Impact of a possible Inclusion of Maritime Transportation under the EU Emission Trading Scheme

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September 2010

Abstract

The importance of environmental protection and limitation of global climate change is evident to most members of Western society. A variety of policy responses has been implemented worldwide in response the the threat. The importance of global transportation is undeniable. Economic activity, growth and development and transport service provision are interdependent and mutually reinforcing. The discussion of climate change is therefore of high sensitivity for both policy makers and general stakeholders. The importance of reducing global emissions in order to tackle climate change put the transport sector into focus.

Considering its significant energy consumption and emissions, a stronger focus on sustainable transport activity is required. The inclusion of aviation under the European Emission Trading Scheme is therefore a first step in order to realign economic interests and environmental reality. The maritime sector not only has the potential to contribute to that goal but also the responsibility to account for its emissions and the resulting damage to nature and society. An inclusion of maritime transportation under the European Emission Trading Scheme might therefore be a possible solution to the problem.

Introducing the EU ETS has a strong negative impact on EU economic growth, output, and real wages. Including the aviation and maritime sectors has positive welfare effects for the EU economy as a whole as well as for the sectors in question, and therefore, from a macro-economic perspective, ultimately the two transport sectors could be brought under the wings of the EU ETS. Taxing the sectors more heavily (e.g. by 10 percent) leads to significant losses in welfare and output and is not recommended. The EU would need to look into the phenomenon of carbon leakage carefully before implementing the enlargement of the ETS in order to avoid the system having a net negative effect on global GHG emissions due to the fact that energy intensive industries move from the EU to – for example – China, where environmental regulations are not so strict and GHG emissions much less limited

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Acronyms and Abbreviations

AAU: Assigned Allowance Unit

AGE: Applied General Equilibrium

BAU: Business-As-Usual

CDM: Clean Development Mechanism

CER: Certified Emission Reduction

CGE: Computable General Equilibrium

CO2: Carbon dioxide

EC: European Commission

ECCP: European Climate Change Programme

EEA: European Environment Agency

EIA: (United States) Energy Information Administration

ERU: Emission Reduction Unit

ETS: Emission Trading Scheme

EU: European Union

EUA: European Union Allowance

GDP: Gross Domestic Project

GHG: Greenhouse Gas

GTAP: Global Trade Analysis Project

IEA: International Energy Agency

IEO: International Energy Outlook

IPCC: Intergovernmental Panel on Climate Change

JI: Joint Implementation

NAP: National Allocation Plan

NGO: Non-Governmental Organisation

OECD: Organisation for Economic Cooperation and Development

PE: Partial Equilibrium

ROW: Rest of the World

SAM: Social Accounting Matrix

UN: United Nations

UNFCCC: United Nations Framework Convention on Climate Change

US: United States of America

1 Introduction

Climate Change is a long neglected subject in international politics. The increasing importance of climate change as the most serious threat to human society and global ecosystems makes rapid and coordinated response on international level necessary. Increasing awareness due to more and more frequent heatwaves, droughts, floods, earthquakes and other natural occurrences induced by accelerating climate change lead to global political and societal action (UN Climate Report, 2009).

1.1 Climate Change

The topic of climate change is highly discussed and of increasing importance to society and policy makers. Due to increased environmental awareness, environmental politics are high on today's political agendas leading to increasing efforts on international level to tackle climate change and to limit its negative effect on global ecosystems and human society. The following section will therefore shortly describe climate change and present general projections about expected future changes in global climate.

General Assessment

The official definition of climate change is a persistent change in the distribution of weather determining variables over a defined period of time. Climate change therefore does not only constitute changes in mean weather occurrences but also in its volatility over time. The scope of change can be within a single geographical area or of global nature.

There are different underlying determinants of climate change besides human induced processes. Plate tectonics impacts land and ocean configuration, generates topography and therefore has an influence on climate and atmosphere-ocean circulation (UN Climate Report, 2009).

Solar output is not stable and underlies variability in the short and long run which has an impact on global temperature. Orbital variations in terms of eccentricity, tilt angle of the rotation axis and axis precession has an impact on the geographical and seasonal distribution of sunlight creating the so called Milankovitch cycles which correlate with phenomena such as the retreat and advance of the Sahara. Volcanism has an impact on earth atmosphere due the emission of gases and particulates (UN Climate Report, 2009).

The United Nations Framework Convention on Climate Change defines climate change in a more practical way as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods" (UNFCCC, 2008).

In 2007 a report by the International Panel on Climate Change (IPCC) published estimations about changes in global warming. Compared to 1990, global carbon dioxide (CO_2) emissions increased by approximately a third. Average global temperature over the past eleven consecutive years was the highest since reliable global temperature measurement was established.

Global greenhouse gas (GHG) emission by human activities rose alone between 1970 and 2004 by over 70 percent. During this period increases in average global surface temperature have been observed.

The impact of greenhouse gases (GHG) and the impact human industrial activity has on changes in world climate are therefore established and generally accepted (Climate Conference Copenhagen, 2010).

Projection Scenarios

The discussion of climate change in general relies partially on observable changes in global environment and predictions about future expected changes induced by human activity in the past, present and future. Appropriate measurement and forecast methods are therefore essential to estimate expected changes in global climate and to establish necessary requirements in order to prevent or at least limit further human induced climate change. The primary aims of climate research is therefore to gain a better understanding of the determinants of global climate and their interdependence as a requirement for the induction of prevention and adaptation policies.

The Forth Assessment Report on Climate Change by IPCC (IPCC, 2007) provides a variety of model projections on future changes in climate variables. Generally, different models and emission scenarios might lead to different projections regarding future changes in world climate. Scenario differences become more important in terms of projection differences the longer the forecast period is set. In the short run the outcome of three scenarios B1, A1B and A2 project increases in mean surface air temperature (SAT) between 2011-2030 in the range of +0.64°C and 0.69°C compared to the mean SAT of the period 1980-1999. In the medium term (2046-2065) projections based on the three different emission scenarios differ to a larger extend. Estimated increases in SAT for scenario B1, A1B and A2 are respectively estimated to be 1.3°C, 1.8°C and 1.7°C.

Projections estimating future changes in regional temperature extremes predict prolonged summer periods while winter periods are expected to decrease significantly. Furthermore the diurnal temperature range is expected to decrease, since daily minimum temperatures are expected to increase faster compared to daily maximum temperatures.

The ongoing melt-down of global ice caps and the associated change of the sea level will also be of significant amount. Again, projections depend on scenario assumptions and differ in extend. Using the SRES B1 scenario, the sea level is expected to increase between 0.18 to 0.38m by 2090-2099 compared to 1980-1999 average. Alternative underlying scenarios lead to different estimations: B2 0.20-0.43m, A1B 0.21-0.48m, A1T 0.20-0.45m, A2 0.23-0.51m, A1FI 0.26-0.59m. Generally the implications might differ to some extend but the tendency of tremendous increases in sea level and resulting impacts on global society remains independent of the choice of scenario and model.

Next to the global level, climate change models have been deployed to provide are more regional focus. Estimations on that level provide important insights into adaptation requirements and policy requirements. A study conducted by the UK Climate Impacts Program (UKCIP) in 2002 estimates expected increases in temperature in the UK between 1.5 and 2.0° C by 2080. Snowfalls in certain areas such as Scotland are expected to decrease by 90 percent while country wide wind speeds are expected to increase by up to 4 percent. Furthermore the sea level is expected to increase by 60cm with increases in water temperature between 1.0 and 2.5° C.

Climate Change is therefore not limited to certain regions of the world nor is the impact on industrialized countries negligible. Considering the general implications made by model predictions as well as differences associated with emission scenarios, the importance of global action in order to limit further acceleration in climate change becomes visible.

1.2 Study Description and Research Question

This research assesses implications resulting from a possible inclusion of the maritime transport sector into the European Emission Trading Scheme (ETS). Political awareness about the importance of the transport sector for global environmental policy and the inability of the International Maritime Organization (IMO) so far to find alternative solutions to reduce emissions made by maritime transportation makes an inclusion of the maritime sector into the ETS a likely policy scenario.

The aim underlying this study is therefore:

To model the expansion of the European Emission Trading Scheme by aviation – implemented by the EU 2020 targets – and maritime transportation deploying a computable general equilibrium (CGE) model as impact assessment methodology, and to estimate resulting effects on welfare, the output of the maritime transportation sector, real wages and trade flows.

The respective research question is therefore:

What macro-economic results and shifts in output are to be expected due to an enlargement of the European Emission Trading Scheme (EU ETS) by maritime transportation following the inclusion of aviation, and what policy recommendation follow from it?"

2 Literature Review

The importance of climate change led to a variety of political responses. The most recent action plan on European level is the implementation of the EU 2020 targets (EC, 2008) following the Kyoto protocol ending in 2013. The main policy tool used to meet requirements inherent to political commitments made by the European Union is the Emission Trading Scheme (ETS). It presently represents the largest and most complex emission trading scheme worldwide. Compared to other existing trading schemes such as in the United States, the complexity and multilayer character of the systems created a variety of problems and obstacles prior to a successful implementation.

The impacts of the political giant ETS are manifold. Next to expected reductions in European emissions, changes for the European economy will result. The enlargement of the ETS scope could improve the efficiency and effectiveness of the system but induce further shocks to the European economy and its competitiveness. The estimation of future changes induced by the ETS are highly discussed and a variety of studies have been conducted assessing possible economic outcomes. Generally it seems established that the emission scheme creates considerable additional costs for the European economy (ECORYS, 2009).

The remainder of the chapter will review existing research and literature on the EU ETS system and gives an overview of the transport market and its sub-sectors. The intended purpose of this chapter is to give the reader a better understanding on the subjects of study and the system in which they operate in order to prepare the ground for further analysis.

2.1 Political Initiatives

The first milestone of international climate policy was the Toronto conference in 1988. The policy recommendation established during the conference was a reduction in global carbon dioxide (CO_2) emissions by 20 percent by 2005 compared to 1988 emissions. Additionally, energy efficiency should be increased by 10 percent.

The year 1988 also represents the foundation of the Intergovernmental Panel on Climate Change (IPCC). The primary objective at the time of foundation was the provision and distribution of knowledge on climate changes and its implications and the creation of an organizational body to be used as a foundation for future collective climate policy.

In order to tackle climate change the United Nations General Assemble created in 1990 an organizational body to develop a legally binding framework as basis for sustainable climate polices.

The implementation of the United Nations Framework Convention on Climate Change (UNFCCC) was finally achieved in 1992 and ratified by 152 states. The primary aim of the framework is the stabilization of atmospheric greenhouse gas (GHG) concentrations at a level preventing dangerous changes in global climate. The time horizon within which the stabilization is to be achieved should be sufficiently in order to allow ecological systems to adopt to changes in global climate, to secure global food production and to allow for a continuous sustainable development.

The implementation is supervised by the Conference of the Parties (COP) which represents the highest body within the climate convention with most member states being part of the board.

The creation of the Subsidiary body for implementation (SBI) and the Subsidiary body for scientific and technical advise (SBSTA) was decided during the COP1 in 1995. The two bodies prepare resolutions for the COP. The SBSTA is advising the COP in terms of scientific and technical issues and prepares reports and studies in order to support the general decision making process of the COP. The SBI supports the implementation and in the following the supervision of resolutions made by the COP.

The climate convention constitutes the framework of international climate policy but leaves actual constitution and design of climate policy open. In December 1997 the

Kyoto Protocol was ratified in order to implement actual and legally binding policies on an international scale aiming on a reduction in GHG emissions following the year 2000.

During 2001 at the third member state convention an action plan and a detailed regulative framework (Marrakesh Accords) were established to implement goals agreed on in the Kyoto protocol. Additionally control and sanction mechanisms were established in order to ensure actual implementation by member states.
In February 2005 the Kyoto protocol came into force after 55 states representing more than 55 percent of worldwide carbon dioxide (CO_2) emissions in 1990 ratified the protocol. However some industrialized nations such as the United States and Australia denied ratification and therefore significantly reduced the scope and impact of the agreement.

