Incentive-based regulation of CO₂ emissions from international aviation

Fredrik Carlsson*, Henrik Hammar

Department of Economics, Gothenburg University, Box 640, SE-405 30 Gothenburg, Sweden

Abstract

We explore the possibilities of using incentive-based environmental regulations of CO₂ emissions from international civil aviation. In theory incentive-based instruments such as an emission charge or a tradable emission permit system are better regulations than so-called command-and-control regulations such as emission limits or technology standards. However, the implementation of these instruments is a complex issue. We therefore describe and discuss how an emission charge and a tradable emission permit system for international aviation should be designed in order to improve efficiency. We also compare these two types of regulations. In brief, we find that an emission charge and a tradable emission permit system in which the permits are auctioned have more or less the same characteristics. The main advantage of a tradable emission permit system is that the effect, in terms of emission reductions, is known. On the other hand, we show that under uncertainty an emission charge is preferred. The choice of regulation is a political decision and it does not seem likely that an environmental charge or a tradable emission permit system would be implemented without consideration of the costs of the regulation. Revenue-neutral charges or gratis distribution of permits would, for this reason, be realistic choices of regulations. However, such actions are likely to result in less stringent regulations and other negative welfare effects. © 2002 Elsevier Science Ltd. All rights reserved.

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1. Introduction

There has been increasing concern over the environmental impacts of civil aviation due to an expected increase in international air traffic and an increased awareness of environmental problems such as global warming and noise pollution. Traditionally, environmental regulations in the aviation sector have been command-and-control (CAC) regulations such as engine standards and restrictions on flight movements. In recent years there has been an increasing interest in incentive-based (IB) environmental regulations such as fuel charges, emission charges and tradable emission permits (TEP). The European Union (EU) Green and White Papers on pricing in transport (European Union, 1996, 1998) recommend IB environmental regulation of the transport sector. In Sweden, for example, landing charges are now not only based on noise pollution but also on emissions of nitrogen oxides (NOₓ) and hydrocarbons (VOC) during landing and take-off. A number of recent papers also discuss IB environmental regulation of the aviation sector, see for example Alamdari and Brewer (1994), Carlsson (1999) and Schipper et al. (2001). In this paper we explore the possibilities of using IB environmental regulation of carbon dioxide (CO₂) emissions from aviation, with a particular focus on international aviation. Regulation of CO₂ emissions raises intricate policy issues due to their global nature.

2. Background

2.1. CO₂ emissions from aviation

The impact of aviation emissions on climate and atmospheric ozone has recently been investigated by the
Intergovernmental Panel on Climate Change (IPCC). Emissions from aviation have an impact on the atmospheric composition and estimated to represent approximately 3.5 percent of the total radiative forcing from human activities. The IPCC predicts an annual increase in aviation fuel use of 3% between 1990 and 2015, they also present a number of scenarios in which the annual growth of fuel use is between 0.8% and 2.8% for the period 1990–2050 (Intergovernmental Panel on Climate Change, International Civil Aviation Organization, 1999). Consequently, we can expect that emissions from the aviation sector will increase in the near future, and if no further regulations are introduced the increase will most likely be large. According to the IPCC, these emissions, together with emissions from other sectors, have a significant impact on the global climate, and a reduction of the emissions is necessary if we wish to decrease the probability of an anthropocentric induced climate change.

