Including Aviation in the European Union Emissions Trading Scheme: a CGE Study

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April 12, 2008

Abstract

This paper presents an analysis of different policy proposals for the regulation of CO_2 emissions from aviation in the European Union in the context of Phase II of the EU ETS. The possibility to extend the current EU ETS to aviation is considered under three different caps, namely a low, a medium and a high cap. The policies are analyzed in the framework of a Computable General Equilibrium (CGE) model. The ETS scenarios are compared with a base case in which the ETS is not extended to any other sector, and an alternative scenario in which a tax on emissions from aviation is imposed. Because of the rigidity of the air transport industry, the economic effects are similar under the policy scenarios. The results suggest that the inclusion of aviation is only efficient in reducing further emissions if a low cap is chosen.

JEL Classification: C68, D58, L91, Q51

Keywords : Computable General Equilibrium, Emission Trading, Air transport

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1 Introduction

The European Union Emissions Trading Scheme (henceforth, EU ETS) is an EU-wide system for the trade of greenhouse gases emission permits. The EU ETS started in January 2005 [1] and was run for an initial 3-year period (2005-2008), which served as a preparatory phase before the start of the Kyoto Protocol in January 2008. This initial period is referred to as Phase I. Assessments of ETS Phase I underline that the generous emission caps and the consequent lack of scarcity of emissions lead to a low trading prices and a scarce success of the program. To answer these problems, in Phase II (2008-2012) emission ceilings have been reduced for all participating countries. Furthermore, the EU has proposed to include a higher number of sectors, namely chemicals and air transport. While the inclusion of the chemical sectors should start in a later period, aviation should be included starting from the end of Phase II in 2011.

EU emissions from international aviation increased by almost 87% in the period from 1990 to 2004. This shows that significant improvements in aircraft technology and operational efficiency has not been enough to neutralize the effect of increased traffic. At this pace, increasing emissions from aviation risk to offset the reductions achieved in the other sectors. In order to limit emissions from aviation the European Commission has proposed to include the sector within the EU ETS [2]. The proposal would only include emissions from domestic flights, and not international flights, as from the discussions arisen at the International Civil Aviation Organization (ICAO) in September 2007 an international agreement on aviation seems far from happening.

Details on the inclusion of aviation in the EU ETS are still missing, and it is still unclear what the required reduction will be. This is however a key point, as a high emission ceiling may lead once again to lack of scarcity of emissions. In the case of a high emission ceiling, the risk is not only to achieve low emission reductions within the emission sector, but also in the other sectors that will be able to buy emission permits from the aviation sector. In this case, a tax on emissions from aviation may be more efficient.

This paper proposes an assessment the proposal to regulate emissions from the aviation sector by considering both a tax and the extension of the EU ETS to aviation under different ceilings. This is done with the use of an EU-wide Computable General Equilibrium Model (CGE). The use of a CGE model allows to combine economic accounts for a range of industries across different geographic regions within the Arrow-Debreu equilibrium framework of interacting markets. This results in a complete and theoretically consistent simulation which captures the full spectrum of economic feedback effects in response to an emission limit. Although the use of a CGE model does not allow to study strategic interactions between industries and, in the specific case of aviation, the choices that each airline company may take, it permits to investigate how the economy can adjust to the imposition of emission limits. Thus, it is possible to check whether including aviation in the EU ETS will lead to consistent emissions reductions within the aviation sector, or in other more elastic sectors.

The paper is organized as follows. Section 2 presents a more precise policy overview and the policy proposals that will be considered. Section 3 explains the model that will be used to simulate the policies. Section 4 illustrates the results from simulations. Section 5 concludes.

[1] Following Directive 2003/87/EC, which entered into force on 25 October 2003

[2] COM/2006/0818 final - COD 2006/0304: Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to include aviation activities in the scheme for greenhouse gas emission allowance trading within the Community {SEC(2006) 1684} {SEC(2006) 1685}

2 Policy Overview

The EU ETS started with Phase I, which later from 2005 to the end of 2007. This first phase was designed as a kick-off trial period to give a chance to the European companies to become confident with emission trading. The emission ceilings for all countries were relatively high and not all EU-25 countries were included, as some only recently entered the European Union. Phase II started at the beginning of 2008 and will last for a 4-year period until the end of 2012. The emission ceilings for this new phase are lower than those of the previous one, as illustrated in Table 1, and all 25 EU Member States are now included in the trading system.

