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The Economics of CO$_2$ Emissions Trading for Aviation

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SUMMARY

1. INTRODUCTION

There has been a growing interest in the environmental impact of aviation, both in terms of noise and aircraft engine emissions. Discussions have included both mitigation measures and methods of internalisation of these environmental costs also described as the principle of polluter pays;

This paper focuses on CO_2 emissions from aircraft engines, which have both local and climate change implications, and where the emphasis of most recent discussions has centred. These have taken place at an international, regional and local level; The Kyoto Protocol addresses measures to limit and/or reduce the emissions of greenhouse gases in the transport sector in Article 2(1), and in Article 2(2) directs the Annex I (developed) countries to pursue these goals through the International Civil Aviation Organization (ICAO) with regard to international aviation. The standing Committee on Aviation Environmental Protection (CAEP) of the International Civil Aviation Organisation (ICAO) was asked to investigate proposals for emissions trading, in addition to ICAO's role in setting international standards for engine emissions. CAEP recommended and ICAO accepted the endorsement of an emissions trading scheme (ETS) for international aviation, the establishment of an open voluntary aviation ETS and the provision of guidance to contracting states on the incorporation of international aviation into domestic schemes. The guidance has been issued but so far no voluntary scheme has been established. Regional schemes such as the European Union (EU) ETS were welcomed but only if the countries of all participating airlines were in agreement. The EU aviation ETS was thus not supported by ICAO. At the regional level, the European Commission's 2006 proposals for the inclusion of aviation in the EU Emissions Trading Scheme (ETS) were finally adopted in 2008 in amended form, most of the details of how it would be introduced in its Directive 2008/101/EC that was published in January 2009. The EU has also set limits on local air quality that affects emission levels around airports, especially from NOx. Thus in Europe, aviation is likely before too long to be required to control or pay for both its local and climate change impacts of aircraft engine emissions. Up to now this has only been subject to longer term changes through increasingly stringent ICAO standards for NOx applied to new aircraft engines during the landing and take-off cycle (but not cruise). Air transport has also been taxed at the country level, with both domestic and international flights included, although these are usually based on passenger numbers with no incentives for reduced emissions.

At the local level, a few airports have introduced emissions charges, and local air quality has become an important issue in airport expansion applications (eg London Heathrow).The pollutants considered as the main ones emitted from aircraft movements (Woodmansey and Patterson, 1994) are CO_2, PM, SO_2, NO and HC. The first, CO_2, has lower unit social cost than the others, but the total amount emitted is far larger (especially for the cruise part of the flight). Social costs are defined as the damage to human health, vegetation, buildings and climate change. Their valuation is discussed in Mayeres *et al.* (1996) and Perl *et al.* (1997). The other pollutants account for a lower weight of emissions but have higher unit social costs. CO_2 is estimated to have the longest life (50 to 100 years) followed by methane (eight-ten years), with NOx lasting only a number of days or weeks. However, the global warming impact from aviation is compounded by the emissions of NO and water vapour in the upper atmosphere, the

latter sometimes leading to contrails and cirrus cloud formation (these effects are summarised in Annex 2 of European Commission, 2005). This is difficult to deal with through an ETS and it is intended to address it through other measures, one of which (standards) is discussed below.

Europe is the region of the world with the greatest pressure to reduce emissions, and it is also the region where almost all of the countries have ratified the Kyoto Convention. The EU has also pushed for the inclusion of environmental impacts in the EU/US aviation bilateral agreement. Growing concern is also evident in other world regions, reflected in the work programme of ICAO referred to above.

The first section of this paper will discuss policy options for aviation in the light of the post-Kyoto pressures for action at an international level. An increasing priority is evident with the lead up to Kyoto 2 in Copenhagen at the end of 2009. Emissions trading will then be examined in the light of the inclusion of aviation into the EU scheme, focusing particularly on the method of allocation and possible distortions that a regional scheme such as this might produce. Next, the likely impact of the EU ETS will be assessed in terms of costs, followed by a discussion of potential price strategies and their effect on demand.

2. THE POLICY OPTIONS FOR AVIATION

The first policy option might be some sort of rationing or upper limit on the number of flights operated. This would be almost impossible to administer fairly at an international level. For an individual country it could be implemented at the level of an airport, and this is effectively already done on a selective basis at certain airports. Runway movement constraints and conditions imposed on building new runways has the effect of limiting hourly and annual aircraft movements, although more passengers can be carried by using larger (and more fuel efficient) aircraft.