In 2009 the COP15 meeting and the United Nations Climate Change Conference were held jointly in Copenhagen in order to define climate policy beyond the Kyoto protocol ending in 2012. The resulting Copenhagen Accord acknowledges climate change and sets the target to limit the increase in global temperature at 2° C. Additionally the accord pledges 30$ billion over the upcoming three year and additional 70$ billion until 2020 to developing countries to effectively deal with climate change. The initial proposal to cap global temperature increases compared to pre-industrialization levels at 1.5° C and to reduce global carbon dioxide (CO_2) emissions by 80 percent until 2050 were politically not feasible. Furthermore, no actual legally binding targets were set by the convention. The intention to create international public law in order to deal with climate change at international scope was therefore not achieved.

2.2 EU 20-20-20

The European Union decided on its environmental policy for the next decades by implementing political reforms aiming on limiting the increase in global temperature at

2° C above the historical pre-industrial temperature (CEC 2008).

The primary aims include a reduction in greenhouse gas (GHG) emissions by 20 percent compared to the baseline of 1990 by 2020. In order to achieve a European wide reduction, the Commission agreed on a set of policies aiming on a sustainable reduction in GHG emission. The primary tool covering about 50 percent of the total emissions cut is the Emission Trading Scheme (ETS). The general reach of the ETS includes now nearly all energy intensive industrial sectors within the European Union with a reduction target of 21 percent using 2005 as baseline scenario.

EU Emission Trading Scheme

The introduction of the ETS will have far reaching implications for European industrial competitiveness and general welfare. The primary idea of the ETS is the provision of a cost efficient and market based policy tool aiming on a general reduction in carbon dioxide (CO2) emissions. The possibility to create an active market using tradeable emission rights theoretically allows for an optimal and cost efficient way of reduction allocation among industries and individual companies. Nevertheless, the reach of the ETS is limited. Approximately 50 percent of the general reduction is the be achieved using non-ETS based policy tools which underlie individual legislation by EU member-states. The primary problem arising from such a division into energy intensive industries underlying the ETS and other industries subject to non-ETS polices are resulting losses in allocation efficiency.

Non-ETS policies

The implementation of the Emission Trading Scheme is restricted to a specific set of industries. The addition of energy intensive industries into the scheme enlarges the reach of the EU ETS to the majority of European industrial sectors. Nevertheless, certain sectors such as transportation (from 2013 onwards aviation will be included), agriculture or waste disposal are still excluded. Therefore, additional legislation on national level is necessary in order to achieve national requirements in terms of greenhouse gas (GHG) emission reductions. The implementation of non-ETS policies remains subject to legislation on member state level and implies a political choice determining the split of reduction requirements between ETS and non-ETS sectors. There is a variety of policy choices ranging from direct taxation to industry emission standard setting.

EU Renewable Energies

The importance of sustainable and secure energy provision is of high importance for European politics. The rise of public and political awareness with respect to the use renewable energy sources and resulting policies aiming on increasing the share of renewable energy is determined by strategical and environmental considerations. The European Union and (formally) all member states implemented legislation aiming on fostering alternative energy supply.
The initial shift in emphasis towards actual implementation of renewable energy policies occurred during the 1990s. Following the White Paper of 1997 (European Commission, 1997) which set targets for renewable energies at 12 percent by 2010, the new target rate of 20 percent implemented by the 202020 goals of the European Union is a major political step towards a more secure and environmental friendly energy provision. National policies increased the market share of renewable energy already in the past, depending on countries and natural characteristics enabling the implementation of certain alternative energies, e.g. Germany wind, biomass and photovoltaic, wind energy in Spain and Denmark or biomass in Sweden, Finland and Austria.

Comparing OCED and EU averages in production of renewable electricity, a general domination of hydro-power with a EU share of 26 percent is observable. Renewable heat generation is primarily based on biomass with a EU share of 22 percent. Also in terms of government expenditures on renewable energy research, the European Union lacks behind US and Japan. Within the European Union the largest share of funding is provided by the German government followed by Italy and in recent years the Netherlands. Nevertheless, there is are positive outlooks for the future of the renewable energy sector within the EU. Wind energy production increased by 40 percent between 1990 and 2000 with continuous growth thereafter. Today approximately 80 percent of OECD wide wind energy production is located within the EU with a worldwide market share in wind turbines of 90 percent (EWEA, 2004).

Other renewable energy sources give rise for concern. Especially in the area of photovoltaic where Japan still holds market leadership while the EU accounts for only 22 percent worldwide.

In order to achieve these ambitious goals while renewable energies face cost disadvantages on liberalized European Energy markets, a dichotomy of support models is used. Feed-in tariffs implemented on one side of the energy market while green certificates are used on the other side seems to be the most appropriate policy mix in order to meet political expectations (Ringel, 2005).

Taking Germany as the most successful example of policy implementation within the EU, different conclusive policy advises can be drawn. The success of German renewable energy policy can be primarily attributed to broad and long-term political support leading to substantial changes using feed-in tariffs as an incentive mechanism. Compared to the alternative of market based quota obligations favored by countries like the UK, Poland or Belgium, the primary advantage of feed-in tariffs is price security for energy suppliers as well as reduced uncertainty in terms of volume and market balancing costs. The implementation of a feed-in tariff system might therefore accelerate the introduction of renewable energies since investments in renewable energies are considerably less risky under the scheme.

The advantage of green quotas on the other hand are market induced competition and higher associated cost efficiency. Considering the rather limited empirical evidence due to short implementation periods, it might be too early to draw a final conclusion on the subject. Nevertheless, at the present state of empirical research the superiority of feed-in tariff systems seems a possibility (Mitchel et al., 2005).

Considering national responsibility for the implementation of legislation and the achievement of the EU goals in terms of green energy, it seems important to conduct further analysis in terms of policy efficiency.

EU Energy Consumption

Green energy production is one side of the strategy aiming on reducing negative impacts of economic activity on the environment. Nevertheless demand side management of energy consumption is of equal importance in order to achieve the ambitious goals set by the European Union (EU). The 202020 framework therefore includes the general aim to reduce European energy consumption by 20 percent by 2020.

Buildings account for about 40 percent of European energy consumption and generate 36 percent of total EU carbon dioxide (CO_2) emissions. Therefore, the Directive on Energy performance in buildings (2002/91/EU) was the basis for a new proposed Recast Directive as part of the 202020 legislation. The primary aim is to further increase energy efficiency requirements in buildings and a general streamlining of the system. The final implementation of the Directive is expected in 2010.

The total number of cold appliances within the European Union (EU-25) households is estimated to be in the range of 260 million. Estimations of data from 21 European countries provided by GfK state that about 18 million new cold appliances were sold in 2004 (Faberi, 2007). The energy requirements associated with cold appliances alone is estimated at 106 billion kWh annually - equivalent to the energy generation of ten nuclear power plants (Faberi, 2007). The replacement of old installations with new energy efficient A++ rated applications bears the possibility to reduce total energy consumption of cold appliances by 60 percent.
Considering the huge impact and saving potential of energy intensive installations, the European Parliament adopted a Directive defining a framework for Eco-design requirements. Generally it is estimated that about 80 percent of future environmental impacts are determined during the product design stage.

Legislation aiming on improved product design is therefore a useful tool to tackle energy consumption and climate change. The policy itself is applied coherently in all EU member states preventing possible impacts on intra-EU trade. Furthermore, no product specific, binding requirements are established but rather general standards are set with respect to relevant product characteristics (e.g. energy consumption). The use of such an implementation process allows for more rapid adjustment and improvement of applicable standards compared to product specific requirements (Directive 2005/32/EC).

2.3 EU Emission Trading Scheme

The importance of climate change is known to educated society and policy makers. Considering different legislative approaches to counter climate change, economic discussion favors the use of market based instruments leading to overall cost minimization within the scope of applicability.

The first initial proposal to implement a Emission Trading Scheme (ETS) in order to reduce greenhouse gas emissions within the European Union was made in 2001 as part of the European Climate Change Program (ECCP). The Emission Trading scheme which was adopted unanimously by the European Union in 2003 is therefore supposed to be a suited policy tool to implement change required by the commitment to the Kyoto protocol (Directive 2003/87/EC).

The Kyoto Protocol defines national emission targets in terms of greenhouse gas (GHG) emissions. In order to achieve required reductions countries can rely on a set of options. The introduction of the ETS will induce reductions by national companies according to sector specific abatement costs. The general cap-and-trade system therefore allows companies and industries with high abatement costs to transfer reduction requirements to other companies and industries facing lower abatement costs. The trans-European market for emission rights does not limit allocation efficiency to national states but minimizes costs across whole Europe. Generally the ETS covers initially the largest “point sources” of carbon dioxide (CO_2) emissions: power plants, glass and ceramics, iron and steel, pulp and paper, oil refining, cement manufacturing and all other industrial installations with a thermal capacity above 20MW (EC, 2007). In total more than 46 percent of European carbon dioxide (CO_2) emissions emitted by 11.500 installations were covered by the scheme.

Complementing the ETS and aiming on further reductions in costs associated with the reduction of emissions, investing parties are enabled to engage in greenhouse gas (GHG) reducing projects outside the European Union and transfer associated reductions to their national emission targets. The “project mechanism” is defined within the Kyoto framework and translated into European law by EU Directive in 2004. In total emission credits generated by the Clean Development Mechanism (CDM) and Joint Implementation (JI) projects were initially limited to 6 percent of total emission allowances.

The implementation of the ETS within Europe was divided into three phases in order to guarantee efficient implementation and reduce system wide problems associated with the introduction. The first period was the so called precursor period from 2005 to 2007. The intentions underlying an initial trial period are expected experience gains helping to improve the efficiency of the system, to develop required infrastructure such as efficient trading systems and to gain information about system inherent abatement costs. Furthermore, companies within the European Union were given the chance to achieve a smooth transition prior to the second trading phase.

After the trial period, a the second trading phase (2008-2012) follows during which companies under the ETS actively engage in greenhouse gas (GHG) reduction in order to meet Kyoto requirements. The third trading phase (2013-2020) goes beyond the commitments made during the Kyoto process and implement new ecological requirements to which the European Union committed in 2009.

In order to achieve compliance with targets set under the ETS, companies face penalties in case of non-compliance with their emission allowances. Fines per additional tone of carbon dioxide emission above allocated or purchased emission rights were set at 40€ per tonne during the first period and were increased to 100€ per tonne during the second trading period on top of the allowance short fall created by not purchasing allowances in the market. The instrument therefore makes total penalties variable and does not create incentives to willingly avoid purchases in the market in case the price of emission rights exceeds associated penalties of non-compliance which would effectively generate a cap for carbon emission prices.

The Allocation Process

The primary mechanism of the emission trading scheme was already presented. The resulting problem of allocation remains a contestable topic. Normally, an authorized authority has to be established in order to organize, supervise and accelerate allocation of permission certificates. Considering different options of initial allocation, the most efficient way of initial allocation remains to be discussed. The primary idea of efficient distribution of certificates by the market mechanism might be limited due to limited competition and market power within European industrial sectors. Allocation methods ranging from grandfathering to auctioning might therefore lead to different degrees of market efficiency.

In the case of the European Emission Trading Scheme (ETS) a decentralized allocation was implemented. Authorities on national level are responsible for setting emission caps and initial distribution of European Union Emission Allowances (EUA). The targets of the Kyoto protocol set general reduction requirements on European level. The burden-sharing agreement between European countries defines national targets in order to meet overall reduction requirements. The actual distribution and general amount of EUA remains on national level and implies a certain flexibility, since the emission market is subdivided into ETS and non-ETS sectors. It remains therefore open how reductions are achieved and how the burden is divided between ETS and non-ETS companies.