Table 1: Emission Ceilings (MtCO_2

Member State	Cap 2005-2007	Cap 2008-2012
Austria	33.0	30.7
Belgium	62.1	58.8
Czech Republic	97.6	86.8
Estonia	19.0	12.7
France	156.5	132.8
Germany	499.0	453.1
Greece	74.4	69.1
Hungary	31.3	26.9
Ireland	22.3	21.2
Italy	223.1	195.8
Latvia	4.6	3.3
Lithuania	12.3	8.8
Luxembourg	3.4	2.7
Malta	2.9	2.1
Netherlands	95.3	85.8
Poland	239.1	208.5
Slovak Republic	30.5	30.9
Slovenia	8.8	8.3
Spain	174.4	152.3
Sweden	22.9	22.8
UK	245.3	246.2
TOT	2057.8	1859.6

Verified emissions for the EU-25 area in 2005 and 2006, respectively 2.010 and 2.026 billion tonnes of CO_2, are both lower than the allowed yearly cap for Phase I, which is 2.152 billion tonnes of CO_2[3]. It has been argued that the emission cap has been respected mostly because the established cap was too high and not stringent enough, which was also the explanation for a low carbon price. It is also important to underline that covered emissions in Phase I only accounted to around 41% of total EU greenhouse gases emissions[4]. This is both because only certain sectors

[3]European Commission, IP/07/776

[4]Commission of the European Communities, SEC(2008) 52, Proposal for a Directive of the European Parliament and of the Council amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading system, COM(2008) 16 final

were covered, of which only installations above a certain size, and because only CO_2 emissions, and not all greenhouse gases, were included. This is very limitative, especially when emissions in non-covered sectors are increasing, at the risk of offsetting any emission reduction deriving from the emission trading system. In particular, emissions from the aviation sector have increased of 87% in the period from 1990 to 2004. For these reasons, the proposal to extend the scope of the ETS Directive, has been oriented, among other sectors such as the chemical industry, to include emissions from air transportation[5].

There are a number of issues involved with including aviation in the EU ETS. First, there are concerns with the effect that regulating emissions from aviation will have on the competitiveness of the sector, especially given that, at least in an initial phase, only European countries will take part to the program. A related problem is that flight prices are very likely to increase consistently, so that the burden of the emission trading regulation would be entirely on the consumers. Second, there are concerns on the effectiveness of the extension of the EU ETS to include aviation with respect to the actual emission reduction achieved. This paper focuses on this last aspect.

Although the proposal to include aviation from 2011 has been widely accepted, there is no agreement on the emissions relative to the aviation sector that would be added to the regular Phase II emission cap. Proposals vary according to the method of calculation of covered emissions, namely whether only intra-EU flights, flights leaving from the EU, or flights in the EU airspace are considered. These three scenarios are all related with a different emission cap, as in Table 2[6]. In the simulations these three ETS scenarios will be compared in order to study their effectiveness in term of emission reductions and costs, which clearly depend on the price of the emission quotas. These ETS scenarios will be compared with a base-case in which the ETS is not extended to aviation. A last scenario considers the case of a carbon tax imposed in the aviation sector, in combination of the ETS in the other covered sectors. The reason to consider a tax is that it concerns uniquely the aviation sector, and therefore it assures additional emission reductions besides the ETS in the aviation sector. It avoids the risk, which may arise in the case of a high emission cap, that extra emission quotas from aviation may simply be used by other sectors.

