Air Transport and Environmental Economics

Stakes, Current Situation, and Possible Options

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Stakes, Current Situation, and Possible Options

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Abstract: 
The aim of this note is to review the recent institutional studies on environmental economics, in order to provide a synthetic vision of the issues and the ways to address them in the air transportation sector. It builds on a previous study\(^1\) carried out in 2002 on behalf of the EUROCONTROL Experimental Centre by the Institute of Transportation Studies (Leeds University).

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1 Introduction

1.1 Aim

The aim of this note is to review the recent institutional studies on environmental economics, in order to provide a synthetic vision of the issues and the ways to address them in the air transportation sector. It builds on a previous study\(^2\) carried out in 2002 on behalf of the EUROCONTROL Experimental Centre by the Institute of Transportation Studies (Leeds University).

1.2 Background

As presented in the European Commission’s white paper\(^3\), there is an increasing interest for the harmonisation of the pricing mechanism both across the different European countries and across the different modes.

The motivations for this harmonisation are twofold: Firstly, to obtain conditions allowing for a fair inter modal competition, secondly, to obtain a pricing as close as possible to the real social marginal cost, including inter alia environmental costs.

The reforms that are likely to arise at the European level will give more and more emphasis on the “user pays”, and “polluter pays” principles while the space left for a purely public financing of transport will be reduced to specific cases.

In this context, and given that the charging system for Air Navigation Services in Europe is already harmonised (which is far to be the case in other modes of transport), there are favourable conditions to progress faster in the air transport market than in the other modes of transport for an “internalisation of externalities”. Studies initiated by the European Commission, IATA, ICAO, EUROCONTROL, and independent organisations have already been launched. With different viewpoints, they start to review which environmental policy would be the most appropriated to aviation. However, there is still a long way to go before seeing any of the alternatives implemented.

1.3 Organisation of the note

After a rapid overview of the international framework for environmental considerations that has grown over the last 30 years, the note presents the ideas gathered in the reports reviewed (mainly the European Commission reports). Based on these ideas, an influence diagram is build, providing a synthetic view of the environmental economics sphere. Latest works on emissions trading and environmental charges are also reviewed.

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2 International initiatives for environment

The international considerations for the environmental matters are relatively recent, the Stockholm Declaration in 1972 can be considered as a starting point. Since then, there is an increasing interest for the notion of sustainable growth, but the process for implementing international policies in this domain is long.

The chronological arrow presented below shows that, over the last 30 years, several international events have paved the way for political actions. However, and despite some real progresses in environmental efficiency, (due to technical progress or regulation actions) the environmental impacts have grown faster than the political actions.

This allows drawing two conclusions:

- Fast actions and more anticipation are needed.
- Even though local actions are less effective than global approaches to mitigate environmental impacts, it may still be preferable to act rapidly at the local level rather than to wait for years that international agreements are reached. Moreover there is a probability that local or regional initiatives could "catalyse a global approach".

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3 Current situation of air transport

3.1 External costs

The Green paper from the Commission of the European Communities\(^5\), and the INFRAS report\(^6\) have drawn a description of the situation, via the concept of externalities for the whole transportation sector. INFRAS concludes to a total value of transport externalities in the EUR17, excluding congestion costs, around 530 Billions € (equivalent to 8% of the GDP). This amount can be split into the different modes of transport as shown below.

![Composition of external costs of transport in EUR 17 by transport mode](Image)


If road occupies by far the first rank, with 92%, aviation comes second with 6%, i.e. three times more than rail. For the 6% attributed to aviation, Table 1 shows how this amount spreads over the different kind of externalities.