A National Allocation Plan (NAP) follows a two step procedure. The initial splitting of reduction targets between the ETS and non-ETS sector and the choice of procedure for the allocation process. The first issue raises questions regarding strategical considerations underlying the split between ETS and non-ETS sectors. The proposed NAP is thereafter analyzed in order to check for compliance with general requirements of transparency, compliance with general objectives of the ETS as well as competition law and regulations regarding state aid. After approval by the European Commission, the implementation of the NAP can follow.

From an implementation perspective further complexity is created. Next to the general centralized demand and decentralized supply mechanism, the introduction of national targets and general EU policy took place at different points in time. The setting of national caps was introduced with the initial trading phases while the overall reduction requirements for 202020 targets of the European Union were introduced after the initial trading phases. Additionally, the question about future enlargement remains open. The primary implementation of the ETS was limited to carbon dioxide emissions while commitments made during the Kyoto process require a general reduction in greenhouse gases (GHG).

The possibility of trading under ETS allows for changes in initial allocation rights between countries, national sectors and companies in order to maximize efficiency. Furthermore no restrictions were set with respect to the possibility to save emission rights for future years within the first and second trading period but transfers from the first to the second phase were prohibited to prevent possible negative spill-overs to following trading periods and the Kyoto protocol implementation. Therefore, also strategical considerations on company level are enabled inherent to the general market based allocation process. The borrowing of emission rights on the other hand is not allowed.

The Trial Period (2005-2007)

During the initial precursor period, countries retained the option to exclude certain industries from the scheme under the restraint to demonstrate equivalent efforts within the sector to reduce emissions.
The general idea of initial testing of the Emission Trading Scheme is the avoidance of possible problems within the Kyoto implementation period. The importance to meet Kyoto targets and the general expectation that the introduction of a complex multilayer

trading scheme will not go without transitional problems and inefficiencies, lead to the prior testing of the trading scheme between 2005 and 2007.

The first National Allocation Plans (NAP) were completed by the end of March 2004 as required by the Emission Trading Directive. In the following, the trial period started in January 2005. Nevertheless, due to short time to completion only 20 percent of all NAPs were submitted to the European Commission prior the set deadline.

The initial trial period was primarily for testing purposes. Furthermore, companies should receive the chance to generate knowledge about the working mechanism of the ETS as well as time to implement necessary improvements at acceptable cost. Therefore, 95 percent of all emission allowances were allocated for free. Following the start of the ETS in 2005, several exchanges in Europe started trading platforms in order to facilitate the exchange of emission rights.

The underlying idea of initiating change at slow pace created only implied reduction targets. Member states were supposed to set targets allowing a transition towards the reduction targets set under the Kyoto protocol for the years 2008 to 2012. Nevertheless, the non-binding character of the trial period lead to significant overallocation of emission rights. The publication of emission statistics in 2005 lead to initial drops in emission prices from 30€/tCO2 to 10€/tCO2 followed by further decreases in market price close to zero towards the end of 2006.

Furthermore the issue of windfall profits became an issue within the discussion of efficient allocation under the ETS. The term windfall profits describes the situation in which companies receiving initially free emission rights, pass on the price of allowances to consumers. Therefore, additional profits are created (Ellerman, Joskov, 2008). Primarily the energy sector was subject to such profit increases. Considering the market structure, it does not seem surprising to see overallocation problems primarily in concentrated sectors.

The Second Trading Phase (2008-2012)

After the initial trading phase the second trading phase from 2008-2012 started aiming on actual implementation of emission reductions required by the Kyoto protocol. The primary intention was to reduce greenhouse gas (GHG) emissions within EU-15 by 8 percent using 1990 emissions as benchmark. New members of the European Union also implemented emission reduction plans outside the EU-15 targets on national level.

The initial allocation process during phase II lead to a variety of problems. National Allocations Plans submitted during 2006, implied an effective increase of carbon dioxide (CO2) emissions by 5 percent compared to 2005 emissions. Additionally the expected inflow of emission rights due to Clean Development Mechanism (CDM) would practically remove any intra-European market for emission rights. The resulting ruling of the European Commission (EC) declared the majority of NAPs to be in violation with the EU ETS Direction. The recommendation made by the EC implied an aggregate reduction of CO2 emission by 5 percent compared to 2005 emission figures based on a numerical equation system ultimately aiming on limiting aggregated NAPs to proposed EU-wide reduction targets. Additionally changes with respect to the “banking” of emission rights applied for phase II. Therefore, companies were enabled to effectively forward emission rights into the third phase of ETS. The underlying intention was to stabilize prices due to an increased validity of allocated emission rights.

The intervention by the European Commission as well as the introduction of more solid calculations underlying the NAP allocations resulted in a general increase in market stability. Increased uncertainty with respect to supply and demand changes even after the initial allocations made by NAPs changed prices originally close to zero to a steady trend. Additionally a higher coherency between national reduction and allocation plans and commitments on European level was achieved. The possibility to effectively check for insufficient reduction targets within NAPs and implied comparison between achievable reductions on EU level with commitments made under Kyoto created a more stable and efficient policy tool.

Considering problems within the energy sector prior the second trading phase, difficulties remained in the second trading phase with respect to closure and new entrance incentives. The problem associated with installation closure lies in the influencing ETS regulation which effectively recovers any emission allowances made for the particular installation after its closure. Therefore, incentives are implemented keeping old and inefficient installations in operation at levels required to keep emission allowances. The regulations made are therefore not in line with the aim of improving average efficiency of installations by the introduction of new technology but rather create an artificial incentive to keep old and inefficient installations running. The second problem relates to the allocation of emission rights to new market entries. The underlying reasoning is the possibility for companies using limited emission allowances as an effective barrier to market entrance. The free allocation of emission rights is therefore designed to counterbalance the effect of market power. Nevertheless, it artificially protects new entrances to the market from emission prices by allocation free pollution rights. The incentive for introducing new and more efficient technology to the sector is therefore further limited.

Post-Kyoto Trading Period (2013-2020)

The outcome of the Kyoto process is a first step towards a ecological sustainable economy. Nevertheless, the limited duration of the Kyoto commitments makes additional legislation necessary in order to continue the already ongoing process over the next decades.

The United Nations Climate Conference of Copenhagen and the associated COP15 meeting in 2010 allowed for such an ongoing commitment. However, the outcome of the conference is limited. The initial targets proposed in the Bali road map to implement new environmental commitments binding by international law did not find necessary political support. Additionally, the aim to reduce global carbon dioxide (CO_2) emissions by 2050 was not realized. The primary achievements of the conference is the agreement to limit global warming to 2° C. Still it remains unclear how to achieve the target limit and how further limitations of greenhouse gas (GHG) emissions can be achieved.

The Copenhagen Accord – representing the final document of the climate convention – can nevertheless be ratified by participating countries leading to a general commitment to reduce emission and the aim of limiting global warming to 2° C.

Economic Impact of EU Climate Policy

(Böhringer, Rutherford, Tol, 2009) analyzed the impact of a divided market for emission rights using comparative-static computable general equilibrium (CGE) models - DART, PART and GEMINI-E3 - under different implementation scenarios. The simulations provide rather conclusive results about efficiency losses. The general expected loss in welfare using the most cost efficient allocation being a single emission trading market ranges between 0.5 and 2.0 percent. Taking second-best policy scenarios into account, the resulting changes show a significant reduction in welfare due to allocation inefficiencies resulting form a market division for emission rights. The division into ETS and non-ETS based measures is expected to increase costs by additional 50 percent. Taking a further subdivision of the emission rights market on national basis, costs increases are estimated at additional 40 percent with a total increase in costs due to inefficient policy implementation between 100 and 125 percent.

Overall estimations of cost increases depend on the underlying model deployed in analysis as well as general baseline projections. Additionally to carbon reductions, EU policy includes a variety of additional aims such changes in energy mix. The associated effects are further increasing costs associated with European climate policy (Böhringer, Löschel, Moslener, Rutherford, 2009). The model (PACE) outcome suggests a significant increase in costs associated with a market division for emission rights. Next to the general costs associated with the introduction of emission rights, green quotas hide additional costs to society. The aim to increase the share of renewable energies will have a negative effect on prices for emission rights due to an enforced substitution towards carbon dioxide neutral energy sources (solar, wind, biomass). From a system wide perspective the estimated increase in costs due to renewable energy standards are considered to be modest. The underlying reason is a relatively small gap between ETS induced changes in energy production and the applicable changes in energy mix by EU policy.

Taking the separation as given, the resulting question leads to how allocation efficiency can be increased under the restriction of a two tear market structure for emission rights. Additionally international carbon rights transactions are possible leading to further complications in assessment of efficiency associated with the introduction of ETS.

Due to the possibility to use international carbon credits (IEC), governments face a situation in which policy optimization is no longer possible. The separation of some sectors from the emission trading scheme (ETS) results in differences for emission prices between sectors and reduced system-wide efficiency. Taking the possibility of international emission purchases into account, only a joint maximization of NAPs and IECs can lead to an optimal solution which is an rather unlikely outcome in reality (Peterson, 2006).

The primary goal of national policy should therefore be the equalization of international carbon prices with the burden induced to non-ETS sectors. A possible solution suggested to the problem is the introduction of a uniform emission tax in non-ETS sectors set accordingly to international carbon prices (Böhringer, 2005). The problem resulting uncertainty of international carbon prices and emissions caused by non-ETS sectors. An efficient implementation of a uniform tax seems therefore not possible. Additionally the interdependence of international carbon price and IEC purchases is not considered. A simultaneous optimization remains therefore required in order to achieve maximal policy efficiency unless carbon prices remain unaffected by European IEC transactions.

Strategic Partitioning under ETS

The implementation of a hybrid emission control policy within the European Union with non-ETS based policies on national level allows for the possibility of strategic behavior with respect to emission allowance allocation. The split of general emission reduction targets between industries underlying ETS and industrial sectors outside the scheme gives rises the problem of emission allowance allocation between the two

pillars. Generally, the possibility of strategic behavior anticipating the resulting effects on trading and non-trading national sectors is given. Depending on single action or strategic behavior by all member-states, different results can be found (Böhringer, Rosendahl, 2008). In the case of strategic partitioning by all member states only small losses in efficiency are to be expected compared to a cost-efficient allocation method. Assuming a rather cost efficient national allocation plan (NAP) in combination with strategic partitioning by countries having some impact on emission price, it can be shown that significant benefits may arise. Nevertheless, most of the associated benefits are attributable to an alignment of the countries marginal abatement costs within the trading and non-trading sector rather than resulting changes in the value of emission rights itself.
Next to the European case, international effects are to be taken into account. The interaction between the EU, US and other countries initiating a carbon trading scheme similar to the EU-ETS might lead to different conclusions regarding strategic partitioning. The primary concern and possible subject of further research on the topic are therefore effects resulting on international rather intra-European level.

Allocation and Distribution Effects

The impact of regional climate policy within an internationally linked system are of highly complex nature. Impact assessment should therefore not only consider intra-regional effects but also consider transregional shifts and diversions.

Taking different reduction scenarios for developed and developing countries into account, significant changes in world market prices (CIF) and resulting changes in trade patterns are to be expected (Keppler, Springer, 2003). Using dynamic applied regional trade (DART) computable general equilibrium (CGE) models to analyze different impacts resulting from regional flexibility in emission allocation predicts that significant reductions in welfare loss are achievable due to emission trading. Additionally to general efficiency considerations of a emission trading scheme, distributive effects will result leading to different welfare effects on national level (Kepper, 2001).

Intensity Targets as Possible Alternative

Emission target are of considerable importance in the discussion of emission trading schemes. The primary problems associated with expected impacts of emission allowances are different underlying projections about baseline scenarios. Differences in economic growth are therefore likely to affect the resulting outcome. The use of intensity targets as an alternative to absolute reduction targets is of increasing interest - especially in the case of developing countries - due to a reduction in uncertainty about future economic costs. The underlying assumptions are nevertheless arguable (Peterson, 2006). Considering general uncertainty about sector and company specific abatement costs, the introduction of intensity target will reduce uncertainty only in case of high correlation between emissions and gross domestic product (GDP). Additionally volatility in GDP and intensity allowances is required to be below emission volatility. A final conclusion about a possible alternative to absolute emission targets using flexible intensity targets requires additional research (Peterson, 2006). Nevertheless, especially in terms of highly dynamic business sectors the implementation of environmental policies should incorporate associated effects due to increased uncertainty.