2.2. Sources of emission reductions

There are essentially two types of aviation emission reductions: (i) a reduction in the number of flights and (ii) a reduction in emissions per flight. A reduction in the number of flights can be attained by a sufficient reduction in the number of passengers, increased seat capacity and/or increased load factors. The amount of CO₂ emissions depends on the carbon content of the fuel type, but on average 3.16 kg CO₂ are emitted per kg fuel burned. Increased fuel efficiency may on one hand decrease emissions of CO₂ and HC, but may on the other hand increase emissions of NOₓ, since higher engine temperatures tend to increase emission of NOₓ. These potential negative side effects make it unrealistic that only CO₂ emission would be regulated. Other factors, such as improvements in the Air Traffic Management (ATM) system, including improvements in communications, navigation and surveillance (CNS) systems can result in a 6–9% reduction of global CO₂ emissions by 2010 (Intergovernmental Panel on Climate Change, International Civil Aviation Organization, 1999). A survey by the International Air Transport Association also indicates that improvements of CNS/ATM systems are sources for improvements in fuel efficiency; in the US and Europe a 5% reduction of CO₂ emissions by 2015 is possible (Dobie and Eran-Tasker, 2001).

2.3. The Kyoto protocol and international aviation

Only emissions from domestic aviation are considered national emission in the Kyoto Protocol. Instead, the Kyoto Protocol delegates the responsibility for international aviation emissions to the International Civil Aviation Organization (ICAO). International aviation treaties have been obstructing environmental charges, and there are still obstacles for implementation of, for example, a fuel tax. The Chicago Convention prohibits taxation of fuel in transit, and many bilateral Air Service Agreements prohibit taxation of fuel. However, in 1996 the ICAO adopted a resolution allowing individual countries to implement environmental charges (International Civil Aviation Organization, 1996). In the resolution, ICAO recommends that any IB regulation should be in the form of charges, and not taxes. Furthermore, there should not be any fiscal motives behind the charge; it should be related to costs, it should not discriminate against air transport and the raised funds should be used to mitigate the negative environmental impact of emissions.

3. Incentive-based instruments for international aviation

3.1. Overview of incentive-based instruments

In theory, IB instruments such as an emission charge or a tradable emission permit system minimizes the total cost of reaching a given level of emission reductions, since each firm reduces its emission until the marginal cost of reduction is equal to the marginal tax or the permit price. Since marginal abatement costs in many instances are heterogeneous and unobserved or costly to observe for the regulator, a CAC regulation in terms of emission limits is less likely to reach a certain level of emission reductions at the same cost (Baumol and Oates, 1988). A comparison of costs among different regulations depends on several factors. Still, the empirical evidence suggests that the costs savings can be large. Tietenberg (1990) compares different regulations of air-pollution to a least-cost instrument, and finds that the costs vary by a factor of 1–22. Compared to CAC regulations, these instruments also provide higher incentives for adoption and diffusion of cleaner technology (Milliman and Prince, 1989). The reason is that cost savings are larger for IB instruments, since...
reduced emissions also reduce direct costs of the regulation.

Although emission taxes are becoming more common in developed countries, only six countries have implemented environmental taxes based on the carbon content of energy products, and some countries have energy taxes that do not consider the carbon content at all (Baranzini et al., 2000). In 1990, the cap-and-trade program for sulfur dioxide (SO$_2$) emissions from electric utilities was introduced in the United States. The first phase of the program was initiated in 1995, and the second began in the year 2000. The program first establishes an aggregated emission limit. Then the emission limits (caps) are distributed at no cost to firms, mostly according to historical emissions and volume of fuel use. This type of system where the permits are initially distributed gratis is called a grandfathering system. A small number of permits are also auctioned annually by the Environmental Protection Agency (EPA). The individual sources are allowed to trade the permits with any party, or to bank them for later use. The implementation of the cap-and-trade program has in many respects been a success (see e.g. Ellerman et al., 1999; Burtraw, 1999). It has also resulted in a number of important lessons on how to design a program of tradable emissions permits (see e.g. Stavins, 1998).

3.2. An aviation tradable emission permit system

The Kyoto Protocol only involves domestic aviation and the responsibility for international aviation has been delegated to the ICAO. Tsai and Petsonk (2000, p. 786) reasonably define international aviation to cover “civil transport between one nation and any place outside that nation”. If two or more countries form a “bubble” it seems likely that the baseline emission would include emissions from flights between the countries within the agreement (Tsai and Petsonk, 2000). Consequently, we have to distinguish between a TEP scheme for international aviation emissions and one for domestic aviation. According to Tsai and Petsonk, customary international law implies that all flights between two nations where at least one is an Annex 1 party would be covered in an international TEP. In addition, any flight involving an Annex 1 carrier would also be covered by the system.