The second option is to setting stricter standards for new aircraft and engines. There is an existing framework for this at the international level (ICAO) although existing standards are considered to give little incentive to speed up the application of technology to reduce emissions. The standards are for new aircraft and cover only NOx, CO and Hydrocarbons during the landing and take-off cycle up to 915m in altitude. These are recommended standards which still need to be incorporated into national legislation. Standards have been set so as not to force the early retirement of aircraft from fleets. A major problem here is the economic life of aircraft and the high costs relative to emissions saved involved in early retirement (Morrell and Dray, 2009).

A third way is by replacing fossil-based fuels with so-called 'drop-in' biofuels which offer very low greenhouse gas emissions. This option is thought by some airlines to be a solution by itself, but the Group on International Aviation and Climate Change (GIACC), set up by the ICAO, proposed a basket of measures which included both biofuels and economic/market-based measures (ICAO, 2009).

A fourth path is through voluntary targets. These have been introduced by many airlines, airline trade associations and aircraft and component manufacturers (*e.g,* through the targets for new aircraft in ACARE, 2002). Airlines usually set targets at between 1-2% a year improvement in fuel efficiency; given longer term traffic growth of four-five%, this does nothing to cap or reduce emissions, but does slow their growth.

None of the above options use market mechanisms to offer incentives for emission reductions, and neither do they incorporate the principle of "polluter pays". This can be achieved either by capping emissions at a given level and allowing entities to buy and sell emissions permits according to whether they are above or below the cap. These are called Emissions Trading Schemes (ETS). Depending on how much of the cap is allocated without cost, entities will pay for their pollution by acquiring additional permits at the 'market price'.

As governments prepare for the UN climate change meeting in Copenhagen (December 2009), the world airline trade association, IATA, has proposed a global sectoral approach for aviation in the successor to the Kyoto Protocol (IATA, 2009). Under such approach, aviation's emissions would be capped and accounted for globally, not by states. IATA would work with ICAO to ensure compliance. Airlines would get carbon credits for every 'environmental' payment, whether in taxes, charges or ETS payments to avoid double counting. It should be noted that there is a number of sizeable airlines that are not members of IATA, and ICAO at present has no power to enforce such a scheme.

The alternative is a fuel or emissions taxes. These would need to be coordinated globally, and would give a long-term signal enabling investment in fuel efficiency. The level of tax would need to decided, but this could be lowered with increased market fuel prices and vice versa, to improve incentives. Implementation would have to be at a country level and there would be a high chance of the revenues collected not being directed to environmental projects. However, the real problem would be to remove a clause in international Air Services Agreements that forbids any kind of fuel tax or levy. These form the basis for international route rights, although their importance has declined with the growth of open aviation areas such as the European Aviation Area.

Emissions trading schemes are becoming more widespread with the EU ETS started in 2005 and a similar scheme (RGGI) for (concerning?) seven states in the northeast of the United States, capping CO_2 emissions at their 1990 level. Voluntary schemes have been launched domestically in the United Kingdom (British Airways participated) and Japan. More recently, both the Australian and New Zealand governments have been planning on introducing a cap and trade scheme to control industrial emissions including those from domestic aviation. These schemes are similar to the EU one, except they have an initial cap on the carbon price paid, exclude international air transport and, for domestic flights, issue permits to fuel suppliers rather than airlines. New Zealand gives domestic aviation a two year delay before it is included.

In the United States, the Waxman-Markey Amendment was narrowly passed in the House of Representatives and will shortly be debated by the Senate. This bill would introduce a cap and trade scheme but only applied to ground based emitters. The bill deals with aviation through stricter standards on new aircraft from 2013.

Introducing an aircraft engine emissions trading scheme has been studied and discussed since the 1990s, both at the world and regional levels. Considerable analysis has been applied to an international scheme by the ICAO's CAEP mentioned above. The reluctance of the United States to be involved and other problems have meant that actually introducing such a scheme at a world level is unlikely for the foreseeable future.

In Europe, the focus switched from a preference for emissions charges and taxes (European Commission, 1999) to emissions trading as the best way forward. A European scheme is now almost certain to become reality for air transport in 2012. The European Commission published an earlier study on economic incentives to mitigate greenhouse gas emissions from air transport in 2002 (CE Delft, 2002). Their analysis was limited to two policy options: an environmental charge and a Performance Standard Incentive (PSI). The latter was based on emissions per unit

of output, but did not address the allocation of permits or trading. In a later study, it concluded that the most effective way of meeting its policy objectives were:

- Emissions trading
- Emissions charges

Both the above are economic instruments that would lead to the internalisation of the cost of climate change. Each could, in principle, be designed to achieve the same level of emissions reduction (European Commission, 2005).