2.4 Transport Sectors

The first image that comes into mind talking about climate change and greenhouse gas (GHG) emissions is transportation. Cities like Shanghai covered in smock putting human society and environment to the test.
The initial image most people have is not far from reality. Transportation, both commercial and private, take up approximately 20 percent of global energy supply.

Associated with such an tremendous consumption the problem of fuel comes into play.

Close to 80 percent of all energy consumed in the sector is sourced from fossil fuels. The associated emissions in greenhouse gases (GHG) of a single ton petrol fuel attributes to the equivalent of 3.760kg carbon dioxide. Considering that the world transport fleet already consists of over 700 million vehicles and is supposed to reach a billion within the next decades, the importance of the transport sector in fighting climate change becomes obvious.

Taking a look at modal shares within the broad defined transport sector, road transportation attributes for about 80percent of total transport induced climate change. The impact of aviation is considerably small compared road transportation accounting only for 13 percent. Sea transportation with 7 percent and rail transport with 0.5 percent follow in line. The comparison should not lead to the conclusion that regulation of non-road transport modes is of lower importance considering the overall huge impact of transportation on climate change.

The troubling situation of regulators face in terms of transport regulation sources in the huge impact of transportation on today's business environment. The essential infrastructure and operating systems enabling modern work division and international trade while fostering economic growth and development is a rather sensitive topic. Additionally modal related industry characteristics such as global character and problems associated with achieving an effective regulatory grip on the industry cause further difficulties.

Road Transport

Road transportation is one of the major sources of greenhouse gas (GHG) emission within the European Union. The number of globaly operated vehicles is suppose to tripple by 2050. Considering that already today more than 700 million cars are in use worldwide, the dimension of change becomes clear.

Counterbalancing to the general increase might be technological advancement leading to cleaner engines and generally lower relative emissions induced by transport. Nevertheless the net effect remains strongly negative partially due attributable to the fact about 90 percent of total increase in global road transport fleet will be in non-OECD countries and therefore subject to lower environmental standards. The Intergovernmental Panel on Climate Change (IPCC) advised the fuel economy to improve by 50 percent in order to tackle general increases in transport activity. In line with the recommendations of IPCC and G8, the United Nations Energy Panel (UNEP) initiated efforts to double the fuel economy.

Increasing efforts to stop further increases in European wide emissions associated with road transport seems therefore essential to the proposed aims of the European Climate inititative. Considering the gap between estimated increases in greenhouse gases by the Intergovernmental Panel on Climate Change (IPCC, 2007) and oberserved increases is of considerable size (Garnaut, 2008) rapid actions seems important to an sucessful implementation of EU 202020 goals. The nature of general transportation differs from other highly pollution industries to the extend that other political tools in terms of demand management aside general GHG taxation are feasible. Considering a general taxation of emissions included in fuel taxes seems to be a second best policy (Stanley, Hensher, Loader, 2009) compared to alternative charging systems including external effects of road transportation. A policy set aiming on GHG reduction should therefore include other political problems associated with the transport sector in general (congestion, noise, road maintainance, a.o.) in order to provide an appropriate and sustainable policy mix which can not be achieved by a single tax on emissions. Associated costs to the transport sector will exceed the effects of emission taxation but will result in considerable benefits to improvements to the transport sectors as a whole (Stanley, Hensher, Loader, 2009).

Considering political debate about the topic, different opinions are to be considered. The general possibility to include road transportation into the EU ETS seems still a possible scenario in order to reduce GHG emissions by road transportation. Especially the consideration of forecasted future increases in European road useage and implied increases in GHG emission might encourage political actions ultimately leading to an inclusion of road transportation.

Considering the actual feasibility of implementation, participants in the transport sector follow the topic carefully. The International Transport Forum (ITF) discussed in 2008 possible ways for carbon dioxide (CO_2) reduction in the industry. The general position presented at the Forum by the Transport Economics Labaratory (University of Leon, France) favoured tradeable emission rights over alterntive ways of regulation in case of a shift in EU policy focus from vehicle manufactures towards road users (Raux, 2008).

The general suggestion of includion of emission permit costs directly into haulage aggreements is considered to be a possible way to minimize associated costs while maximizing incentives for transport companies to lower emission implementing more efficient routing and utilization. An alternative solution suggested by a member of the Centre for Economic Studies (Catholic University of Leuven, Belgium) is a general reduction in fuel taxes in combination with the implementation of alternative taxation determined by vehicle type and kilometers travelled. Generally the discussion within the industry about possible ways of effective GHG emission reduction in combination with efficient implementation methods is ongoing.

Rail Transportation

Compared to other modes of transportation rail transport is rather environmental friendly. Nevertheless, strong dependance on utilization rate and fuel mix set conditional requirements to that conclusion. A possible example is Switzerland where trains are operated on an energy mix consisting of hydro- and nuclear energy or Norway where over 95% of energy consumed by rail transportation is covered by hydroelectric energy.
Taking a look at emission figures, trains perform rather well. In order to ship one tonne of cargo within Europe will cause emissions of 2.3kg of carbon dioxide equivalent compared to 330kg using short haul plane carriage (<5000km), 209kg on medium haul (5000-8000km) and 117kg on long distance transport (>8000km) . The relative efficiency of rail transportation compared to aviation therefore strongly depends on travel

distance.

Considering the market for personal transportation rail faces strong competition by aviation. From a network perspective, Europe operates one or the most advances network system in the world. Nevertheless, low cost carriers (LCC) as competitors while facing negative impacts due to schedule and connection unreliability and delays shift consumer choice towards aviation as the preferred mode of transportation. In order to counter such problems, seven European Rail operators created Railteam - an association providing integrated high speed passenger transportation within European borders in order to increase market share of rail transportation momentarily between 7 and 10 percent. Additionally, the European Rail sector represented by the Community of European Railway and Infrastructure Companies (CER) further committed to further emission reductions by 30 percent between 1990 and 2020 (CER,2008). Nevertheless, the time frame associated with the commitment was not chosen by accident. Considering that reductions of over 21 percent were already achieved between 1990 and 2005, leaving a rather small reduction left in order to meet self-declared requirements.

Considering the high efficiency of rail transportation in terms of environmental friendliness, policy makers focus in shifting transport movements from road to rail. The political reasoning of such polices can not only be found in environment considerations but also from general transport considerations (road grid, congestion, etc). Taking a look at national policy implementations of the European White paper (White Paper, 2001, EC), Sweden shows huge success in implementation.

Between 2002 and 2007 passenger growth of 16 percent were achieved compared to the EU15 average of 9 percent (ETIF, 2009, EC). In the freight segment increases of 21 percent were realized during the period while growth for EU15 only accounted for 17 percent. The rail modal share in 2007 increased in the passenger segment by 9 percent compared to the EU15 average of 7 percent. The modal share of rail transport in the freight segment increased by 36 percent in Sweden and 15 percent in the EU15. Generally, the example shows that a policy mix of low access charges and increases in public infrastructure investments shows clear improvements for the competitiveness of the rail sector (CER, 2010) ultimately supporting environmental goals of the European Union.

Alternatively to the Swedish policy mix, the case of the German White paper implementation shows an alternative. Public investments remained stable during the implementation period while actual debt of DB was reduced. Nevertheless, passenger and freight growth rates were measured at 12 and respectively 41 percent between 2002 and 2007. Furthermore the modal share of rail increased by 8 percent in the passenger and 22 percent in the freight segment. A possible explanation might be the introduction of the LWK Maut (road usage fee) counterbalancing comparatively high access charges in the German railway sector.

Generally, the rail sector show potential to contribute to a solution of emission problems. Strategic consideration additionally support political support for initiatives implementing market opening, infrastructure provision and associated regulation in order to increase modal shares of rail transportation being the most emission efficient transport sector.

Air Transportation

The aviation industry is one of the major emitters of greenhouse gases (GHG) and as subject to increased attention by policy makers and interested society. Total emissions attributable to commercial aircrafts departing or arriving at European airports accout on average for about 218 million tons CO2 annually between 2004-2006 (Reuters, 2008). The Intergovernmental Panel on Climate Change (IPCC) estimated that total contribution to climate change of aviation expressed in radiative forcing (RF) accounts for 3.5 percent including non-carbon dioxide (CO2) emissions. The underlying problems are ozone generation due to nitrogen oxide emissions and contraides both accelerating global warming. Including effects of contrails the estimated impact on global warming increases to 4.9 percent (Lee et al., 2009). The increase underlines the importance of non-CO2 emissions as major contributor to global warming and the necessity to extend the regulative body in order to include non-CO2 emissions in emission schemes. Primary difficulty is the lack of scientific research on the topic creating barriers for effective regulation of non-CO2 emissions on international level.

Next to the subsector broadly defined as cargo transportation, personal transportation causes major concern. Alone between 1990 and 2003 miles-flown by passangers increased by over 80 percent. Considering that an economy class flight alone accounts for 220kg carbon dioxide (CO_2) emission (business class 510kg, first class 770kg), the impact of increasing commuting on international scale is a primary concern with respect to efforts trying to limit climate change. Estimated increases in emission rangend from 340 million tons CO_2 by 2015 to 400 million tons annually by 2020. The declaired aim of EU climate policy is therefore a reduction of about 182 million tons CO_2 annually by 2020 (Commission of the European Union, 2006A,7).

The inclusion of the aviation sector into the emission trading scheme (ETS) is therefore a first step in order to reduce air transport related emissions. One of the primary characteristics describing the aviation industry is its global reach. Policies aiming on regulating the sector in order to increase emission efficiency should ideally take place on a global level in order to minimize distortions. The primary authority trying to achieve a globaly accepted regulatory body for the aviation industry is the International Civic Aviation Organization (ICAO) - a specibody of the United Nations (UN) including 188 member states. Depending on the stakeholdergroup, different policy preferences can be observed. Next to the now induced inclusion in the ETS, technological innovation as a source of emission reduction is prefered by most participants in the airline industry (Staniland, 2009).

Primary problems associated with the inclusion of the aviation sector in ETS arises from two facts: aircrafts being a mobile not a stationary source of pollution and the generally global character of the industry itself.

During the initiation period, airlines will receive at the start of consecutive five-year periods a contingent of emission rights (AAUs). Based on annual emission, the operating company will therefore "surrender" a specific amount of AAUs.

The implementation of ETS raises a variety of additional issues associated with its implemenation. The definition of an accountable entity was put at the level of aircraft operators. Alternatively, the use of airports and aircrafts constructors was discussed during the policy design stage. The term airline operators reflects on the fact that changes in definition leads to changes in the reach of EU policy. The documentation of the UK department for transport defines 52 European airlines and 35 non-EU airlines which would become subject to ETS. Using the definition of aircraft operators the EU Commission released a list of 2.700 companies attributable to ETS. The primary difference in numbers is derived by inclusion of non-passanger-carrying airlines. The subject clearly shows the importance of clearly defined accountable units and associated documentation.

The inclusion of aviation in the emission tradin scheme (ETS) is of considerable importance not only in terms of environmental impact but also in terms of resulting economic impact. The introduction takes place on an intra-EU level and charges initially only carbon dioxide ($CO2$) emissions resulting from flights taking place within the European Union. The resulting impacts a specific form of carbon taxation on the aviation sectors depends strongly on initial allocation method and underlying business model (Morrell, 2007). Generally a greater impact on LCC can be found. Using a baseline or grandfathering approach in distributing emission allowances, the resulting negative effects for LCCs are considerably higher compared to conventional network carriers. The underlying reason can be found in the possibility for internal cross-subsidization between short, intra-EU flights and long haul connections outside the reach of the EU emission scheme. The competitive position of European network carriers compared to their non-EU counterparts is worsening in all scenarios due to general increases in operating costs induced by any form of emission reduction scheme. Considering the possible intorduction by auctioning, different results can be found. Estimations differ in underlying assumptions regarding the land-take-off (LTO) cycle leading to different results - ranging from most beneficial (CE Delft, 2005, study) to most costly option (Morrell, 2007).