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\(^7\)http://themes.eea.eu.int/Sectors_and_activities/transport/indicators/cost/external_costs/tab_factsheets_ILR
Table 1: Share of external cost in transport (EU17, 1995)

<table>
<thead>
<tr>
<th>Type of effects</th>
<th>Share of total cost (all modes)</th>
<th>Share of total cost (Aviation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accidents</td>
<td>29%</td>
<td>1%</td>
</tr>
<tr>
<td>Noise</td>
<td>7%</td>
<td>8%</td>
</tr>
<tr>
<td>Air pollution</td>
<td>25%</td>
<td>3%</td>
</tr>
<tr>
<td>Climate change</td>
<td>23%</td>
<td>74%</td>
</tr>
<tr>
<td>Nature and landscape</td>
<td>3%</td>
<td>4%</td>
</tr>
<tr>
<td>Separation in urban areas</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Space scarcity in urban areas</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Additional costs from up- and downstream processes</td>
<td>11%</td>
<td>10%</td>
</tr>
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</table>

Source: INFRAS/IWW, 2000

It appears clearly that the most important problem for aviation environmental cost is climate change, for which the main causes are the CO₂ emissions. Emissions of CO₂ from transport in general accounted for 28% of the total carbon dioxide emissions (EU15 area), and aviation emissions for 3.7% of the total (EU15 area), (or 13% of the transport emissions) in 1998\(^8\).

The INFRAS study estimates that aviation (passenger transportation only) contribution to climate change can be priced at \((530 \times 6\% \times 74\%)\) €23.5 billion. This estimation is not precisely documented, CO₂ is valued at €135 per tonne, but it is not said if this high value (many studies use €30 per tonne of CO₂) is a deliberate choice to indirectly include NOₓ, H₂O, formation of contrails and cirrus clouds, etc.

By now, transport related pollution has mainly been addressed with regulation, on fuel quality, emission standards, and vehicle inspection and maintenance programmes. In the aviation sector, Sweden was the first country having implemented an emission tax (for hydrocarbons and oxides of nitrogen emissions) on domestic flights.

About noise, day-time transport noise with a ceiling fixed at 65dB(A) is estimated to affect 20% of the European Union’s population. Road is the main responsible for this situation, with 19% of the EU population exposed, while it is only 1.7% for rail, and 1% for air transport noise. However, these average values hide high discrepancies across European countries. A report from the Commission of the European Communities\(^9\) (1999) “Air Transport and the Environment” states that, in particularly populated member States, about 15% of the population is affected by aircraft noise. Unfortunately, the reference to the noise ceiling used to compute these 15% is not given.

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\(^8\) EUROSTAT (2001) Transport and the Environment

3.2 Trends for aviation emissions

3.2.1 Past observations

According to EUROSTAT estimates for the period 1985-1998, the transport sector in Europe played an increasing role in the production of carbon dioxide emissions. While its share of total European (EU15) emissions was 19.7% in 1985, it has steadily increased to reach 28% in 1998.

This increasing trend in the transportation sector actually hides very different situations when transport modes are taken separately.

- Rail has the lowest share in CO2 emissions and is the only sector where emissions decrease in absolute term.
- Road emissions ranks first, and increase in absolute value, but its share in the total transport emissions is stable, or even very slightly decreasing.
- Inland navigation emissions are the most chaotic through time, but occupy the lowest share just after rail. The 1998 share is finally the same as in 1985.
- Aviation emissions are increasing in absolute term, and aviation’s share in the transportation sector is the only one steadily growing.

The figure below illustrates the performance evolution of each transport mode relative to its contribution in CO2 emissions in 1985. It appears clearly that the situation observed in the aviation sector raises sustainability issues.
3.2.2 Projections

The IPCC special report on aviation\(^\text{10}\) is, according to its authors, “the most comprehensive assessment available to date of the effects of aviation on the global atmosphere”. Compared to the other reports reviewed in this note, the focus is more on impacts (using the concept of radiative forcing\(^\text{11}\)) than on emissions. The notion of radiative forcing, and the work that has been done under the aegis of IPCC is very useful for costing different pollutants, as it provides a common denominator. Costing only one pollutant allows for an indirect cost estimation of all other pollutants.