GAO (2009) argues that an emissions tax is "generally a more economically efficient policy tool to address greenhouse gas emissions than other policies, including a cap-and-trade program...."(reference) This is because "...it would better balance the social benefits and costs associated with emissions reductions." (reference) However, both the tax and cap need to be set at the right level and an aviation tax would have to be agreed internationally. The ETS also has the potential to achieve emissions reductions at the lowest cost or impact on GDP. Yet, as with a tax, the cap could be set at the wrong level, although in this case, the efficiency loss would be greater than setting the tax at the wrong level (Stern, 2006). Those industries with lower abatement costs, such as coal fired power stations, would sell allowance to those with much higher marginal costs, such as air transport. Aviation has already exploited many of its lower abatement cost options as a result of its dependence on highly priced kerosene, and is thus likely to need to purchase allowance from others to expand. This underlines the importance of an aviation scheme with open trading.

A study by CE Delft (2005) for the European Commission examined concepts for amending Directive 2003/87/EC to address the full climate change impact of aviation through emissions trading. The study concluded that aircraft operators would be the best entity upon which to base the system, with allocation decided at the EU, rather than individual member state, level. It also came out in favour of including only CO_2, at least initially. It looked at the possibility of restricting the scope to intra-EU flights, as well as including all flights to/from EU airports. This, and other main recommendations of the study, formed the basis for the scheme that was adopted.

As to the allowance allocation method, the study reported that "auctioning appears to be the most attractive option for allocation". This was because it was the most efficient method, it treated new entrants and incumbents equally, it provided credit to airlines taking early action and it involved the issuing authority with lower data requirements. On the other hand, it imposes a greater financial burden on the industry. Their second-best option was benchmarking, and the least attractive was grandfathering, although either of these could be combined with the other method.

3. EMISSIONS TRADING AND AIR TRANSPORT

3.1. The principles of the EU aviation ETS

Following the proposal at Kyoto, the ICAO's Committee for Aviation (CAEP) considered and evaluated measures to reduce aviation emissions including the possible introduction of an ETS. It concluded that fuel taxes were impossible to introduce and encouraged regional emissions trading initiatives (subject to third country agreement). Thus, nothing was likely on a

global scale. In the meantime, the EU moved ahead with the incorporation of aviation into its existing ETS that was implemented for other ground-based polluting industries from 2005 (onwards)

The EU Directive for aviation was finally introduced in January 2009, and its provisions are expected to be incorporated into the legislation of each member country by the end of the year (European Parliament and Council, 2009):

- Includes aviation in the existing scheme for greenhouse gas emission allowance trading
- First year 2012
- All flights to/from European Community airport
- Various exemptions including smaller aircraft, military, training and rescue flights
- Greenhouse gases cover only CO_2
- Cap based on actual emissions averaged across calendar years 2004, 2005 and 2006
- Cap set at 97% of baseline in 2012, and 95% for 2013 to 2020
- Emissions allocation based on benchmark
- Initially 15% of allowance to be auctioned
- Provisions for free allowance to be given to start-up airlines (with no operations in 2010) and those of which the Revenue Tonne-kilometres (RTKs) are growing by more than 18% pa

Some details were still to be finalised, such as the method of auctioning and the percentage of auctioning in subsequent years. The baseline 2004-06 cap is expected to be published later in 2009, and the actual amounts allocated to airlines will have to await the 2010 shares of RTKs.

From the time of publication of the European Commission's first proposal (2006) and the emergence of the Directive, there was considerable industry lobbying and studies, and the stronger role of the European Parliament is also reflected in the outcome. The latter proposed that the Commission's original proposal of a 100% cap was reduced to 90%, with all flights included from 2011 (not just the intra-EU flights in the original). The European Parliament Green Party was advocating 100% auctioning, with the Parliament settling on 25%. This crucial variable was initially set at 15% for 2012 but left open for 2013 to 2020, presumably dependent on how other industries in the scheme are (were to be) treated. Given the state of the economy in general and the air transport industry in particular, it would not be surprising to see little change in the auctioning share.