Maritime Transportation

The use of maritime transport equipment includes commercial, military and recreational activities. The primary use is nontheless of commercial nature and therefore primary focus of legislative efforts to reduce global greenhouse gas (GHG) emissions. Greenhouse gas emssions attributeable to the maritime transport sector accounted for 651 million metric tonnes carbon dioxide (CO_2) equivalent of emissions in 2005. Emissions from international bunkers increased by 54 percent between 1990 and 2005 leading to total emissions of 551.6 million metric tonnes of CO_2 equivaltent in 2005 (1990: 357.9; PEW Center on Global Climate Change, 2009). The total increase in greenhouse gas emissions worldwide during the same period accounted only for 24 percent. Total increase in emissions attributeable to the use of fossile fuels increased by 29 percent.

Comparing the figures two trends become oberservable. First, increases in emssions within maritime transportation are more than twice as high compared to overall increases. Secondly, emissions of international bunkers increased more rapidly than overall emissions by fossil fuel combustion.
The comparision underlines the importance of the maritime sector for efficient internalization of external effects causing climate change. Especially the sharp increase in emissions give rise to conserns and attracts increasing attention by policy makers. The fact that according to estimations maritime shipping only accounts for less than 2 percent of global greenhouse gas emissions (IEA, 2008a) should therefore not deflect attention from the general trend of increasing emission within the sector and the necesity for further regulatory efforts to caputure maritime emissions within global environmental framworks.
Furthermore, emission statistics provided by various sources and often used for argumentation are highly suspective. Primary problem underlying the assesment process are different reporting systems and unreliable estimation methods of emissions in non-OECD countries. Emission figures of maritime transportation are therefore highly questionable and the possibility that actual emissions exceed official statistics by far is given (PEW Center on Global Climate Change, 2009). The use of bottum up approaches to estimate actual emission cause by maritime transportation is increasing (Corbert, Koehler, 2003; Corbert, Koehler, 2004; IMO, 2008). The approach estimates fuel consumption using the global merchant fleet, operation time, power requirements and implied fuel requirements in order to conduct more reliable estimations. Both

approaches imply uncertainties with respect to data integrety and measurement methods (Endresen, Sørgård et al. 2004). The most recent assessment presented by the International Maritime Organization (IMO) using a bottum-up approach to estimate global fuel consumptions estimates carbon dioxide emissions of the sector to be 50 percent higher than IEA statistics (IMO, 2008). Total emissions by the transport sector might therefore account for 3 percent of global carbon dioxide (CO_2) emissions.

Next to the emission of carbon dioxide (CO_2) other types of emission impact radiative forcing (RF) and climate change (Endresen, Sørgårdet al. 2003; IPCC 1999; Schäfer, Heywood et al. 2009). The impact of non-CO_2 emissions such as methane (CH_4), sulfure oxides (SO_x), nitrogen oxides (NO_x),
nitrous oxide (N_2O), particulate matter (PM) and hydrocarbones (HC) are not only a function of general fuel combustion but include altitude, fuel quality, engine operation conditions and humidity as determinants. The overall effect of these emissions depends on the geographic location of occurance and might either have warming (positive RF) or cooling (negative RF) effects.

Similar to contrailes caused by aviation, ship trails are created by bunker combustion in ship engines (Durkee, Noone et al. 2000; Lauer, Eyring et al. 2007). Despite the fact that the underlying physics are not completely understood, it seems proven that the emission of sulphate and black carbon lead to cloud formation at the maritime boundary layer. Due to low elevation, negative radiative forcing is resulting (Endresen, Sørgård et al. 2003). The overall effect of emissions and contrails is therefore of high uncertainty and additional research is ongoing to improve understanding of the subject (Brasseur 2008; Endresen, Sørgård et al. 2003).

Demand for maritime transport services is determined primarily by international economic growth, increasing globalization of production, sourcing and distribution networks and associated international trade (UN, 2008).
The largest share of increase is attributeable to developing regions within Asia leading to increasing export flows of manufacturing products and imports of oil products, grain and raw materials necessary for production (UN, 2008). Trade flows primarily take place between developing countries and the industrialized world.

Nontheless, intra-regional trade is increasing steadily. In 2007 trade flows between Asia, the US and Europe accounted for 81 percent of international exports and 94 percent of international imports measured in shipped tonnage. The share of Asia is slighly above 50 percent and represents therefore more volume than Europe and US aggregate. Trends in international trade are observable as well. Between 2000 and 2007 economic growth lead to an average export growth of 5.5 percent annually, exceeding increases in world GDP by more than a factor of two (WTO, 2008). The primary share of international trade flows continuous to be transported by maritime shipping. The total share of maritime transportation in international transport flows was about 80 percent during the period from 2000 to 2007 (UN, 2008).

Future demand for maritime logistics services under business-as-usual (BAU) projections is expected to grow steadily with annual growth rates of 2.1 to 3.3 percent annually until 2050. Total transport demand until 2050 is therefore expected to increase by 150 to 300 percent (EIA, 2009; IMO, 2008). Associated grrenhouse gas (GHG) emissions over the period will therefore grow by 120 to 220 percent by 2050 asuming BAU (EIA, 2009; FAA 2009; IEA, 2008b; IMO, 2008). The difference in growths rates reflects general projections about increases in fuel efficiency.

The feasibility as well as associated effects of a maritime emission trading scheme was subject of a recent study by CE Delft (CE Delft, 2010). The outcome of the study suggest that the inclusion of maritime transportation within an ETS system is feasible. The inherent requirments are the creating of effective monitoring and allocation systems. Considering the fact that the largest part of the world merchant fleet is owned by industrialized nations while registered in non-developed flag states, the location of responsibility on shipowner level associated with onboard measurement of emissions might be a possible way of implementation. Required supervision and revision of compliance with emission allowances can be governed by an international authority cooperating with international flag states to ensure actual enforcement. Estimated increases in operating costs of an emission trading scheme assuming full actioning and an estimated allowance price in the range of 15USD/tCO2 are between 4 to 8 percent depending on vessel type, fuel price and ship size. High fuel prices of 500US$/t might therefore reduce the increase in operating costs to a fraction of 3 to 7 percent (CE

Delft, 2010).

Considering that developed countries own more than 60 percent of the world merchant fleet [in deadweight tonnage (dwt)] in addition to the fact ca. 67 percent of global imports [in monetary terms] is conducted between developed nations, the largest share of ETS related costs will be beared by industrialized nations. The total share of maritime transportation on total import value ranges from less than 10 percent in develped and 5 to 15 percent in non-developed countries. Due to the fact that these figures include costs such as port handling costs which are not affected by an introduction an ETS system, total increases in import value is estimated to be below 2 percent.

Negative externatilities of an emission scheme on developing countries might be counterbalanced by reallocation of revenues earned by the autioning of emission allowances. Assuming a allowance price between 15 and 30 US$/tCO2, total revenues of the emission scheme account for 15 to 30 billion US$ annually (CE Delft, 2010).

3. Methodology

Applied General Equilibrium (AGE) model are of increasing importance in analysing economic policies. The underlying reason is the ability to include interdependencies between economic agents, sectors and global economies providing are more realistic presentation of economic activity.

In order to analyse the impact of an inclusion of maritime transportation under the emission trading scheme the analysis uses the global trade analysis project (GTAP) model - a computable general equilibrium (CGE) model. Alternatively, a partial equilibrium solution could be used for analysis. However, a partial equilibrium solution to the research question is inconclusive. Considering the broad use of transportation as an input for production and distribution of goods, a partial equilibrium solution is not able to cover all effects associated with a possible inclusion of maritime transportation. The use of a CGE based approach allows to take broader macro economic changes and welfare effects into account. Furthermore, a detailed analysis of associated changes can be conducted based on obtained results.

3.1 GTAP model

The model is a multi-regional Applied General Equilibrium (AGE) model which differentiates between 57 industrial sectors of 112 regions (GTAP, Version 7). The underlying theory of the model is similar to other AGE models. Generally, one can make a broad distinction between two types of equations: The first part includes accounting relationships which balance receipts and expenditures of conomic agents within the economy. The second part can be described as a set of behavioural relationships that specify optimization behaviour of economic agents as described by micro-economic theory (e.g. Demand function).

In order to draw information required for solving the model, the GTAP Database (Version 7) is used. Depending on model specifications, the database is able to provide that information using GTAPAgg (a specific aggregation program used to prepair data for the solver).

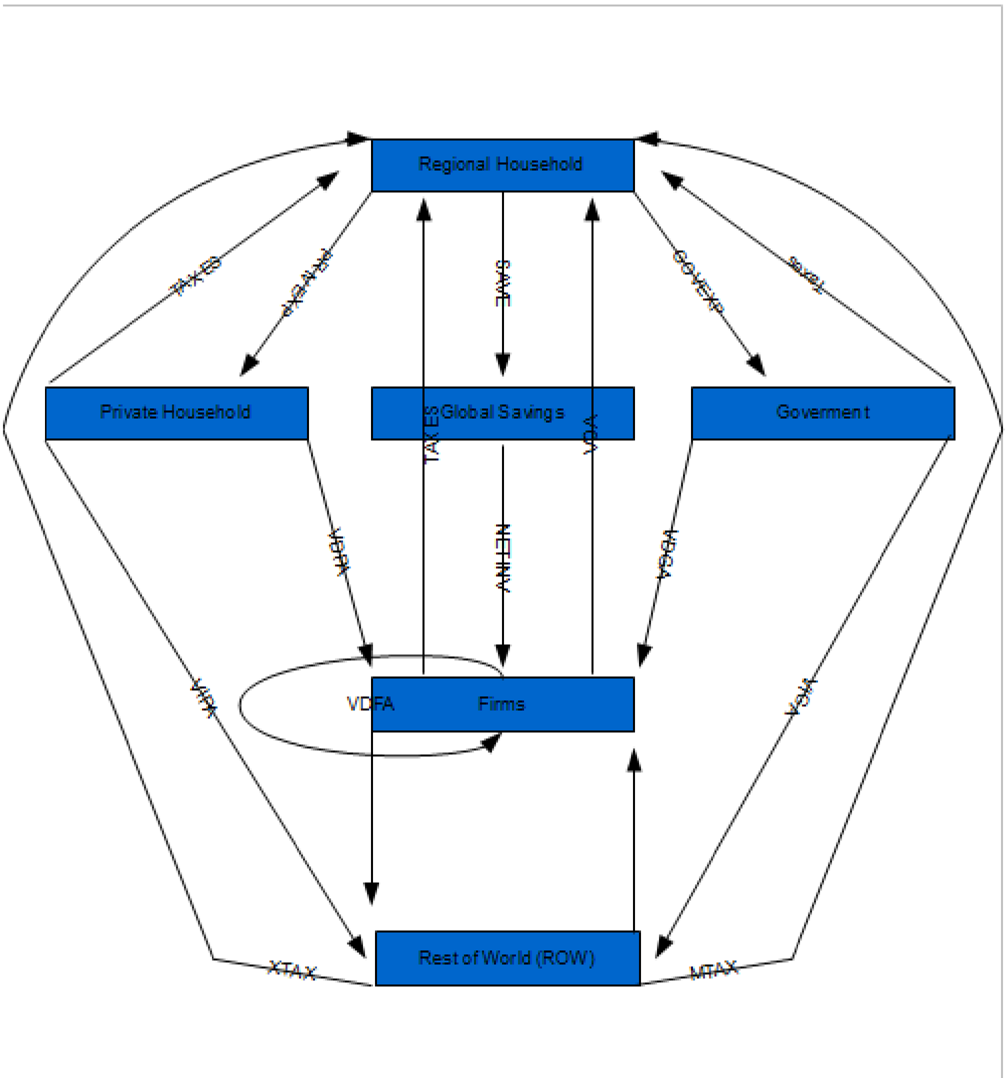

Figure1: GTAP Model

Regional Household

The model starts by defining a regional household for each country or region which collects the entire income generated by the regions economic activity. The primary benefit of the use of a regional household is the resulting limitation of agent spending to received income. Furthermore, it allows for a direct policy evaluation in terms of welfare effects. Based on a Cobb-Douglas utility function the income is thereafter distributed over three types of final demand: Savings (SAVE), private household expenditures (PRIVEXP) and government expenditures (GOVEXP). Based on that standard closure, the split of final demand remains approximately constant. Slight variations are caused by the non-homothetic private consumption function.
Changes in regional income are therefore inforcing changes in regional final consumption in an equiproportional way. Nevertheless, alternative specifications can be used in order to fix any component of final demand due to a shift in preferences. A certain level of activity can therefore be fixed making the associated parameter of preference variable in the model (McDougal, 2001).