Table 2: Policy Scenarios

Scenario	Description	Extra Allowances ($MtCO_2$)
BASE-CASE	EU ETS	0
LOW CAP	EU ETS with aviation	71
MEDIUM CAP	EU ETS with aviation	156.5
HIGH CAP	EU ETS with aviation	178.5
TAX	EU ETS with carbon tax on aviation	0

[5]Commission of the European Communities, SEC(2006) 1685, Summary of the Impact Assessment: Inclusion of Aviation in the EU Greenhouse Gas Emissions Trading Scheme (EU ETS), COM(2006) 818 final

[6]Scenarios have been decided following Anderson et *al.* [1]

3 Model Description

The model employed for policy simulations is a static multi-region CGE based on Harrison, Rutherford and Tarr [5], outlined in Rutherford [11]. The model divides the world into 25 regional economies, each of which contains one representative agent, and 15 industries (see Annex I). Agents are endowed with labor and capital, which are internationally mobile. They rent out these resources to domestic industries in return for factor income. Each industry produces a single homogenous output good, demanded by other producer sectors and the representative agent. The economies are linked by bilateral goods trade according to the Armington [2] assumption, whereby regions' exports of a given commodity are differentiated, and the use of each commodity is given by a constant elasticity of substitution (CES) composite of domestically-produced and imported varieties of that good.

Agents minimize expenditure and, as in the previous sections, are assumed to have a Cobb-Douglas utility function. Consumers also have a constant marginal propensity to save out of their income. The government is explicitly represented, though it has a passive role. Industries are modeled as cost-minimizing representative firms whose technology is given as a nested CES production function. Parameters differ across regions. Therefore, as in the previous sections endowments of labor and capital are a substitute for use of intermediate goods, between which there are the same sectors that have been considered as dirty sector in the numerical analysis. However, in this section actual emissions of CO_2 will be considered as the dirty input. These are accounted for as a product of the fuel combustion installations that are regulated by the EU ETS, but that are located in industries outside the program's covered sectors. Emissions associated with use of fossil fuel must be covered by allowances within the sectors that are covered by the EU ETS, as specified in Annex II.

The CGE model formulates the general equilibrium problem of equalizing demand and supply simultaneously across all markets as a mixed complementarity problem, or MCP (see Mathiesen [9], Rutherford [10]). Cost minimization by the industries and expenditure minimization by the representative agent in each region give rise to vectors of demands for commodities and factors. Demands are functions of domestic factor prices, domestic and international commodity prices, industries' activity levels, and the income levels of the regional representative agents. These demands are combined with the general equilibrium conditions of market clearance, zero-profit and income balance. This yields to a square system of non-linear inequalities that forms the aggregate excess demand correspondence of the world economy (cf. Sue Wing [12]).

The benchmark dataset is the GTAP6 database (Dimaranan and McDougall [4]). This database is a snapshot at the world economy in 2001. Data from bilateral trade, transport and protection data are combined with individual country social accounting matrices and energy balances in order to constitute an approximation of the world economy as if it were in a full economic equilibrium. The original dataset contains 87 world regions and countries, and 57 sectors, but it has been aggregated to the 25 regions and 14 sectors described in Annex II. Elasticity of substitution between energy inputs is assumed to be .5, elasticities of substitution between domestic and imported intermediate products range from .3 to 11.0 according to the different products, and elasticities of substitution of intermediates across regions rance from 3.8 to 33. These are adapted from from Dimaranan, McDougall and Hertel [?] and are assumed to be the same across regions. A baseline projection of economic activity in 2010 was prepared by scaling the endowments in each region according to the historical growth rates of GDP from 2001 to

2007, and forecasts of GDP growth for the period 2008-2012 from the 2007 IMF World Economic Outlook.

The emission coefficients that link CO_2 emissions to the model's projection of economic activity were computed by first estimating emissions by sector and fuel for each region based on the International Energy Agency (IEA) energy balances for 2001 following Lee [8], and then dividing quantities of emissions by the economic values of the corresponding flows of fossil fuels given in the GTAP6 database. The result is a consistent set of relationships between the economic quantities of the sectoral demand for fossil fuels and their associated CO_2 emissions for the benchmark year. It is assumed that this continues to hold throughout the period of operation of the EU ETS[7].

Some assumptions were required to estimate the sector coverage. For each combustion sector, it has been necessary to estimate the share of total CO_2 emissions that were attributable to large combustion installations. The only data available in the regard were the 2001 IEA energy statistics on countries' emissions from "unallocated producers" (that is generators of electricity or heat for own consumption, as opposed to for sale) whose use of fossil fuels had not been apportioned between industrial and "other" sectors. Accordingly, unallocated producers have been treated as representing emissions of combustion installations in all of the combustion sectors in each country. The average proportion has been calculated for each country and used to assign the amount of emissions from unallocated producers. Although using the average value is not very realistic, the limitations of the data make it impossible to capture sectoral heterogeneity.