Taking British Airways as an example, 85% of its 2004-06 aircraft emissions of around 16m tonnes CO_2 would be worth €544m at a CO_2 price of EUR40 per tonne. This gives an average of EUR16 per passenger, many of which are on long-haul sectors. New entrants might be deterred in a limited way by this free allocation. However, a fund will be established both for new entrants and those airlines growing by more than 18% a year. The Directive states that 3% of the total allocation of allowances shall be reserved for such applications, with a maximum of 1m allowances per airline. Since there are unlikely to be any fast growing airlines, all or most of this should be available to start-ups, with the upper limit allowing the new entrant up to between 2m and 5m passengers a year, depending on business model and length of haul.

3.2. Benchmarking

There are two different approaches to the allocation of the free allowances: grandfathering and benchmarking. The former gives airlines allowances in proportion to their emissions in the

base year or years, while the latter seeks to reward those airlines that have already taken steps to reduce their emissions through investment or improved operations. Benchmarking penalises those airlines that are less efficient than the 'average' and rewards those that do better. The 'average' can be formulated in different ways.

Benchmarking using a traffic rather than capacity metric has the advantage of rewarding airlines that have already introduced efficient aircraft, and those that achieve higher efficiency than their competitors. It is thus favoured by airlines that have high passenger load factors, *e.g.*, Low-Cost Carriers or LCCs (Frontier Economics, 2006).

Benchmarking involves the determination of a baseline efficiency measure, say RTKs per tonne CO_2, fixing an overall CO_2 cap, and allocating CO_2 allowances depending on an airline's share of RTKs. This was the EU aviation ETS approach:

$$RTK_{total} = \sum_{i=1}^{n} RTK_i \tag{1}$$

$$E_{total} = \sum_{i=1}^{n} E_i \tag{2}$$

$$A_i = \frac{(E_{total})}{RTK_{total}} * RTK_i \tag{3}$$

n = number of airlines taking part

RTK_{total} = Total RTKs in the reference year (calendar 2010) for those taking part

RTK_i = Total RTKs performed by the airline i in 2010

E_{total} = Emissions assigned to all airlines in the base period 2004-06 (average)

E_i = Emissions assigned to airline i in the base period times 97% (less amounts reserved for new entrants and fast growers) in the first year and 95% subsequently

A_i = Emission allowances assigned to each airline for each of the years 2012 to 2020

First, this method puts a smaller burden on those airlines operating with high load factors and over longer sectors. Second, those airlines flying shorter sectors would tend to be penalised, although Sentance and Pulles (2005) argue that this would encourage passengers to take less polluting forms of transport, such as rail. The latter distortions could be addressed in alternative benchmark approaches, but with increased complexity (Morrell, 2007). Other distortions are addressed in Faber *et al.* (2007).

Figure 1 shows a hypothetical example of the difference in allocation using the EU ETS proposed method of benchmarking. The average fuel efficiency used in the allocation (assuming the base and reference year emissions are the same) is likely to reflect a relatively long sector length, given the inclusion of routes to/from non-EU countries. Taking 1,000 nm or 1,852km as the average, operators of identical aircraft types could get 1.4 tonnes of free CO_2 allowance more than it actually emitted over its longer than average sector length or 2.6 tonnes less than it emitted. A similar relationship would apply to the latest technology aircraft of this size (B737-700) and equivalent Airbus types (*e.g.,* the A320 family). It should be added that for routes of this traffic density a more fuel efficient aircraft would not be currently available.

If these allowance shortfalls are monetarised using a CO_2 price of EUR40 per tonne, the extra costs incurred by the 230km operator would be EUR103 per flight or less than one euro per passenger.