Private Household and Government

Private Household demand can be differentiated between value of domestic private household purchases at agent prices (VDPA) and value of imported private household purchases at agent prices (VIPA). Similar to the case of households government expenditures can be differentiated between value of domestic goverment purchases at agent prices (VDGA) and value of imported goverment purchases at agent prices (VIGA). The model uses conditional demand equations for imported commodities. Imported and domestically produced commodities are therefore nested. The elasticity of substitution between imports and domestic goods in the nested function is assumed to be equal for all uses. The optimization of private consumption is achieved by a constant difference of elasticities (CDE) function. Alternatively the use of fully flexible functional forms or CES/LES functions is possible. The use of a CDE function isnt as general as the fully flexible from but more flexible than the CES/LES option. Furthermore, it can be easily calibrated based on income data and demand elasticities (Hertel, et.al, 1991). In the case of government expenditures the model deploys a Cobb Douglas sub-utility function implying constant expenditure shares across commodities.

Firms

Firm contribute to regional income with the value of output at agent price (VOA) which represents the compensation for the use of endowment commodities by the firm. Endowment commodities are land, capital and labour which are defined as non-tradable goods in the model. Intermediate inputs clearly define the linkages between different industries within the economy. The use of intermediate inputs is defined by the variable value of domestic firm purchases at agent prices (VDFA).

The use of a nested production function is included in the model using the assumption of constant return to scale (CRS). In terms of technology the model assumes weak seperability between intermediate inputs and endowment commodities. Under the assumption of profit maximization, firm will therefore define an optimal composition of primary factors independently of intermediate input prices. As a result the elasticity of substitution between different primary inputs as well as between different intermediate products is equal. Further simplification is achieved by aggregating primary factors and combining intermediate inputs under constant elasticity of substitution. The resulting total number of substitution parameters is therefore reduced to two per sector.

Additionally a linkage between domestic production and non-domestic demand (exports) is represented by the variable VXMD. Imported intermediate inputs are represented by VIFA. In order to avoid problems arising from total specialization in production, the model implements the Armington assumption which allows for intra-industry trade. Products are therefore differentiable between origion and no perfect substitutes. Therefore an additional nest is implemented in the production tree in order to combine domestic and international inputs. Again the assumption of similar elasticity of substitution for all uses is implemented. In a first step the firm will therefore determine the optimal source of intermediate imports. In the following step the derived composite import price is used to derive the optimal composition of domestic inputs and imports.

Government Intervention

Government intervention is simplified denoted as taxes. Opposed to other value flows, taxes are not met by and opposed directed flow of goods and services. In the model tax value flows are transfered from private households, government and firms to the regional household account. Government tax value flow are representing consumption taxes levied on government consumption. In the case of private household the tax value flow represents consumption as well as income taxes net of subsidies received to be paid to the regional household account. The tax flow from firms to the regional household account represent taxes on intermediate inputs - both domestic and imported - and production taxes net of subsidies received.
In order to derive the level of taxation, the model compares the transaction value in market and agent prices. A possible difference between the two represents a tax or subsidy. The approach therefore does not take individual taxes or subsidies into account nor their ultimate use but instead defines taxes as a policy tool leading to a difference in agent and market prices. In order to derive the agent price, the market price is multiplied with the power of the respective ad valorem tax. Based on demand and supply elasticities for a specific market, changes in market and agent price

result.

On the demand side the power of the ad valorem tax is defined as TPD = VDPA/VDPM. In the absense of government intervention market and agent price are equal and the power of the tax is equal to one. In case a tax is imposed on the product in question, the resulting agent price will be higher than the market price leading to TPD>1. In the of subsidies the resulting agent price will be lower than the market price leading to TPD<1. It follows that total tax revenues DPTAX = VDPA - VDPM.

On the supply side a tax is defined as value of output at market price divided by the value of output at agent price TO = VOM/VOA. In case of a production tax the agents price is now lower than the market price leading to a to<1 while a subsidy results in to>1. The overall tax revenue is defined as PTAX = VOM - VOA.

Further tax value flows to the regional household account are import taxes denoted as MTAX and export taxes XTAX. Differently to domestic taxes the tax or subsidy power is defined by the ratio of market to world prices.

In the absense of taxes and subsidies the domestic price PM and the FOB price (PFOB) are equal. The power of an export tax TXS (i,r,s) is defined as the value of exports of commodity i from region r to region s valued at exporters domestic market by destination price [VXDM (i,r,s)] divided by the value of exports of commodity i from region r to region s valued at world price by destination [VSWS (i,r,s]. In the case of export taxes TXS is smaller than one. The reverse holds in case of an export subsidy. Total export tax revenues are defined as XTAX = VXWD - VXMD.
Alternatively, in the case of import taxes or subsidies domestic and CIF price are no longer equal. The power of an import tax TMS (i,r,s) is calculated by dividing the value of imports of commodity i from region r to region s valued at market price by source [VIMS (i,s,r)] divided by the value of imports of commodity i from region r to region s valued at world price by source [VIWS (i,s,r)].
In the case of import taxes TMS is larger than one. The reverse holds in case of an export subsidy. Total import tax revenues are defined as MTAX = VIMS - VIWS.

Savings

The demand for investments within the model is savings-driven. Due to the static nature of the model, the installation of current investments is not implemented and therefore does not affect production capabilities of industries in a region. Nevertheless, demand for investment goods will impact industrial activity due to a change in the production structure. The composition of capital goods for investment purposes is defined similar to the case of intermediate input demand previously described. Accounting for the multi-regional character of the model, savings and investments are calculated on an international basis. Therefore, the price for the saving commodity equals between regions. Generally global savings and global investments must equal in order to fulfill equilibrium requirements and Walras' law.

Considering that all accounting relationships are defined in a simultaneous system of equations, a single identity can be droped. In the case of the GTAP model the savings-investment relationship is excluded. An additional calculation of the saving-investment identity therefore allows a consistency check for the model. By definition the model can be solved for N-1 prices while one price is defined exogenious making the remaining prices relative to the numeraire. In the first versions of the GTAP model the price for savings was used as the respective numeraire while newer versions use the average return to primary factors.

3.2 Data Aggregation

In order to provide a clearer pricture and to avoid unnecessary information, GTAP allows for data aggregation among industry sectors and regions. The total amount of regions and industries considered in the model was reduced to have a stronger focus on the research question.

Regions

The regional aggregation resulted in the following regional aggregation:

- EU27
- OECDAsia
- NAFTA
- China
- Least Developed Countries (LDC)
- Rest of World (ROW)

The categorization is based on key characteristics and regional economic integration. Countries are therefore either grouped according to their economic and political ties (e.g. EU and Nafta) or general economic characteristics (e.g. developing countries). This allows a general interpretation in terms of welfare effects for specified regions in the model.

Industries

In GTAP it is possible to select up to 58 sectors from agriculture to manufacturing and services. Because our research focuses on the possible inclusion of the maritime and aviation sector in the ETS, we have chosen for the following sectors:

Agriculture, Forestry and Fishing (aggregated), ETS Sectors (all sectors initially already entering ETS), other goods, fossil energy (coal, gas, oil), maritime transportation, air transportation, other transportation, construction, and all service sectors (aggregated).

The service sectors are not very interesting in terms of GHG emissions, but it is interesting to see what happens with the ETS sectors, maritime transportation, air transportation and other transportation when ETS is slowly increasing its sectoral coverage.

The aggregation of industries is follows methodological considerations. The differenciation between ETS and non-ETS sectors is of importance in order to model the EU ETS. Furthermore the differenciation between different transport sectors is required in order to seperate effects and to allow for sector specific policy implementations.

3.3 Model Assumptions

Considering the complexity of the EU Emission Trading Scheme a variety of simplification are made in order to generate a clear yet suited model. In reality the emission scheme aims at the reduction of a set of greenhouse gases emitted. Modeling each emission would require an enlarged database containing not only information about emissions per source of fossile energy but also a differenciated industry emisson data. The use of a differentiated view therefore seems too complex for the analysis. Instead the model assumes a fixed composition of emission accross the set of energy sources used. A general reduction of fossile energy sources will therefore fulfill the requirements made by the EU ETS.

The creation of a emission market facilitating trade and allocation of emission rights is a difficult task within the modeling process. Therefore some simplifications are made in order to model the emission trading scheme. The primary difference between an emission trading scheme and a broad set carbon tax lies in the ability of overall cost reductions associated with a more efficient allocation of emission rights leading to the minimization of total abatement costs. The use of a tax to mimic the ETS scheme has therefore the flaw of overestimating associated abatement costs. In order to compensate for that two possible solutions are given: an increase in energy efficiency or a reduction of emission targets. Both options provide a way to account for the less cost efficient allocation. The model used incorporates the loss in allocative efficiency reducing the admission targets in order to close the gap.

The modeling process therefore swaps the tax on fossile energy sources and the output quantity making the later one endogenous. This allows for a reduction of fossil fuel in the model which will lead to the required reduction in emission. In order to account for energy efficiency gains either due to technological progress or due to the non-included substitutability of capital and energy, the model includes an ETS sector specific efficiency gain for the use of fossile fuel.

3.4 Model Scenarios

The first step of simulating a policy experiment is the creation of a baseline scenario for the year 2020 based on which a comparision with different scenarios can be established. Therefore the base data set of the model has to be altered accordingly in order to simulate economic development up to the year 2020. Generally different assumptions are to be made in order to generate the update base data which will thereafter be the basis for comparision. In order to model economic development changes in terms of productivity and capital accumulations are made based on forecast data provided by the OECD. In a second step the EU ETS system is introduced based on the previously described implementation and its underlying assumptions. The baseline scenario will be used in order to compare the economic implications of different policy scenarios. We apply the standard CGE closing conditions to close the model and generate likely outcomes relevant for policy makers.

Scenario A: Basic ETS

The first scenario represents the expected economic changes resulting from the implementation of the European Emissions Trading Scheme. The scenario is of importance because it draws attention to the effects caused by introducing the ETS in a large amount of sectors in the economy. Furthermore, it serves as a scenario to which the following scenarios will be compared, for example scenarios C and D where we include maritime transportation.

Scenario B: Inclusion of air transportation under the EU ETS

The inclusion of the aviation sector under the EU emission trading scheme was concluded in September

2005. The first policy scenario will therefore include the aviation sector under the ETS. The usefulness of a separate inclusion of the aviation sector roots in a better comparison of inter-modal shifts caused by the introduction of the maritime sector – especially modal shifts in general equilibrium. This is also important from the perspective of resulting policy recommendations. Considering the ongoing discussion about differences between the two industries a more differentiated analysis gives additional insights into economic consequences in terms of welfare effects, trade effects and impact on industry segments.

