million tonnes. Thus, from 2020 onwards transport needs to reduce emissions by 300 000 tonnes annually.

Starting with HDV transport and using elasticity value -0.05, estimated for Finland, shows that the reduction in HDV transport reaches at the highest EUA price only 9000 tonnes, which is much less than the average 40 000 tonnes reduction for 2020 under the baseline drawing on national climate policy measures. Applying the European elasticity -0.3 reveals how the same reduction could be achieved only if the EUA price is above 25 euros. Given that this elasticity exaggerates the Finnish adjustment potential, probably much higher EUA price would be necessary.

Turning next to road transport without HDV, we find that, again under the lower, short run elasticity, the reductions obtained remain below 120 000 tonnes that current policies produce. Should transport have a higher long-run elasticity, 15 euros EUA price would result in similar reduction. For achieving 2030 targets, a much higher EUA price than 30 euro would be necessary. As these elasticities represent overestimation of the Finnish adjustment potential, the impacts in Finland would actually be even smaller than table 5 suggests.

All in all, table 5 shows that including transport to emissions trading via an upstream trading (by involving producers and suppliers of transport fuels) makes transport to reduce its emissions as a response to increased fuel prices. So, clearly incentives to reduce emissions are present. These incentives are, however, weak, because transport has inelastic demand for fuels. This finding holds especially true for Finland, where distances are long and most of the industrial transportation takes place as road transportation. But it has also an important bearing for the whole Europe: even though more elastic, adjustment in the European HDV transport can be expected to be rather modest. Therefore, relative to current policy measures, emissions trading entail only a minor impact. Should transport be included in the EU ETS via upstream trading, it would be necessary to build other complementary policies to achieve climate policy targets.

4 Conclusions

We posed and examined the following questions. In what ways the transport sector could be included in the EU ETS? Would emissions trading provide incentives to reduce emissions in the transport sector to match the needs of climate policies and, for instance, the goals set by the European Council for 2030? Finally, how much would emission allowance price increase transport sector's costs? Drawing on the European Commission report (2014b) we examined the inclusion of transport to the European Union Emissions Trading Scheme via upstream (imposing trading liability on fuel producers or suppliers) or downstream (imposing trading liability on HDV operators) solutions. Our analysis was based on a qualitative assessment and quantitative analysis drawing on the Finnish data.

Our qualitative analysis suggests that upstream solutions would be easy to implement. They would undeniably strengthen the demand for allowances and increase the EUA price. For transport this solution works like an increase in fuel tax. Therefore, it provides similar incentives to reduce emissions as fuel tax. Upstream solution does not, however, promote vehicle technology towards lower emissions. Hence, it does not cover all necessary parts of the policy needed for reducing transport emissions. Consequently, if included in the EU ETS, transport would first benefit from a low impact of the allowance price but if electricity production becomes gradually carbon free, then under further tightened emission cap transport would face high costs, as no effective means to reduce emissions would be available. Downstream solutions provide better incentives to reduce emissions, because now EUA price does not show up as a tax but instead as a cost that could be avoided by taking appropriate measures (excluding improvements in vehicle technology). Unfortunately, downstream solutions are hardly feasible due to a high number of small operators, high transaction costs for both operators and administration and an obvious risk of fraud.

Our quantitative analysis of upstream solutions reveals that given very inelastic demand for fuels, upstream trading leads only to a minor increase in fuel prices and would not result in major reduction of emissions. Under the price elasticity estimated for Finland, emissions reduction at a 30-euro EUA price would be only a quarter of what current policies produce as 2020 goals. Achieving much tighter 2030 targets would be practically impossible.

All in all, our analysis confirms generally what is well-known: reducing transport emissions is a hard challenge to the regulator. Reducing emissions clearly requires progress in vehicle technology and fuel composition as well as in other variables such as infrastructure. In the presence of multiple targets, economics suggests the so-called Tinbergen Rule: the society should use at least as many instruments as is has targets. A carefully designed policy package is the best policy option.

Our final comment relates to the fact that at least in Finland the carbon dioxide-based fuel tax and the EU ETS would overlap in putting a price on CO_2 emissions. Emissions trading would change the existing current price incentive mechanism only marginally. Thus, it is questionable if it provides any additional improvement in regulating transport emissions. Furthermore, the same impact would be achieved in an easier way by just raising the fuel tax rates. In principle, double taxation of emissions is not recommended by the EU legislation, even though examples of double taxation exist. Nevertheless, this makes the inclusion of transport in the

EU ETS politically and practically more difficult. This aspect has not been given attention in the Commission’s documents.

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