Figure 1. **Impact of benchmarking on B737-400 flight with hypothetical average at 1,850km sector length**
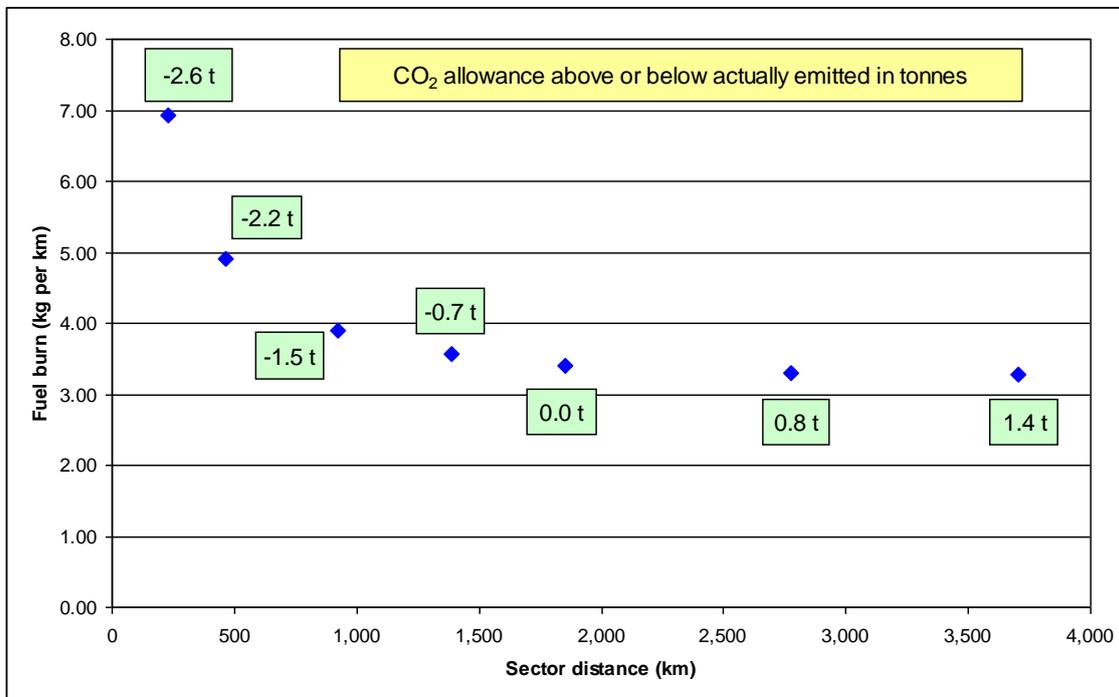
The use of RTKs rather than ATKs might be considered to favour Low-cost carriers (LCCs) at the expense of network carriers. LCCs would favour the RTK metric which would inflate their share of the reference RTK total used for allocation relative to the network, lower load factor airline. However, the cost of additional allowance required by the LCC would be a higher share of its average ticket price. Furthermore, the network airline would have fewer passengers to pass on the cost to, but more passengers that were less price-sensitive and the cost would be a lower percentage of the average ticket price. The network carrier is making a choice to offer fewer seats and operate at a lower load factor to encourage higher yielding (less price-sensitive) passengers.

3.3. Distortions from the EU ETS scope

Air travel markets are often served on a multiple sector basis, especially longer haul ones. Such markets cannot always be operated non-stop, but a one-stop service can be attractive in terms of price, timing, earning frequent flyer awards, etc. An example given by EU carrier Finnair (Ihamäki, 2009) is the New York/Delhi market:

- New York - Helsinki - Delhi (11,821km) served by Finnair
- New York - Dubai - Delhi (13 229km) served by Emirates Airlines

There is no non-stop flight serving this market. The two sectors operated by Finnair would emit an estimated 294 tonnes of CO_2 while the Emirates flights 326t. Finnair would have to submit an equivalent amount of allowances under the EU ETS, while both Emirates sectors

would be outside the ETS scope. Taking EUR40 per tonne CO_2 would result in Finnair paying EUR11,740 or EUR43 per passenger.

It should be added that the Finnair is serving the New York/Delhi market using more fuel efficient sector lengths. Fuel burn per kilometre flown generally declines up to around 4 000km to 6 000km in length and then starts to increase due to the additional fuel required to carry the larger fuel load (Peeters *et al.*, 2005). This is more pronounced and at the lower end of this range for flights with very high load factors, as is often the case today. One estimate suggests that serving the market with one long non-stop flight might add 4% to total fuel burn, allowing for the landing and taking off at the intermediate stop (Green, 2002).[i] Thus, in the above example, an additional 13t of CO_2 is emitted due to this effect (+4%), the remainder due to the longer overall distance flow (+1,408km).

On the other hand, Emirates would burn an extra 32.2t of jet kerosene, or 3,292 US gallons from its indirect routing. At the peak mid-2008 price of USD4 per US gallon, this would mean extra costs of USD13 168 or $48 (EUR34) per passenger. Thus, Finnair's ETS cost disadvantage is offset to some extent by the extra fuel cost incurred by Emirates, assuming the high fuel prices experienced in 2008. Other flight time related costs such as aircraft and engine maintenance would also be higher for Emirates.