Scenario C and Scenario D: Inclusion of maritime and air transportation under the EU ETS

The third and forth scenario include additionally maritime transportation under the EU ETS. The primary aspect of these scenarios is to determine overall welfare effects of doing so. Compared to partial equilibrium analysis variations such as changes in terms of trade and income effects will be incorporated. The primary assumptions inherent to the scenario is the required reduction in emissions by the sector. Scenario C assumes a tax that yields a 5 percent reduction in emissions caused by maritime transportation while Scenario D is based on a more stringent tax yielding a 10 percent reduction. Based on the uncertainty associated with the implementation of European wide allocation plans, a differentiation between scenario C and D is made in order to compare differences in overall reduction requirements.

4. Results and Analysis

In this section, we will present the results of our model runs based on the four scenarios explained in the previous chapter. We present the macro results of the analysis for the respective scenarios. The primary output of the model selected and presented in this section are changes in: real income per region, terms of trade, regional imports, regional exports, real factor income unskilled labour and real factor income skilled labour. In the second part of this section sector specific results are presented in order to analyse sector specific shifts as a result of the respective policy scenario.

4.1 Macro-economic Results and Analysis

	Scenario A: Introduction EU ETS	Scenario B: Inclusion Aviation	Scenario C: Inclusion Aviation and Maritime (5%)	Scenario D: Inclusion Aviation and Maritime (10%)
Real Income (% change)				
European Union(EU27)	-3.15	-3.09	-3.04	-4.09
OECDAsia	0.2	0.2	0.2	0.19
NAFTA	-0.01	-0.02	-0.03	-0.01
China	-0.06	-0.06	-0.07	-0.06
Least Developed Countries (LDC)	0.29	0.28	0.33	0.28
Rest of World (ROW)	-0.8	-0.8	-0.83	-0.77
Terms of Trade (% change)				
European Union(EU27)	3.11	3.08	2.9	2.9
OECDAsia	-2.45	-2.41	-3.05	-2.24
NAFTA	-1.34	-1.29	-1.35	-1.25
China	-3.6	-3.53	-4.32	-3.33
Least Developed Countries (LDC)	5.37	5.32	6.45	5.28
Rest of World (ROW)	-0.39	-0.43	0.15	-0.43

	Scenario A: Introduction EU ETS	Scenario B: Inclusion Aviation	Scenario C: Inclusion Aviation and Maritime (5%)	Scenario D: Inclusion Aviation and Maritime (10%)
Regional Imports (% change)				
European Union(EU27)	-14.75	-14.73	-17.07	-9.56
OECDAsia	8.49	8.47	9	8.17
NAFTA	0.34	0.38	0.16	0.65
China	4.96	5.01	4.7	5.38
Least Developed Countries (LDC)	5.01	4.9	5.59	5.13
Rest of World (ROW)	-3.1	-3.15	-3.12	-2.83
Regional Exports (% change)				
European Union(EU27)	-17.34	-17.3	-19.45	-12.09
OECDAsia	10.49	10.43	11.65	9.9
NAFTA	2.96	2.94	2.8	3.34
China	8.41	8.37	8.95	8.49
Least Developed Countries (LDC)	0.03	-0.04	-0.43	0.25
Rest of World (ROW)	-2.99	-3	-3.55	-2.72
Real Wage Skilled Labour (% change)				
European Union(EU27)	-18.32	-18.26	-15.93	-24.67
OECDAsia	-1.63	-1.6	-2.07	-1.47
NAFTA	-2.92	-2.87	-3.36	-2.79
China	-7.22	-7.09	-8.74	-6.85
Least Developed Countries (LDC)	0.37	0.32	0.56	0.19
Rest of World (ROW)	-13.32	-13.26	-14.16	-13.21
Real Wage Unskilled Labour (% change)				
European Union(EU27)	-19.5	-19.44	-16.9	-26.09
OECDAsia	-1.71	-1.68	-2.15	-1.55
NAFTA	-2.92	-2.87	-3.14	-2.75
China	-6.52	-6.4	-7.99	-6.04
Least Developed Countries (LDC)	-0.77	-0.79	-0.81	-0.76
Rest of World (ROW)	-13.64	-13.57	-14.67	-13.37

Scenario A: Introduction of the EU ETS

The introduction of the European Emission Trading Scheme has a negative impact on European real GDP. The introduction of the scheme with its current specifications in terms of industry selection under Scenario A leads to an overall reduction in EU27 real income by 3.15 percent. The finding is in line with other CGE based analyses generally estimating a reduction in real GDP between 3 and 5 percent.
Negative effects in terms of real GDP can be found for Nafta, China and Rest of World (ROW), but only to a very limited extent. All other regions specified – OECDAsia, and LDC - experience positive changes in real GDP. A major effect of introducing the ETS is the increase in prices due to a simulated tax on energy prices. This is a global effect. So even though the value of GDP goes up in nominal terms, or almost not down at all for the EU (-0.3 percent), in real terms production is affected globally. LDC are not negatively affected because they do not produce many energy-intensive products (relatively), while prices go up. China will see an increase in nominal GDP, but inside the country a reallocation from services sectors to energy-intensive manufacturing sectors as they shift out of the EU. This internal re-allocation of resources has a small net negative real income effect, combined with a deterioration in the Chinese terms of trade; i.e. Chinese exports buy them less imports after introduction of the ETS in the EU. This picture is further confirmed by looking at imports and exports. For China, imports increase as relative purchasing power will increase. Nonetheless, exports increase faster, creating a larger surplus on the Chinese trade balance than before. Exports go up because of reallocation of some energy-intensive industries away from the EU to China, making China even more the workshop of the world than it already was before introduction of the ETS. EU imports drop because EU products get more expensive and disposable incomes of EU citizens fall – the price consumers pay for a cleaner economy (assuming ETS works and does not suffer too much from carbon leakage effects). EU exports decrease significantly due to a loss of competitiveness of EU industry vis-a-vis the same industries in other regions of the world (e.g. China, OECDAsia). With rising global prices as a consequence of introducing the ETS, real wages globally drop (with the exception of LDC, where wages show a marginal increase in real terms). Nominal wages are expected to rise or at least not to too much, but due to faster rising price levels, purchasing power in most global regions is eroded and internationalisation of carbon emissions will lead to losses in real incomes. This effect is expected for both skilled and unskilled labour.

Scenario B: Including aviation in ETS

The expansion of the ETS to include aviation in the year 2012 will increase air transportation costs, because the social costs of carbon emissions on flights are being internalised in the price. This will lead to an increase in the cost price for air travel, both for passengers and cargo. For the economy as a whole, the inclusion of aviation into the ETS is only a minor change, notwithstanding the fact that the sector is of an enabling character for many other sectors. The small increase in transport costs into and out of the EU (not in other regions) works as a small transport cost margin for the EU economy (where most trade comes from and goes to), thus reducing the estimated negative effect by 0.06 percentage points to a total loss in real income of 3.09 percent. Compared to Scenario A similar effects on other regions can be found, though they remain well within the error margins of the model. Total trade is increasing minimally due to higher transport costs. LDC exports are affected negatively by the small increase in transport costs, since they depend relatively more on air transportation to reach the large EU consumer markets. ROW exports and imports do not change, combined with drops in exports from OECDAsia, China and NAFTA, this suggests that trade becomes a little more regional because of higher aviation costs; i.e. the EU will trade relatively more with countries like Russia, Ukraine, Iceland, Morocco and Egypt, rather than China, the US, Brazil or South Korea. Wage effects for skilled and unskilled workers are minimal, though tend to be positive. This may be due to the fact that as a consequence of higher transport costs, companies try to compensate by increasing productivity which leads – in turn – to very small wage increases (compared to scenario A).

Scenarios C and D: Including aviation and maritime transport in ETS

When adding the maritime transport sector to the ETS, in addition to the aviation sector, again only small economy-wide effects can be observed when taxing the sectors so emissions are reduced by 5 percent (scenario C). Again, adding the sector to ETS leads to a small increase in real GDP compared to the previous scenario (not compared to a situation without ETS). For the EU's main trade partners, the US (in NAFTA) and China, additional transport costs lead to lower real GDP levels, and less trade with the EU. Exports of NAFTA drop, while exports from China increase, albeit not with the EU, but with other regions, notably OECDAsia and NAFTA. In scenario D the impact is reversed and real GDP for the EU decreases further than in scenario A. With an increase in GDP at 5 percent, and a decrease in GDP at 10 percent, It seems therefore that an optimal level of emission reduction can be found for the maritime transport sector, somewhere between the 5 and 10 percent reduction of greenhouse gas emissions through direct energy taxes.EU terms of trade still improve albeit less in scenarios C and D. The values of imports and exports do not change much in scenario C, but they do go up significantly in value terms (nominal terms) in scenario D – which is mainly due to further increases in the price levels that are passed on from transporting companies to consumers. This further increases the costs of living, and reduces disposable income levels, having a negative effect on real wages (much stronger in scenario D than in scenario C) in the EU. EU consumers take a larger share of the burden in scenario D in terms of real wage loss, also compared to other regions in the world, where the negative effects of ETS are partially shifted back to the EU.

4.2 Secondary Results and Analysis

	Scenario A: Introduction EU ETS	Scenario B: Inclusion Aviation	Scenario C: Inclusion Aviation and Maritime (5%)	Scenario D: Inclusion Aviation and Maritime (10%)
Sectoral Output Aviation (% change)				
European Union(EU27)	-17.28	-6.08	-5.55	-7.6
OECDAsia	9.73	2.95	3.87	2.59
NAFTA	2.6	-0.33	-0.43	-0.28
China	7.86	1.38	1.89	1.07
Least Developed Countries (LDC)	3.63	-3.41	-3.74	-3.26
Rest of World (ROW)	1.19	-4.83	-5.52	-4.4
Sectoral Output Maritime (% change)				
European Union(EU27)	-6.86	-6.98	-5.19	-9.88
OECDAsia	3.58	3.61	3.02	5.79
NAFTA	2.86	2.9	2.13	4.58
China	2.06	2.08	1.6	3.27
Least Developed Countries (LDC)	1.63	1.67	1.31	2.63
Rest of World (ROW)	-1.89	-1.78	-3.68	0.85
Sectoral Output Other Transport (% change)				
European Union(EU27)	-7.59	-7.33	-5.89	-10.16
OECDAsia	0.88	0.73	0.61	1.05
NAFTA	0.38	0.35	-0.25	1.13
China	2.72	2.71	2.43	3.69
Least Developed Countries (LDC)	1.31	1.33	1.11	1.98
Rest of World (ROW)	-1.69	-1.72	-2.45	-0.79
Sectoral Output ETS Sectors (% change)				
European Union(EU27)	-32.95	-32.95	-32.95	-33.02
OECDAsia	15.29	15.28	16.35	14.61
NAFTA	7.45	7.41	7.22	7.76
China	7.5	7.5	7.4	7.84
Least Developed Countries (LDC)	15.49	15.48	15.72	15.64
Rest of World (ROW)	10.24	10.26	10.06	10.18

	Scenario A: Introduction EU ETS	Scenario B: Inclusion Aviation	Scenario C: Inclusion Aviation and Maritime (5%)	Scenario D: Inclusion Aviation and Maritime (10%)
Sectoral Output Agriculture (% change)				
European Union(EU27)	0.22	0.12	0.09	0.4
OECDAsia	-2.09	-2.03	-2.07	-2.09
NAFTA	-1.95	-1.91	-2.02	-1.99
China	0	0	0.08	-0.01
Least Developed Countries (LDC)	-0.94	-0.9	-1	-0.88
Rest of World (ROW)	-0.15	-0.13	-0.24	-0.1
Sectoral Output Construction (% change)				
European Union(EU27)	-1.56	-1.54	-1.38	-2.36
OECDAsia	-0.13	-0.12	-0.3	-0.03
NAFTA	-0.87	-0.87	-0.87	-1
China	-3.65	-3.57	-4.39	-3.36
Least Developed Countries (LDC)	-0.37	-0.38	-0.27	-0.44
Rest of World (ROW)	-1.54	-1.57	-1.46	-1.48
Sectoral Output Services (% change)				
European Union(EU27)	3.88	3.88	3.25	4.85
OECDAsia	-0.55	-0.55	-0.6	-0.59
NAFTA	-0.18	-0.17	-0.06	-0.29
China	-1.65	-1.63	-1.54	-1.95
Least Developed Countries (LDC)	-0.02	0.01	0.29	-0.26
Rest of World (ROW)	0.35	0.36	0.7	0.07
Sectoral Output Other Goods (% change)				
European Union(EU27)	-0.79	-1.07	0.73	-3.61
OECDAsia	-2.45	-2.27	-2.28	-2.09
NAFTA	-0.28	-0.19	-0.73	0.36
China	0.2	0.21	0.19	0.33
Least Developed Countries (LDC)	-3.5	-3.27	-4.72	-2.26
Rest of World (ROW)	-5.25	-5.05	-7.2	-3.62

Sectoral Output Fossilefuels(% change)				
European Union(EU27)	0.44	0.43	0.42	0.54
OECDAsia	0.15	0.14	0.18	0.14
NAFTA	0.2	0.19	0.23	0.19
China	0.15	0.15	0.18	0.15
Least Developed Countries (LDC)	0.12	0.12	0.14	0.12
Rest of World (ROW)	0.2	0.2	0.22	0.19

In addition to the macro-economic effects, we also looked at sector-specific results. We have calculated output effects, trade flows, and wage effects. For the purpose of this analysis, we focus on the output effects at sectoral level, following the same four scenarios as identified in chapter 3. The results of sector-specific outputs following our policy experiments, are presented in the tables.