The final component of the calibration procedure is aimed at accounting for the high international crude oil and natural gas prices, which are expected to be a key factor in the abatement of emissions and in the trading of allowances. Preliminary runs of the models showed the prices of oil and gas in the European countries falling in real terms over the period 2001-2010, when world prices have been increasing. To remedy this situation supplies of the fixed factor in the oil and gas sectors in the NAFTA and Rest of the World regions have been reduced, and fixed factor supplies have been restricted in the remaining regions. As a result, import prices of these commodities in European countries are 90-100 percent higher than in the 2001 base year.

4 Simulation Results

The possibility to have sector-specific emissions, as described in Section 3, allows to run simulations on the EU ETS and to obtain results on overall emissions as well as emissions related with air transportation. The model also calculates the price of CO_2 under the different scenarios considered, which in turns allows to calculate the overall costs of emission trading. Results are summarized in Table 3.

Let us start by comparing the three aviation scenarios, namely low, medium and high cap, with the ETS without aviation. The overall emissions reduction is higher for the low-cap scenario than for the ETS without aviation. However, if the cap allowed increases, thus both in the medium and high cap scenarios, overall emissions reduction is lower than in the case of simple ETS. In fact, in the ETS scenario, emissions from aviation are reduced as an effect of the cap imposed on the covered sectors, which leads to a price increase in production factors. Including aviation in the ETS leads to lower emissions in the aviation sector. In fact, whereas in the ETS

[7] This is equivalent to assuming no autonomous energy efficiency improvement (AEEI) over period 2001-2012

scenario the final emissions from aviation amount to 113.1 $MtCO_2$, in the other cases the range from 107.3 to 109.5 $MtCO_2$. In the rest of the covered sectors, emissions are reduced more than the base case only when the low cap is imposed. In the other cases, emissions increase.

Table 3: Simulation Results ($MtCO_2$)

	ETS	LOW CAP	MEDIUM CAP	HIGH CAP	TAX
Extra emissions from aviation	0	71.0	156.5	178.5	0
Emission quotas allowed	1962.7	2033.7	2119.2	2141.2	1962.7
Initial Emissions	2392.7	2392.7	2392.7	2392.7	2392.7
Initial Emissions Aviation	118.5	118.5	118.5	118.5	118.5
Post ETS emissions	1962.7	1926.4	2010.2	2031.7	1962.7
Final Emissions Aviation	113.1	107.3	109.1	109.5	100.4
Total Final Emissions	2075.8	2033.7	2119.2	2141.2	2063.2
Price CO_2 (€/tCO_2)	23.7	25.3	21.6	20.7	23.6
Tax (€/tCO_2)	0	0	0	0	56.7 - 98.8
Cost (€)	10187.1	12079.1	8457.1	7646.6	11672.0

For what regards the costs of the ETS, these are higher in the case of a low cap, which leads to higher emission reductions and a higher CO_2 price. This is in fact 25.3 €/tCO_2 in the low-cap scenario, which is higher than the base case one of 23.7 €/tCO_2. In the medium- and high-cap cases, the costs, as well as the CO_2 price are much lower, 21.6 and 20.7 €/tCO_2 respectively. Note that because the emission reductions are also lower in these scenarios, the overall costs end up being much lower than the base case.

Also note that,once aviation is included in the ETS, emissions become slightly lower than in the base case. The rest of the emission allowances are either reduced, in the case of a low-cap, or bought, in the case of higher caps, by the other covered sectors. This is because it is very hard for the aviation sector to reduce the consumption of fuel, necessary for the flight operation. Being this sector very inelastic, most emissions are reduced in the other sectors in the case of a low-cap. In the case of higher caps, note that emission quotas are bought by other sectors, therefore it appears that including aviation in the ETS would tunr out to be advantageous for the other covered sectors, that would have the chance to buy more emission permits.

The immediate conclusion from the comparison between these scenarios is that the inclusion of aviation, if really targeted to achieve a further reduction in CO_2 emissions, would only be worth it under a stringent cap. In the cases of a higher cap, emissions would end up begin higher than without the inclusion of aviation. In this case, emission quotas would be bought by the other covered sectors.