An alternative and probably more common pattern would be to locate the sixth freedom traffic hub to the East of the EU rather than within it (as per the last example). These are hubs such as Dubai, Mumbai, Singapore and Bangkok that can attract traffic between Australia, the Far East and to a lesser extent Africa and the EU. An example that does not require much extra flying is London/Singapore:

- London - Singapore (10 851km) served by British Airways non-stop
- London - Dubai - Singapore (11 304km) served by Emirates Airlines via its hub

The two sectors operated by Emirates would emit an estimated 415 tonnes of CO_2 using a B747-400 aircraft while the non-stop British Airways B747-400 would emit 387t. Emirates would have to submit allowances only for its first sector under the EU ETS, or 200t. British Airways' entire flight would be within the ETS scope, with allowances required for 387t of CO_2. Taking EUR40 per tonne CO_2 would result in an Emirates' London/Singapore passenger paying an ETS charge of EUR24 and a British Airways' passenger EUR43.[ii] In this example, Emirates would consume an additional 8.9 tonnes of fuel, which would approximately cancel the difference at fuel prices of USD4 per US gallon of jet fuel (an additional fuel charge of USD32 or EUR23 per passenger). In this case, the one-stop route provides the most fuel efficient mode of operation.

Longer routes, such as between the EU and Australia, might confer an even larger advantage on sixth freedom carriers located outside Europe along this 'Kangaroo' route. However, no airline can operate non-stop and much would depend on whether the EU ETS applied to the initial destination outside the EU, as would appear to be the case.

The question arises as to whether EU carriers could overcome this disadvantage by making use of their own or their partners' non-EU hubs. Setting up their own hubs outside the EU is at present severely restricted by their lack of traffic rights under third country Air Services Agreements. Most major network airlines are members of strategic alliances and could make use of such hubs through code sharing or joint ventures.

An example of this is the Hamburg/Los Angeles market which Lufthansa currently serves via its Frankfurt hub. This involves a two sector operation but with the economies of scope that are available from combining other markets through the hub (*e.g.,* Berlin/Los Angeles, Bremen/Los Angeles, etc.). A non-stop Hamburg/Los Angeles flight has very limited feed at

both ends of the market, and is unlikely to be economic. The relative viability of the non-stop flight would only be marginally improved from the saving of ETS allowance costs as a result of more direct flying, without the extra take-off and landing.

Lufthansa's major alliance partner in the United States is United Airlines, and it could operate a joint service, say, Hamburg-Washington DC-Los Angeles with the first sector operated by Lufthansa (and subject to ETS) and the second sector by United (not subject to ETS), with its own code. The Washington-Hamburg DC flight might be operated by a reasonably fuel efficient aircraft, since it would benefit from feed traffic from the Americas to/from Hamburg, but this is already available to United without ETS or Lufthansa involvement. Lufthansa will have limited feed to provide from the Hamburg end, and thus United gain little from such co-operation with the EU carrier.

Overall, EU carriers' increased use of non-EU hubs operated by alliance partners will not be much of a solution for them, given that the net cost incentive will be small. It would weaken their own strategic position and probably reduce the number of viable long-haul flights that they could operate, with limited alliance benefits. Any attempt by the EU to try to levy a charge on the non-EU sectors connecting to flights to/from EU airports would achieve little environmental gain in return for a serious diplomatic backlash.

Finally, since rail is not included in the ETS, there is the potential for some change in the distortion between the two modes, especially high speed rail (apart from that stemming from other taxes or subsidies). Little research has been done on any likely impact, but a recent study of the effect of the Dutch government tax on air tickets of EUR11.25 per departing European passenger estimated only a "slight shift to car and train" (Jorritsma, 2009). The tax was subsequently withdrawn.

4. THE APPLICATION OF THE EU AVIATION ETS

4.1. Allowance costs

The final cost of acquiring the necessary allowances for the first year of the scheme will not be known until the end of 2012, when airlines have a last chance to purchase them in the market. Even the initial free allowance cannot be estimated until the 2010 RTK traffic has been reported.

Table 1 shows the range of possible impacts of ETS allowance costs on air fares and profits. The earlier studies assumed that only departing flights from EU airports would be included. Even if 100% of the cost of allowances is passed on, the impact on an intra-EU flight is unlikely to exceed EUR5 per passenger at what are historically relatively high market prices of CO_2. Long-haul passengers could pay up to EUR40 on these assumptions, but this attributes none of the costs to the cargo shippers (see below).