As a matter of fact, aircraft environmental effectiveness per passenger improved over the past years, however it was not sufficient to offset the traffic growth. Between 1990 and 2015, IPCC forecasts that an increase of 5% revenue passenger kilometre would lead, thanks to improved aircraft efficiency, to only a 3% increase of fuel use. This figure is in line with the EUROCONTROL study “Forecasting Civil Aviation Fuel Burn and Emissions in Europe - Interim Report: February 2001”.

If past trends and current projections both indicate a high probability that aviation will play an increasing role in future environmental impacts, it is however difficult to put a precise figure on aviation’s future contribution.

\(^{10}\) Intergovernmental Panel on Climate Change (1999) Aviation and the global atmosphere.

\(^{11}\) “Radiative forcing is a measure of the importance of a potential climate change mechanism. It expresses the perturbation or change to the energy balance of the Earth-atmosphere system in watts per square metre (\(\text{Wm}^{-2}\)). Positive values of radiative forcing imply a net warming, while negative values imply cooling. » IPCC report.”
The relative contribution will depend on:
- Air transport growth
- Global economic growth
- Aviation technological progress and fuel quality
- Adoption of future institutional regulation, time and scope of application of the Kyoto protocol
- Metrics used to reflect the environmental contribution (CO₂ only, or radiative forcing)
- Geographical area upon which the contribution is computed
- etc.

Globally, the IPCC projects that the contribution of aviation to the radiative forcing (3.5% in 1992) will be, in their base case scenario up to 5%. In the worst case scenario, this share could be up to 15%.

Locally, aviation’s contribution to climate change could even be much higher. In a news release of the UK Royal Commission on Environmental Pollution, it is stated that: “If travel expansion goes unchecked, aviation will be costing about a quarter of the UK’s climate change budget by 2020, and by 2050 this could have risen to over an half or even three quarters of the budget” (detailed figures, references and assumptions available at http://www.rcep.org.uk/news/03-01.html)

As a consequence, environmental policy in the aviation sector is borne to be a subject of growing interest. Complementary measures such as regulation and economic incentives programs will be necessary to keep this evolution under control.
4.1 Links between goals, policies, industry reactions, and environmental effectiveness

Existing studies often address one particular policy option without giving the full range of possible actions, and rarely present complementarity versus substitutability aspects. ICAO recommends that environmental actions in air transport follow a “balanced approach”, which means that actions to curb air transport environmental effect should use the full set of available levers. This should allow for a fair repartition of efforts between actors and result in an increased efficiency.

As the goals for environmental actions can follow different logics and as the resulting interactions can take different paths, the following influence diagram is proposed, helping to get a “big picture” of the environmental economic issues in air transport, and to better understand the links between goals, policies, industry reactions, and environmental effectiveness. It also resituates economic options among political and technical options.

There are basically two possible approaches (goals) in the establishment of an environmental economic policy: either to fix a pollution ceiling decided politically, or to force market prices to include external costs.
• Emission ceiling based on a political consensus:

Then, if a price is given to the externalities, it is fixed at a level such that the economic mechanisms and the industry behaviour lead to the target. The drawback of this approach is that it is most probable that the target does not rely on safe levels (from a scientific viewpoint), and that the amount of the charge does not correspond to the external costs. However it has the important advantage of enabling actions without having to debate on the cost valuations. Once the design of the system is done, fine-tuning the level of the target is still possible, and the charges can be recomputed accordingly.

• Internalisation of external costs:

This approach is more "economic oriented". Based on valuation methods such as revealed or stated preference, damage or prevention costs, a price for the externality is assessed. This approach gives more sense to the level of the charge, but has still some limitations such as, possible strategic answers form the individuals interviewed, the non perception of the global impacts, or the assumptions related to the methodologies. Finally, there is no guaranty that the internalisation of external costs allows for a significant reduction in quantity of externalities.