Before drawing policy conclusions, let us compare the ETS with aviation case with that the ETS combined with a tax on aviation. This second benchmark case, should show what would happen if instead of targeting an overall emission reduction of CO_2, emissions from aviation were targeted individually. The simulation relative with this scenario has been implemented in the model with the imposition of a harmonized tax on use of fuels from the aviation sector of .5 €on the expenditure on fuel. It is then possible to calculate ex post the equivalent tax on emissions, which varies according to the efficiency of the sector, which varies in each country. The equivalent CO_2 tax ranges from 56.7 to 98.8 €/tCO_2, respectively in the Netherlands and in Denmark. The tax level is quite arbitrary and it has been chosen so that emissions reductions from aviation are similar to those achieved in the case of ETS with aviation, though a little higher as the purpose it to see what happens if emissions from aviation are targeted. In this case the overall emission reduction is higher than that of the simple ETS, but lower than that of the low cap. The cost is also higher than in the case of ETS but lower than in the case of ETS with aviation with low cap. Given that this scenario appears to have similar effects to the inclusion of aviation in the ETS, as it also has lower flexibility, the choice of ETS with aviation still appears to be the best option.

The conclusion from this analysis is that, given that the ETS offers a higher flexibility and allows for the distribution of emissions between the different sectors, this is the best option. However, this will only be effective if the chosen emission cap is low enough to lead to reduction in the emissions from aviation, without increasing emissions in the other sectors. Without a stringent cap, the inclusion of aviation in the ETS would simply result in the creation of additional quotas that will be bought by other sectors. This would lead again to the case of too high availability of quotas, just as in Phase I.

5 Conclusion

This paper has presented an analysis of different policy proposals for the regulation of CO_2 emissions from aviation in the European Union in the context of Phase II of the EU ETS. The possibility to extend the current EU ETS to aviation has been considered under three different caps, namely a low, a medium and a high cap. These scenarios have been compared with a base case in which the ETS is not extended to any other sector. It is found that the inclusion of aviation is only efficient in reducing further emissions if a low cap is chosen. A further comparison has been done between the ETS scenarios and the case of ETS combined with a tax on emissions in aviation. In this case, results are similar to including aviation in the ETS, though with lower flexibility. We conclude that, although this will entail higher costs, the choice of including aviation in the EU ETS will be efficient only if a low cap is chosen. As the EU has chosen for a stringent climate policy, it coherently do so by choosing a low cap for aviation. Otherwise, the overall effectiveness of Phase II of the EU ETS may be undermined.

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Annex

The following tables illustrate the regional and sectoral aggregations used for the numerical analysis and the computable general equilibrium model.

Table 4: Regional Aggregation

Code	Description	Participant to EU-ETS
NAF	North-American Free-Trade Area[a]	
AUT	Austria	√
BEL	Belgium	√
DNK	Denmark	√
FIN	Finland	√
FRA	France	√
GER	Germany	√
UK	Great Britain	√
GRC	Greece	√
IRL	Ireland	√
ITA	Italy	√
NLD	Netherlands	√
PRT	Portugal	√
ESP	Spain	√
SWE	Sweden	√
CHE	Switzerland	
EFT	European Free-Trade Area[b]	
REU	Rest of EU[c]	√
CZE	Czech Republic	√
POL	Poland	√
HUN	Hungary	√
RET	Rest of Eastern Europe	
RUS	Russian Feredation	
XSU	Rest of Former Soviet Union	
ROW	Rest of the World	

[a] USA, Canada, Mexico
[b] Norway and Iceland
[c] Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, Slovenia, Slovakia

Table 5: Sectoral Aggregation

EU-ETS Covered Sectors	**Combustion Sectors**	**Non-Covered Sectors**
Refined coal and petroleum[a]	Coal Mining[a]	Sea and Land Transportation
Pulp and paper	Crude oil and gas mining[a]	Rest of Economy Aggregate
Electric power	Gas production and distribution[a]	
Non-metallic mineral products	Non-ferrous metals	
Iron and steel	Chemical, rubber and misc. plastics	
Aviation	Durable manufactures	
	Non-durable manufactures	

[d] Sector producing a fossil fuel whose use generates emissions of CO_2