As argued by, for example, Zhang and Nentjes (1999), there is much to gain from allowing inter-source trading, compared to inter-government trade. The reason is that individual sources have better information about their abatement costs, and trade between individual sources in different sectors can lower total abatement costs since sources with high costs can buy permits from sources with low costs. This would also increase the number of trades and lower transaction costs since fixed costs are shared by more agents. Furthermore, the possibility for a firm to exploit market power is reduced. A system that allows for inter-source trading is more complex and requires functioning domestic TEP systems in the individual countries as well as functioning monitoring and enforcement systems (Zhang and Nentjes, 1999).

3.2.1. Upstream and downstream TEP system

How then should domestic TEP systems be designed? We can distinguish between an upstream and a downstream system. In a downstream system end-users are required to hold permits, while in an upstream system the incidence point is at either the extraction, processing or transportation/distribution point in the fuel cycle. It would not be efficient to include all end-users, such as car owners, directly in a TEP system because of the high transaction costs. In a report to the European Commission on a TEP system for greenhouse gases in the EU, Helme et al. (2000) suggest that CO$_2$ emissions from energy use in larger power plants, refineries, and iron and steel, inorganic chemical, cement and paper pulping plants should be included in a downstream TEP system. The other sectors should be covered in an upstream system as described in Hargrave (1999). The upstream system would require fuel producers/distributors to hold permits for the potential CO$_2$ emissions embodied in their fuels. The distributors would then mark up the fuel price, charging the end-users for the permit price. This system would thus work very much like a CO$_2$ tax, although total emissions would still be known. Zhang and Nentjes (1999) also propose that the permits should be grandfathered to fuel-intensive sectors, while auctioned to fuel-extensive sectors and the fuel distributors. The main reason for grandfathering to the fuel-intensive sectors is to avoid political pressure against the regulation. It is unclear whether domestic aviation would be included among fuel-intensive sectors. Helme et al. (2000) do not explicitly mention the aviation sector, but they seem to imply that the whole transport sector should be covered by the upstream system. In principle, the aviation sector could be included in a downstream system, while other transport sectors are included in an upstream system. However, treating different modes of transportation differently may turn out to be problematic, since it could affect the competitiveness between the modes.

A TEP for international aviation can also be of either an upstream or a downstream type. However, in this particular case the two systems are similar. There are not enough number of participants to make transactions costs too high, and monitoring and enforcement may not be too costly in this type of system. Second, monitoring and enforcement could actually be at the upstream point. For example, fuel distributors may be
responsible for holding permits when selling fuel to carriers.

3.2.2. Lessons on distribution of permits

There are two systems for the initial distribution of the permits for international aviation: a country-based system and a carrier-based system. Gander and Helme (1999) propose a carrier-based system, while Hewett and Foley (2000) propose a country-based system. As discussed by Hewett and Foley, it is not clear how a carrier-based system could work in practice. The main problem is monitoring and enforcement; in a country-based system the individual countries would be responsible for the enforcement, while in a carrier-based system an international body such as the ICAO would have to be responsible. It is unclear whether it would be possible for the ICAO to serve as a separate UNFCC party, or if the airlines themselves could become parties. Furthermore, it is unclear what enforcement rights the ICAO could have. Apart from this, the differences between the two systems are small. In a country-based system the permits would be distributed or auctioned to the air carriers by the individual countries, while in a carrier-based system an international body such as the ICAO would assume this responsibility. In the country-based system, countries could apply different principles when distributing the permits to the airlines. This could have a discriminating effect, if for example some countries distributed the permits at no cost, while other countries sold the permits to the airlines.