4.2 Costing methods for externalities

The techniques used to cost environmental impacts, as well as the existing valuation studies are reviewed in detail by the ITS report\(^\text{12}\). The nature of the work, in this area, is such that the references collected by ITS are mainly academic.

Only a brief description of the costing techniques used in environmental economics are presented hereafter:

*Revealed preference* methods consist in measuring the change of cost of some goods to deduce the value of others goods. The consumer’s preferences can be observed through market choices among different combination of goods. For example, the estimation of house prices in function of their environmental characteristics (among others) allows costing the noise.

*Stated preference* techniques rely on individual's declaration (and not effective behaviour). Stating what they would be ready to do (willingness to accept a compensation), or to pay (willingness to pay), the cost of the externality for the interviewed population is found.

*Alternative cost methods* aim at valuing the costs incurred, which is different from individual valuation of externalities. It includes replacements cost, opportunity costs, and consequential costs.

Numerous valuation studies are reviewed in the ITS report. They try to give a monetary value to one or several environmental impacts. For a given impact, different methods give differences values, and the comparison between studies is difficult. Depending on the impact some methods seem more adapted. Very few studies have (all else equal) applied several methods to a given impact.

\(^{12}\)Review of Research Relevant to Rail Competition for Short Haul Air Routes, EEC/ENV/2002/003
This section provides a description of the policy options that can be applied to the air transportation sector. The structure and content of the section relies on the European Commission’s report, which is the reference document for the commission’s work program on the subject. It distinguishes two basic approaches to curbing transport externalities, the direct regulation (also called command and control), and the market based instruments (incentives rewarding the best practices and/or punishing the worst). In the following of the note, the emphasis is put on the market-based instruments, whereas the other approaches are given for completeness.

5.1 Direct regulation (command and control)

5.1.1 Noise standards

The latest revision of the ICAO norms for noise, the introduction of the chapter 3, dates from 1977. It does not represent the most efficient technology nowadays. A more stringent standard, (chapter 4) is being developed by ICAO. "Commencing 1 January 2006, the new standard will apply to newly certificated aeroplanes and to Chapter 3 aeroplanes for which re-certification to Chapter 4 is requested" - ICAO.

5.1.2 Gaseous emissions standards

ICAO also defines the emissions standards for the certification of aircraft engines. The norms concern the landing and take-off cycle (LTO). These standards are not adapted when we aim at assessing the contribution of air transport to global environmental problems. Climb and cruise emissions are, at the moment, not defined by any ICAO standards.

5.1.3 Air Traffic Management (ATM) operational measures

The IPCC report estimates that ATM improvements can reduce fuel burn by 6% to 12% within the next 20 years. Non-optimal routing due to a lack of route optimisation, current standard practiced, or avoidance of congestion point cause extra costs to airlines and have a negative impact on the environmental performance. Changes in the rules of operations, (such the implementation of RVSM) can have a positive impact on aircraft emissions.

5.1.4 Airport operational measures

Around airports, the operational procedures (such as continuous descent approach) have a direct impact on the noise perceived on the ground. Adjusting the flight path and climb/descent rates in function of ground based monitoring systems could allow for some progress.
5.2 Market based instruments

5.2.1 Taxation of aircraft fuel

The taxation of aircraft fuel is able to have a positive effect on the environment, mainly by the increase of cost it would impose on air transport, thus reducing demand or possibly reorienting this demand towards other modes of transport.

The taxation of aircraft fuel is in debate, not only for its probable environmental effectiveness, but also as a necessary condition to progress towards fairer competition between the modes of transport.

The report of the Commission of the European Communities\textsuperscript{13} (2000) presents the major steps of the debate on the taxation of aircraft fuel:

- A council directive of October 1992 states a compulsory exemption for commercial aviation fuel.
- In 1996 a review of this directive was done. The commission recommended that excise duties on mineral oil should be extended to aircraft fuel as soon as the legislation allows it. This proposal also said that on an optional basis, national flights and flights between member states could be taxed on the basis of bilateral agreements.
- This proposal generated discussions, and the need for a more comprehensive study appeared. The Resource Analysis thus conducted a study\textsuperscript{14} on the subject, commissioned by the EC.
- This study, reviewing 15 different options, concluded that it would not be practicable / desirable to introduce taxation targeting exclusively intra-community flights.