From this Table, we can infer some important conclusions. We will focus on three main points only, not to diverge attention away from the purpose of this research.

First, when we look at the ETS sectors, we see that – as expected - inclusion of the energy-intensive industries in the ETS leads to a significant reduction in output in the range of 32-33 percent (scenario A). This is a major blow for sectors like glass, ceramics, and steel – but in fact for the entire EU manufacturing base. As a consequence trade flows will shrink significantly, which leads to significant reductions in output of the maritime transport sector, the aviation sector and the other transport sector (i.e. rail and road), even though these are not included in the ETS. This is typically a general equilibrium effect. Another general equilibrium effect is the fact that service sectors benefit from the introduction of ETS, because with resources shifiting out of the energy-intensive manufacturing sectors, both capital and labour become available for the services sectors that will therefore expand. Wage changes tell us that this effect is mainly a push effect; i.e. people are being shed in the manufacturing sectors that get hit by the EU ETS and have to look for new jobs, finding them in the service sectors.
When we look at the international consequences, we see that the trading partners of the EU benefit from introducing the ETS, since many firms will relocate outside the EU, shifting production – and thus reflfected in increases in outputs – in OECDAsia, China, NAFTA, etc.

Second, let’s take a much closer look at the different transport sectors. We have split them out on purpose to distinguish between the four modes of transport: air, water, road and rail. Road and rail transport are combined into ‘other transport’. When we introduce the aviation sector into the ETS (scenario B), we see two main effects. First of all, the aviation sector benefits from inclusion into ETS, while aviation sectors elsewhere lose out. This can be explained by the fact that if ETS is already in place, inclusion of aviation in ETS with a system where any destination or source of flight in the EU is liable to an ETS tax, not only EU carriers but all carriers flying into or out of the EU are hit. This therefore affects other regions in the world negatively, whereas before, the ETS would only tackle EU ‘domestic’ industries. The aviation sector, in essence, spreads the costs of ETS beyond the EU border. The second effect is an (expected) intermodal shift. If aviation becomes a more expensive mode of transport we would expect to see a reduction in output for the aviation sector to the benefit of the other modes of transport. Indeed, we see that compared to scenario A, maritime transport and rail and road (í.e. ‘other’) transport grow.

When we also introduce the maritime sector into the ETS (scenario C), we find that the EU maritime sector benefits. Though this may seem strange at first, again the global nature of the sector combined with the specific way the EU ETS will be introduced can explain this result: all vessels destined for or leaving from an EU port will be subject to EU ETS, thus having to pay the carbon tax, irrespective of the nationality. This implies that, unlike a manufacturing sector like glass that is located in the EU making only the EU glass sector subject to ETS, the maritime sector puts part of the ETS burden on the EU’s trading partners. Indeed, we see OECDAsia, NAFTA and China ‘pay’when we look at the output of the maritime sectors in those regions. Again, we see an intermodal shift with output increases for the aviation and other transport sectors. It is interesting to note that the growth in rail and road transport is much larger when the maritime sector joins the EU ETS than when the aviation sector joined.

Finally, taxing the maritime and aviation sectors twice as heavy as in scenario C, with a 10 percent energy tax as simulated in scenario D, we see the output results worsen drastically, This increase will hit the two sectors disproportionally hard, also in comparison to other ETS sectors, which results in significant reductions in output for both sectors in the EU. But whereas the maritime sector and other transport sector in other regions in the world benefit from this, benefits do not accrue to the other aviation sectors. Apparently the degree of integration of the aviation sector is so deep, and income effect so strong, that a decrease in output in one area (read: the EU) immediately drags down results in other regions of the world – an effect that is outweighed by the substitution effect and less integrated systems for the other modes of transport.

Deeper cuts in GHG emissions in the two transport sectors (scenario D) lead to reductions in output in all manufacturing related sectors, while the agricultural sector is rather unaffected and the service sector clearly benefits. Apparently, for the agricultural sector, the increase in transport costs is roughly equally offset by more capital and labour becoming available, while for the service sector the latter efffect seems to dominate.

4.3 Policy Recommendation

Taking a look at the analysis provided, it seems to be established that the inclusion of both the aviation and maritime transportation sectors under the ETS are able to mitigate negative effects associated with its introduction, at least with emission target reductions of 5 percent. The primary findings also clearly indicate a positive relationship between emission reduction targets and the resulting economic impact on the European economy after the ETS has been introduced. Introducing the ETS has strong negative impacts on GDP levels and growth, which is in line with other research done (Ecorys, 2009). From a macro-economic perspective, it therefore seems in the European interest to push for an ongoing debate ultimately leading to an inclusion of maritime transportation under the EU ETS.

Turning to sector specific results, the picture that emerges is adding very interesting insights. First of all, based on our results, we would recommend the European Commission to include both the aviation and maritime sectors into the EU ETS. This will lead to relative gains for the sectors compared to not being in the EU ETS while the system is anyhow being introduced (optimal for the transport sectors would be if ETS were not introduced at all!). Heavily taxing them (10 percent instead of 5) is not recommended based on our results, as this will significantly reduce output of the transport sectors, other ETS sectors, other goods sector and – as seen in our macro-economic analysis – of the EU economy as a whole.

From a policy perspective, the fact that introducing EU ETS may lead to reallocation of EU industries to outside the EU boundaries (e.g. to China) – a perspective, especially attractive for energy-intensive industries, which may lead to a phenomenon called carbon leakage, is worth investigating in more detail. If significant carbon leakage takes place, the EU ETS may actually be the cause for an increase in global GHG emissions, rather than the intended decrease.

What is also interesting from a policy perspective is that ‘playing with inclusion or not’of maritime and aviation sectors, the intermodal shares of air, sea, road and rail transport are affected. EU ETS could assist in optimising the intermodal balance from the perspective of GHG emissions, reducing the share of road transport (most polluting), in favour of some of the others. Inclusion of the maritime and aviation sectors into the EU ETS may – from this perspective – not be an optimal idea.

Turning to the global picture, the possibility of multilateral enlargements of the ETS to include the US or some OECDAsian countries (China is not likely to join), might be considered to be an option. The high negative impact to some regional economies might lead to considerations about future international enlargements as an alternative to the inclusion of maritime transportation. Considering negative economic impacts associated with the limitation of carbon emissions, the political willingness for implementation is limited in some regions. Nevertheless, the outcome of this study indicates that unilateral solutions by the European Union might come at higher costs compared to a multilateral enlargement and also affect other global regions in the world negatively, whether they join or not.

5. Conclusion

The importance of global transportation is undeniable. Economic activity, growth and development and transport service provision are interdependent and mutually reinforcing. The topic is therefore of high sensitivity for both policy makers and general stakeholders. The high importance of reducing global emissions in order to tackle climate change put the transport sector into focus. Considering its significant energy consumption and emissions, a stronger focus on sustainable transport activity is required. The inclusion of aviation under the European Emission Trading Scheme is therefore a first step in order to realign economic interests and environmental reality. The maritime sector not only has the potential to contribute to that goal but also the responsibility to account for its emissions and the resulting damage to nature and society. An inclusion of maritime transportation under the European Emission Trading Scheme might therefore be a possible solution to the problem. The research question that has guided this research is linked to this and states: “What macro-economic results and shifts in output are to be expected due to an enlargement of the European Emission Trading Scheme (EU ETS) by maritime transportation following the inclusion of aviation, and what policy recommendation follow from it?”

Macro-economic findings

The costs of the European Emission Trading Scheme are significant. Nevertheless, the inclusion of transport activities under the ETS leads to significant improvements of the initially negative effect. Especially the case of maritime transportation has the potential to reduce initially negative effects caused by the ETS. Taking a look at real income, a 5 percent reduction in maritime emissions increases EU real income by 0.06 percentage points. Further tightening of emission targets is expected to generate significant negative effects, suggesting that between 5 and 10 percent emission reductions is an optimal policy for the EU to pursue. Generally, this research seems to confirm that inclusion of the aviation and maritime sectors into the EU ETS aligns economic activity with ecological care and efforts to develop a long-term sustainable future for the EU and the world.

Sector-specific findings

From a sectoral perspective, we reach some interesting insights. First of all, introducing ETS is going to hurt the EU economy and the energy intensive industries in particular. In fact, because it hurts the EU manufacturing base, it seems to leave the agricultural sector largely unaffected, and even benefits the EU services sectors. Wage effects tell us that this is a difficult process where jobs are shed in the manufacturing sector and employees have to search for new jobs, finding them in services. Internationally, other regions in the world benefit from the EU ETS system in terms of economic growth and output growth. For the transport sectors the inclusion in the EU ETS leads to inter-modal shifts – increasing the use of those sectors that are not being included into the system. Essentially, inclusion of air and maritime transport leads to increases in the use of road and rail – whether this is optimal from a GHG emission point of view remains to be seen. Inclusion of the aviation and maritime sectors benefits the sectors and EU economy as a whole, because they both internationalize the costs of the EU system, placing some costs with the trade partners, instead of with the EU alone. Heavy taxation of the sectors leads to significant welfare losses, both for the sectors, as for the EU economy as a whole.

Policy recommendations

Introducing the EU ETS has a strong negative impact on EU economic growth, output, and real wages. Including the aviation and maritime sectors has positive welfare effects for the EU economy as a whole as well as for the sectors in question, and therefore, from a macro-economic perspective, ultimately the two transport sectors could be brought under the wings of the EU ETS. Taxing the sectors more heavily (e.g. by 10 percent) leads to significant losses in welfare and output and is not recommended. The EU would need to look into the phenomenon of carbon leakage carefully before implementing the enlargement of the ETS in order to avoid the system having a net negative effect on global GHG emissions due to the fact that energy intensive industries move from the EU to – for example – China, where environmental regulations are not so strict and GHG emissions much less limited. The EU could also contemplate an environmental import tax to keep out products that have been produced in an environmentally unfriendly way. This simple idea is – as yet – marred with practical problems. Finally, in order to redistribute the effects differently, the EU might want to engage in active multilateral talks to broaden its system. Though some trade partners might not be too thrilled, this research shows that the negative economic effects for the EU do carry over to others, reducing the economic benefits to see the EU go this road alone. Whether it tips the Nash equilibrium into multilateral mode remains to be seen, but a negotiation and policy opening is provided by this research.

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