The next step in the implementation of the permit system would be to decide how to allocate the permits among the carriers. There are essentially two systems: auctions, where the EPA or, for example, the ICAO auctions the permits to the individual sources, and grandfathering, where firms receive the permits for free based on historic emissions. The auction could be revenue-neutral, where the revenues from the auction would be distributed to the participants according to some rule of distribution (Hahn and Noll, 1982). Although grandfathering, or a revenue-neutral auction, is more likely to be implemented for political reasons, it may have problems that must be considered. First, grandfathering can serve as a barrier to entry, since new entrants must purchase permits from incumbent firms (Stavins, 1998; Burtraw, 1999), and there is evidence that grandfathering has slowed down the introduction of new sources and new technologies (Nelson et al., 1993). One way of reducing this effect would be to at least auction a share of the permits. Second, grandfathering implies smaller incentives for adoption of new and cleaner technology compared to a system in which the permits are auctioned or to an emission tax (Fisher et al., 1998). Third, the transaction costs of grandfathering permits to small sources may be high. Fourth, in the case of transaction costs, the initial allocation of permits affects the post-trading equilibrium resulting in reduced trade and increased abatement costs (Stavins, 1995). Finally, there is recent literature showing, given pre-existing tax distortions, important differences between on the one side emission charges and auctioned permits, and on the other side refunded emission charges, revenue-neutral auctions and grandfathered permits. Environmental regulations such as emission taxes and emission permits increase the price of the goods relative to leisure, which tends to compound the distortions of the existing taxes in labor markets—a so-called tax-interaction effect (Parry, 1995). For example, a carbon tax has a spillover effect on the labor market since the tax tends to reduce the overall level of economic activity and hence the demand for labor. The distortions of a labor tax therefore increase because of this spillover effect. This effect can be offset by a revenue-recycling effect, which means that the distortionary taxes are lowered using the revenues from the environmental regulation. By doing this the tax-interaction effect can, partly or completely, be offset by the revenue-recycling effect. If the regulation does not result in any revenues or if they are recycled to the regulated industry, there will be no revenue-recycling effect. Goulder et al. (1997, 1999) show that the revenue-recycling effect can indeed be important for the efficiency effects of the regulation.

3.2.3. Heterogeneity of agents and policy implementation

One should not underestimate the political advantage of a grandfathering system. In practice, the choice of a policy instrument may be between grandfathered TEP and a CAC regulation, and then a grandfathered TEP scheme may still be preferred. We still believe that a minimum requirement is that some of the permits are auctioned, especially to reduce entry barrier problem of grandfathering. An alternative is to auction all permits, but refund the revenues to the airlines, much like the refunding system of the environmental NO\textsubscript{x} charge in Sweden (Sterner and Höglund, 2000). This solution would not be optimal, but it would at least reduce some of the problems that arise from of a complete grandfathering of the permits.

The most reasonable definition of an emission permit is that it is equivalent to a tonne of carbon, and that one permit allows the use of a quantity of fuel that contains a tonne of carbon. The cap for international aviation should be set in accordance with international agreements. We see no particular reason for why international aviation should have a less strict regulation than other sectors. After the initial allocation of permits, airlines are allowed to trade them. An airline will buy

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5A labor tax, for example, is distortionary in the sense that it increases the cost of labor relative to leisure and hence reduces the demand for labor.
more permits if the price is lower than the marginal abatement cost, and sell permits if the price is higher than the marginal abatement cost. Airlines will thus consider all possible alternatives for reducing emissions, including more fuel-efficient engines, reduced number of flights and increased ticket prices. Some of these measures can easily be taken in the short-run, while others such as investments in new aircrafts are long-run effects of the regulation. If no trade between sectors is allowed, total emissions will be equal to the cap. If trade between sectors is allowed, total emissions can be higher or lower than the cap, depending on the abatement costs relative to other sectors.