As a conclusion, some countries do actually impose a tax on fuel for their national flights only, but the application to international flights is still to be debated. The Commission recommends to intensify the work on this area within the ICAO.

5.2.2 Emissions trading

Presentation

Emissions trading can take two different forms. Either it consists in allowing to exchange polluting permits in a framework capping the global amount of pollution (this is called “cap and trade” scheme), or, it consists in defining a minimum performance standard (which can be expressed in relative value) where the actors earn polluting permits when they perform better than the standard, and it is then called a “baseline and credit” scheme.


\textsuperscript{14} Analysis of the taxation of aircraft fuel, Resource Analysis, Delft 1998.
Over time, the aim is of course to reduce progressively the ceiling, or respectively to strengthen the minimum performance commitments, as the knowledge progresses on the real optimal level of pollution from society standpoint. Then, the parties having cheap solutions to decrease their pollution level have interest to sell their rights to others parties, for which the cost of reducing pollution would be higher (or more time consuming) than buying the right to pollute.

The OECD report

The OECD has produced a report\textsuperscript{15} making a wide presentation of tradable permits (TPs) applied to many different sectors, including transport. Past experiences such as the RECLAIM programme targeting SO\textsubscript{2} and NO\textsubscript{x}, the lead trading programme for phasing out the use of lead in gasoline for automobile, etc. are presented.

The ways to evaluate such experiences are also discussed, highlighting the difficulty of this exercise, especially because no standard methodology exists, and because of the tricky identification of progress that were made thanks to the TPs, and the ones that would have occurred anyway.

To date, we see that many countries in Europe wish to anticipate the future introduction of international schemes for greenhouse gas (GHG) emissions, that will occur under Kyoto protocol and European Union targets. Some countries like Denmark, United Kingdom, Norway and Sweden are engaged in a process of implementation of domestic emissions trading. By introducing some national forms of TPs, they follow a learning by doing logic, aiming at preparing their national industries to future challenges and possible competitiveness impacts that will occur in the future.

Strengths of TPs

Strong points of TPs are presented to be a better control (compared to alternative tools) of the level of pollution, and a larger flexibility in the ways offered to the concerned sector to meet the targets. Focussing on quantities rather than prices, tradable permits are expected to be superior to taxes or charges (focusing on prices) particularly in situations where the demand sensitivity to price is suspected to be low, and on oligopolistic markets.

In addition, tradable permits allow decentralised agents to manage by themselves how the pollution will be geographically distributed, but this may be criticised for the potential apparition of hotspots.

In the case of aviation, we observe that:

- Most studies on price elasticities conclude to a low sensitivity of air travel demand to ticket fares
- On most routes, and despite the deregulation of the sector, markets are monopolistic or at best oligopolistic
- Emissions of GHG in atmosphere do not raise any problem of hot spots

\textsuperscript{15} OECD (2001) Implementing Domestic Tradable Permits – Recent Developments and future challenges.
As a conclusion, the aviation sector could be a good candidate for application of TPs as a mean to reduce the global emissions.

However, TPs are not without generating issues. For example, because technological trade-offs may be necessary to achieve a given target for one particular pollutant, this could result in an uncontrolled increase of another pollutant. This questions the need for and the potential efficiency of schemes concerning multiple pollutants at once. Besides, the way initial permits are distributed (grandfather rights or auctioning) may lead to an unwanted concentration of market power. Finally, the efficiency of TPs is constrained by their acceptability and the familiarity of the concerned agents with the instruments. This may result in longer time before being able to implement then.