Table 1. **Summary of previous EU aviation ETS impact studies**[UW1]

	Short-haul	Medium-haul	Long-haul
European Commission (2006)[1]			
€ per return ticket impact:			
Allowance price: € 6 per tonne	0.90	1.80	7.90
Allowance price: € 30 per tonne	4.60	9.00	39.60
CE Delft (2005)[1]			
€ per return ticket impact:[2]			
Allowance price: € 10 per tonne	0.20	0.40	1.00
Allowance price: € 30 per tonne	0.70	1.30	2.90
Ernst & Young - York Aviation (2007)			
€ per return ticket impact:	*Low-cost*		
Allowance price: € 30 per tonne	0.81		
Average one-way fare €	47.44		
Percent increase in fare	1.7%		
Change in demand (elasticity -1.5)	-2.6%		
UK Defra (2008)			
Impact on airline profits			
Price elasticity 1.1-1.3	8-18%		9-20%
Price elasticity: 0.6-0.7			15-20%
Frontier Economics for ELFAA (2006)			
€ per return ticket impact:	*Low cost*	*Full service*	
Allowance price: € 27 per tonne	2.72		5% of av.fare
Allowance price: € 40 per tonne	4.00		8% of av.fare
Change in demand (elasticity -1.5)			
Allowance price: € 27 per tonne	-7.5%	-2.0%	
Allowance price: € 40 per tonne	-12.0%	-3.0%	
Merrill Lynch (2008)			
€ per return ticket impact:	*Low cost*	*Full service*	
Allowance price: € 30 per tonne	1.54	3.52	

1. ETS scope restricted to only departing flights from EU airports
2. Assuming that the 100% free allowance is not valued and passed on in higher fares.

The European Commission commented that at an allowance price of EUR30 "these ticket price increases are modest. Their modesty is also demonstrated by the very limited impact they have on reducing forecasted demand ..." (European Commission, 2006).

The allowance prices assumed are generally based on past market prices. However, studies have suggested that air transport is likely to be a purchaser of allowances given its growth rate and its marginal cost of abatement. This and a tighter scheme for ground based emitters could push up the market price of CO_2 to well above the EUR30-40 assumed above. The consultants 'Green Aviation' forecast prices in the range of EUR30-50 in the 2012-2013 timeframe.[iii] Airlines can purchase CO_2 emissions derivatives well in advance of the first year in which allowance for their own emissions needs to be found (2012). There will therefore be winners and losers in such trading activity. Auction prices for European Aviation Allowances (EUAAs) are unlikely to go above the market or future prices for European Allowances (EUAs) at the time, since the former can only be used by other airlines.

As Figure 2 shows, there is quite a strong correlation between oil and carbon prices. Electricity generators have a large influence on the carbon market price, and when the price of oil is high, they switch to 'dirtier' coal which needs to be covered by a greater number of allowances which are likely to have to be purchased in the market. This means that airlines

could be faced by increased volatility of combined fuel and fuel emissions costs, some of which will be smoothed out by hedging. It should be noted that the CO_2 prices quoted here are for EUAs. These are used by ground based emitters in the scheme but can be purchased in the market and submitted by airlines. Airlines are allocated EUAAs which can only be submitted by airlines and not the other emitters. There is likely to be a spot and futures market for EUAAs but with much less trading and liquidity than the ones for EUAs and other instruments.