The experience from the SO2 permit system in the US is that flexibility in timing, in terms of banking permits for future use, was an important factor in its performance (Stavins, 1998). Zhang and Nentjes (1999) also argue that the permits should not be limited regarding in which period or place they can be used. Since CO2 is a uniformly mixed pollutant, restriction on the place does not make sense. However, regarding timing, there may be advantages in issuing time-restricted permits. In particular, given a grandfathering of the permits, a time-restriction of the permits would reduce the barrier to entry effect. Furthermore, the system can then more easily handle future reductions in the total number of permits. At the same time, there are efficiency gains of having a flexible system with respect to timing.

3.3. An international aviation emission charge

An environmental charge in terms of a passenger charge or a fuel charge would in general not be optimal, since it would not provide direct incentives for reducing the emissions. In the case of CO2 emissions, a fuel tax would be optimal since the amount of CO2 emissions only depends on the carbon content of the fuel type. However, other emissions such as NOx depend on factors other than fuel use. Since higher combustion temperatures tend to increase emissions of NOx, increased fuel efficiency may while decreasing emissions of CO2 and HC, increase emissions of NOx. In a so-called first-best setting, an optimal emission charge is equal to the marginal damage cost of the emission. With such a charge a firm would reduce its emissions until the marginal abatement cost is equal to the marginal damage of the emission. The emission/fuel charge should therefore ultimately be related to the marginal damage cost of CO2 emissions. However, if the goal is to reach a certain level of emission reduction, information regarding abatement costs and price elasticities is necessary. It would therefore be difficult to reach a certain goal of emission reduction by means of an emission charge. However, a regulator can iteratively change the charge until the goal is reached, or initially set the charge very high in order to reach the goal.

A large number of studies have estimated the marginal damage cost of CO2 emissions. Barker and Rosendahl (2000) estimate that a carbon tax of approximately 150 ECU ($0.18/kg CO2) per ton of CO2 is required for Western Europe to meet its Kyoto targets. Bleijenberg and Wit (1998) use $0.02 and $0.10/kg CO2 as the lower and upper bounds for the marginal damage cost. Here we will use the estimates by Bleijenberg and Wit for illustrating the effects of a carbon charge on international aviation. These estimates can be used when calculating the corresponding flight or fuel charge; the two estimates correspond to a charge of $0.06 and $0.316/kg fuel, respectively. Table 1 below gives estimates for two specific flights reported in Bleijenberg and Wit (1998).

For the B747-400 flight, the CO2 charge is equivalent to 30% of existing airport charges for the low estimate, and 140% for the high estimate of CO2 shadow prices.

Since the charge is directly linked to emissions, airlines would consider all possible alternatives for reducing emissions, including more fuel-efficient engines, reduced number of flights and increased ticket prices. The decision on how to react to the environmental charge is a complex decision, but airlines would generally try to reduce their CO2 emission for as the marginal cost of the reduction is smaller than the emission tax.

Bleijenberg and Wit (1998) is perhaps the most comprehensive study on the potential impacts of environmentally related charges on aviation. It focuses on charges levied on pollutants emitted by aircrafts in European airspace, but the conclusions that can be made are more general. A number of options are evaluated, the most relevant from our perspective being: (i) an emission-based charge on pollutants emitted by an aircraft in European airspace, with standardized charges

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Estimated CO2 charge for different flights</th>
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<tbody>
<tr>
<td><strong>Distance (km)</strong></td>
<td>500</td>
</tr>
<tr>
<td><strong>Load</strong></td>
<td>%67</td>
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<tr>
<td><strong>Aircraft</strong></td>
<td>F50</td>
</tr>
<tr>
<td><strong>Estimated cost</strong></td>
<td>Low</td>
</tr>
<tr>
<td><strong>Charge per flight ($)</strong></td>
<td>46.7</td>
</tr>
<tr>
<td><strong>Charge per passenger ($)</strong></td>
<td>1.1</td>
</tr>
</tbody>
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Source: Bleijenberg and Wit (1998).
for routes and engines. Pollutants included are CO₂, NOₓ, SO₂ and VOC. The revenues generated from the charge are allocated to the EU, which distributes the funds among the member nations. (ii) The same as the first alternative, but the revenues are instead recycled to the airlines based on the number of passengers- and tonne-kilometers produced. (iii) A fuel charge package, which consists of a fuel charge levied on bunkerfed fuel and an emission-based landing charge on pollutants emitted during the landing and take-off cycle. Further, certain engine standards are implemented in order to avoid increased NOₓ emissions.