The European Commission Programme

The European Commission, as part of the Kyoto protocol actors, has committed itself to achieve a level of GHG emission equal to its 1990 level minus 8%, between 2008 and 2012. This allows the European Commission to redistribute individual targets to European states via a so-called “burden sharing” agreement. The green paper of the European Commission about GHG emissions trading\textsuperscript{16} presents how this Kyoto target and emissions trading could be implemented in a European framework. Actually, emissions trading within and across Europe are not presented as the only solution to reduce emission, but as a mean to minimise the cost of meeting the Kyoto targets. Considering this is a new instrument to address climate change within Europe, the European Commission has proposed to start an internal scheme by 2005, letting time to be prepared for 2008-2012.

This report has been followed by a proposal of the European Parliament and the council\textsuperscript{17}, which goes one-step further, studying concrete issues on the implementation of the emissions trading scheme. The sectors that have been identified to share the reductions of emissions are electricity and heat production, iron and steel, refining, glass, pottery and building materials, paper and printing. These sectors cover approximately 46% of the CO\textsubscript{2} emissions in the EU and do not include the transport sector, despite its 28% contribution to CO\textsubscript{2} emissions.

Besides, an IATA report\textsuperscript{18} concludes that "international aviation is very likely to be required to limit or reduce its greenhouse emissions, most probably from 2013, but possibly from 2008.


\textsuperscript{18} IATA Emissions trading for aviation – workstream 3: Key findings and conclusions, 2001.
Conclusion

TPs can be substitutes or complements to other measures. In case on complete substitution, one has to keep in mind that there is a risk of loss of revenue (in case of prior existence to a tax feeding the government budget). Even if auctions are put into place for the initial allocation of TPs, the amount that will be gathered is not guaranteed.

Compared to the introduction of charging mechanisms (see next paragraph), the emissions trading mechanisms applied to aviation are considered as longer-term solutions by the European Commission. However this is a kind of paradox because transport is among the main producers of GHG, and it would be in theory well applicable to air transportation, but it is at the moment excluded from programmes. For noise, a market could be imagined at the airport level, where air carriers could exchange noise permits under a predefined quota.

5.2.3 Environmental charges

A report\(^\text{19}\) of the Centre for Energy Conservation and Environmental Technology (1998) has studied several options for a European environmental aviation charge. This is probably the most comprehensive study on environmental aviation charge related to emissions (it does not address the noise issues). This study shows that several options for an environmental aviation charge exist, that they would be efficient, and legally feasible. Economic distortions of each option are evaluated in the study.

Four important choices in the design of a European aviation charge are identified:

- The definition of the aim of the charge: The primary aim of the charge should be to reduce the impacts on environment from aviation. Reductions in the air traffic growth, generation of more revenue for the governments, or establishment of equity between the modes of transport are possible consequences of the charge, but they should not be considered as the main goal of the charge.

- The charge base: Ideally one should charge in proportion of impacts. However, as impacts are not easily quantified, the second best solution would be to charge the true level of emissions. If again difficulties are encountered in the measurement of emissions, estimated emissions, quantity of fuel burn, or even the number of movements could become the charge base.

- The level of the charge: This should be chosen to maximise the environmental effectiveness, while minimising the economic distortions on the market. As seen in a previous section, internalisation of external cost is a possible way to fix the amount of the charge. However, it is also possible to set the level of the charge so that a “political ceiling” or target is reached. A fuel charge based on the existing level of taxation in other modes of transport is also a possible alternative.

The allocation of revenues: The issue with the allocation of revenues is that the decisions impact both the aviation sector, and the public sector. The three main options are an allocation to national States, European level, or airlines companies (also called revenue neutral charge).

Based on combinations of charge bases and allocation options, five charging mechanisms are studied:

- A calculated emission charge, with revenues allocated to European level.
- A calculated emission charge, with revenues allocated to airlines.
- A calculated emission charge, on landing and takeoff cycle only, with revenues to National States.
- A fuel charge package, with revenues to national States.
- A movement-based ticket charge, with revenues to national States.

For each option, the following criteria for evaluation are used: the environmental effectiveness, the potential economic distortions, the legal issues, the implementation, and the distributional complications.

To assess the option's effectiveness, a price elasticity of demand for air transport is needed. Based on existing studies, the authors use an average value of –0.8, which means that, all else equal, an increase in fares of 1% would lead to a decrease in demand of 0.8%.

Finally, a relative ranking of the five charge options on five criteria is presented (1=best; 5=worst)

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<th>Option</th>
<th>Environmental effectiveness</th>
<th>Economic distortions</th>
<th>Legal issues</th>
<th>Implementation</th>
<th>Distributional complications</th>
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<td>1</td>
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<td>Revenue neutral emission charge</td>
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<td>1</td>
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<tr>
<td>LTO emission charge</td>
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<td>2</td>
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<td>Fuel package charge</td>
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Source: CE (1998) A European environmental aviation charge
5.3 Voluntary agreements

Voluntary agreements are efficient ways to improve environmental efficiency. Car manufacturers follow this approach in Europe to progressively reduce emissions of carbon dioxide, particules, oxides of nitrogen etc. This way of proceeding has the advantage of being well perceived by the industry as it is a kind of bottom-up approach leaving a wide flexibility in setting future standard that are technically and economically realistic.

5.4 Innovative options

- Progressing toward a fair internalisation charge, thus differentiating with accuracy among polluters could require the introduction of new technologies. Black box recording the precise level of emissions depending on the polluter’s behaviour, could be an enabler for the internalisation of external costs.

- Carbon offset programmes could allow the air transport industry to continue their development (and increase their level of emissions) on counterparts of investments in carbon sinks (forestation). However the scientific uncertainties on the efficiency of such programs do not allow to consider this option in the short or even medium term.
The report has shown that institutions and policy makers have only recently launched the international basis for coherent environmental actions. In the meantime, and despite significant efforts, the rapid economic growth has lead to increasing volume of activities actually offsetting the technological progress. Finally, the global environmental impacts keep on growing, and the transportation sector is generating significant levels of external costs.

If road occupies by far the first rank in transport externalities, aviation’s share has been continuously growing during the last decades, and projections show that this trend will continue. Among external effects generated by the development of air transport, climate change appears to be the main component. This occurs principally via the production of carbon dioxide, but also nitrogen oxides and formation of condensation trails. The International Panel on Climate Change estimated the overall effects of these emissions in term of radiative forcing\(^\text{20}\). In 1992, the aviation sector was considered responsible for 3.5% of the total radiative forcing effects, and the share was projected to grow to 5% in 2050. However, in case of application of the Kyoto protocol, and depending on the regional emissions repartition, aviation could, in specific locations, be responsible for much higher shares of emissions.

By now, policies have, with a relative success, mainly focused on “command and control” options to curb these effects. However, the scope of environmental impacts and the high increasing trends observed are such that several leverages (technical improvements, direct regulations and economic incentives) will have to be combined for more efficiency.

In this note, we have reviewed the range of possible economic actions. It appears that the three main candidate options to curb aviation environmental impacts are fuel taxation, emissions trading, and environmental charges.

Naturally, industry's preference goes for emissions trading, the solution which would let the maximum flexibility in the management of externality reduction. While precise means and calendars for implementation are still uncertain, it seems now very clear that, the framework set by the Kyoto protocol, the existence of an international organisation for aviation like ICAO, and the European Commission's stronger and stronger implication in setting policies for the aviation sector will accelerate the future introduction of "mixed" environmental policies.

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\(^\text{20}\) "Radiative forcing is a measure of the importance of a potential climate change mechanism. It expresses the perturbation or change to the energy balance of the Earth-atmosphere system in watts per square metre (Wm\(^{-2}\)). Positive values of radiative forcing imply a net warming, while negative values imply cooling. » IPCC report."


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