The charge levels for these three options are estimated to correspond to a fuel price increase of approximately $0.20$/l (Bleijenberg and Wit, 1998), which is a dramatic increase. If the airlines increased the fares correspondingly, fares would increase by $4 for a short one-way trip and $10–15 for a long one-way European flight. However, in the long-run, considering the development of more fuel efficient and environmentally friendly engines, the increase in ticket prices is estimated to be approximately 25% lower than suggested above. Alam-dari and Brewer (1994) investigated possible reactions to an increased fuel tax on European airlines, by asking airlines to assess their reactions to a fuel tax. They discovered that the most likely reactions would be increased fares, replacement of less fuel-efficient engines, and cutting of costs in other areas of operations; however, a reduction in the number of flights was not one of the most likely reactions to an increased fuel tax. Wit and Bleijenberg (1997) also found that the most likely response, in the short-run, would be increased ticket prices.

Given a demand price elasticity of −0.8 and a number of assumptions regarding measures taken by airlines to reduce the environmental impact, Bleijenberg and Wit (1998) evaluate the environmental impact of the different charge options. The charges are evaluated in comparison to a 2025 business-as-usual scenario. In the business-as-usual scenario, CO₂ emissions are expected to increase by 190% compared to the base year 1992. With an emission charge of $0.2/l, the increase in emissions would instead be 100% compared to the base year. Consequently, even with a substantial increase in fuel prices, CO₂ emissions are expected to double by the year 2025. The relative performances of the charge options are similar, with alternative (ii) having a lower impact due to the recycling of the revenues. The reason why alternative (iii), the fuel charge, performs similar to an emission-based charge is the assumption of the accompanying emissions standards and an emission-based LTO charge. The economic distortions of a European fuel charge are expected to be relatively minor according to Bleijenberg and Wit. For scheduled carriers, it is expected that European-based carriers will, compared to other carriers, face a smaller improvement of economies of scale due to a reduction in the growth of the market. In addition, Bleijenberg and Wit argue there is a fundamental difference between the emission-based charge and the fuel charge. Half of the fuel charge can be avoided by an airline by shifting to an airport outside the airspace of the charge, while the effect of such behavior on the emission-based charge is minor since the charge is based on emissions in the European airspace. However, as discussed by Tsai and Petsonk (2000), it may be sufficient that one of the airports is situated in an Annex 1 country for total emissions to be covered by the regulation. Airlines can still fuel at airports outside the agreement and there may be incentives to locate European hubs outside the agreement. Consequently, compared to an emission-based charge, a fuel charge discriminates airports that are within the agreement in favor of airports outside the agreement, which would most likely be airports on the eastern border of the European Union.

The emphasis that the proceeds from the environmental regulation should be refunded to the aviation sector, either directly or earmarked for reductions of the environmental impact, is an understandable requirement. There are, however, several problems with refunding, similar to the arguments against a grand-fathering of emission permits. The incentives for adoption of cleaner technology are reduced (Höglund, 2000; Sterner and Höglund, 2000), and if the number of airlines is small, the incentives for emission reductions will be reduced (Carlsson, 1999). Furthermore, in the case of existing distorionary taxes, the tax interaction effect (see Section 3.2) cannot be offset by a revenue-recycling effect.

### 3.4. A comparison of the instruments

With regard to international agreements, we believe that an emission charge has one major disadvantage: the difficulty of knowing the effect of the instrument on total emissions. With an emission permit system, the effect will be known, while an emission charge would either have to be set very strict in order to ensure goal achievement, or it would have to be changed iteratively. If policymakers are risk-averse and do not wish to face the situation of not fulfilling the international agreements, they may end up with a regulation that is too strict. Clearly, there may be problems with fulfilling the international agreements with TEPs also, for example if a large share of the sources chooses not to comply with the regulation.

If we disregard the desire to reach a certain level of emission reduction, an emission charge is likely to be preferred under uncertainty. It is reasonable to assume that the marginal damage is essentially constant. This means that if marginal abatement costs are uncertain, an emission charge is preferred over emission permits.
(Weitzman, 1974). The reason is that the optimal policy depends on marginal abatement costs, and with an emission charge the total abatement varies with the marginal abatement costs. With TEPs, sources will have to abate irrespective of the abatement costs, which in the case of uncertainty can result in large losses. One alternative would then be to use a hybrid policy instrument. Roberts and Spence (1976) have suggested combining TEP with an emissions charge and a subsidy. In this hybrid system, sources are allowed to emit without permits, but have to pay the emission charge. Alternatively, sources can sell unused permits to the regulator. Consequently, if abatement costs are higher than was expected, sources could opt for the emission tax instead, and thereby reduce total abatement costs.

Other factors that affect the choice of policy instruments are: transaction costs, market structure and political feasibility (Stavins, 1995). Transaction costs in the permit market are important for performance. Higher transaction costs tend to reduce trade and raise permit prices; hence increasing total abatement costs. TEP regulations are sensitive to strategic behavior and can create barriers to entry. The success of a TEP thus critically depends on the market structure.8 There are a number of design issues for decreasing the possibility of strategic behavior, such as auctioning of permits and not grandfathering. Ironically, these design issues are also important for the political feasibility. Grandfathered permits are much more likely to be accepted by many of the actors than auctioned permits or emission charges. Finally, the importance of a functioning market with small possibilities of strategic behavior, also directs the attention to the benefits of allowing trading of permits across sectors and countries if a TEP scheme is chosen. Efficiency of the regulation increases with the number and size of the permit market.

4. Conclusions

What general conclusion about an environmental regulation can be made, given the premise that a regulation of CO2 emissions from international aviation is to be implemented? First, if possible to implement, an IB regulation is likely to be preferred to CAC regulations. Second, in practice the choice between an emission charge and TEP is more dependent on distributional and political considerations than efficiency considerations. An emission charge and a TEP with auctioned permits have more or less the same characteristics. The aviation sector is strongly opposed to environmental taxes on the grounds that environmental regulations should not have a fiscal motive. As we have discussed, environmental regulations impose an efficiency loss due to distortionary taxation, and therefore it may be important to use the revenues from the regulation to lower the distortionary taxes.

There is no reason why the aviation sector should have a less stringent regulation than other sectors, so the cap or the charge should be set in accordance with the international agreements. The most difficult question with a TEP is how the permits should initially be distributed. A grandfathering of the permits is likely to have negative efficiency effects and it is a positive discrimination of existing airlines. Grandfathering is also bound to create a discussion about how the permits should be distributed. We would therefore recommend an auctioning of the permits, and not a grandfathering. Clearly, it would be important that all countries involved in the regulation would apply the same type of distribution to the airlines. Two possibilities that should be further investigated are to refund the revenues back to the airlines and earmarking the revenues to, for example, research in more environmentally friendly engine technologies. An additional design of the TEP that should be considered is to allow for additional emissions at a fixed emission charge level, or alternatively that an additional number of permits are issued if the permit price is higher than a predetermined level. This charge or level could change over time. The advantage of such a hybrid design is that the total abatement costs would be known.

References


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8 Although it should be noted that optimal environmental charges also depend on the market structure, see for example Simpson (1995) and Carlsson (2002).
International Civil Aviation Organization, 1996. ICAO Council Resolution on Environmental Charges and Taxes, ICAO.