Figure 2. **Jet kerosene spot and Carbon futures (EUA) market prices**
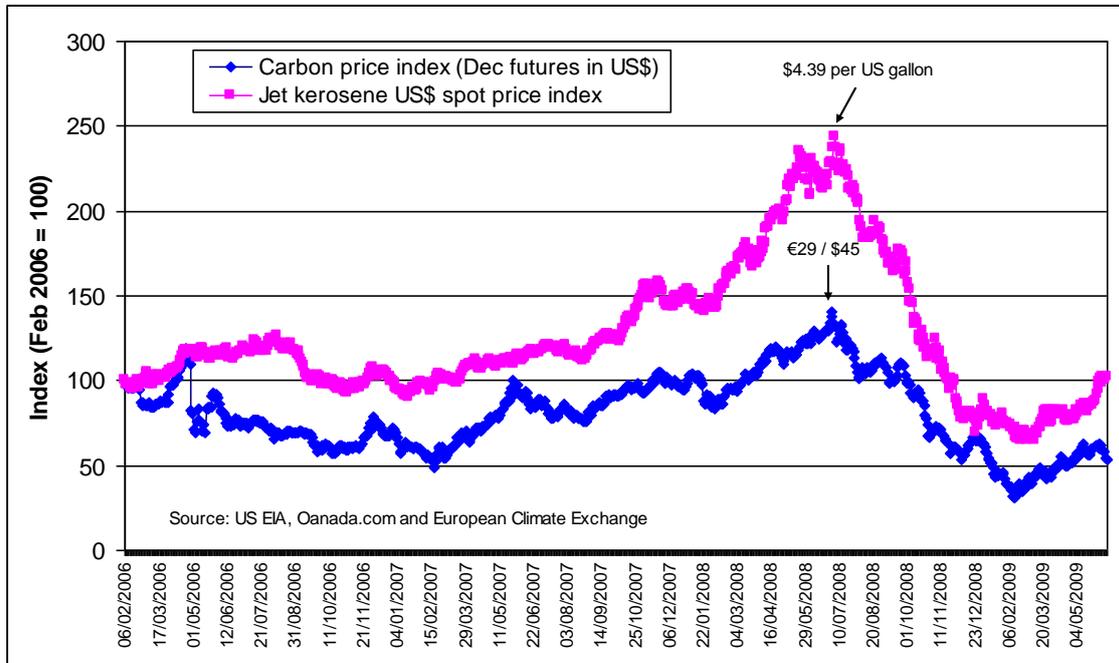
The above studies generally concluded that the impact on LCCs would be lower per passenger, but higher in terms of percentage reduction in traffic. This conclusion is arrived at using similar elasticities and the higher share of ETS surcharge in relation to their average fare, which could be as low as EUR40-50.

None of the above studies passed on the allowance cost for each flight to the cargo shippers, even though they account for a sizeable part of the payload on long-haul flights. The European Commission's analysis (based on CE Delft, 2005) took a B777-300 for their long-haul assessment and passed on the estimated long-haul allocation of EUR9,422 per flight to the 238 passengers carried (340 seats at a passenger load factor of 70%), giving EUR39.60 per passenger at a CO_2 price of EUR30 (see Table 1). These should be doubled to allow for the fact that the scheme covered both arrivals and departures at EU airports (which would only affect flights between EU and non-EU airports). However, the long-range B777-300 can carry up to just over 25 tonnes of cargo in the lower deck compartment (depending on cargo density) or around 40% of total payload. If only 60% of ETS costs are allocated to passengers rather than the full 100%, the impact on the long-haul ticket price would be €47 rather than just under EUR79. This should be viewed against airline fuel surcharges which, in June 2008, reached a peak of £218 (EUR275) per long-haul flights of more than nine hours on British Airways.[iv]

The Ernst & Young and York Aviation study (2007) was commissioned by airline trade associations covering all business models. It concluded that a large part of the ETS costs would have to be absorbed in reduced profits, with network airline operating margins reduced from 4% to 2.4% (for a CO_2 price of EUR30 per tonne), passing on around 35% of ETS costs to

passengers. Low cost carriers would face margins reduced from 15% to 11.1%, passing on 30% of costs.

4.2. The impact on airline pricing

The costs incurred by airlines as a result of the EU ETS can either be absorbed in reduced profits, passed on to the consumer in higher fares and rates or a combination of the two. Profits could also be enhanced by passing on the value of free allowance received (opportunity costs) or passing on over 100% of the costs incurred. Previous studies do not always make it clear whether they also include these opportunity costs, and it is assumed they do not where they are not specifically identified.

One consideration is the possible marketing advantages of including the ETS charge as a separate add-on to the fare. This might be attractive to some passengers in confirming that the polluter is paying (and to the airline in withdrawing its voluntary offset mechanism). In this case, the non-EU airline gets a clearer signal from its competitor and can include a similar charge but reduce the underlying fare accordingly.[v]

The European Commission's impact assessment assumed that airlines would be able to pass on all of the allowance costs incurred. This was based on CE Delft (2005) assumptions:

- All of the extra costs of ETS allowance would be passed on in markets subject to the ETS
- Cross-subsidisation between services subject to ETS and those outside it would not occur because this would imply raising fares in non-ETS markets to offset fare reductions in ETS markets; if this increased profits it should be done regardless of the EU ETS
- There is no empirical evidence either way on the pass through of the opportunity costs, so their evaluation included both approaches

The IATA (2007) assumed that 75% of the ETS allowance cost would be passed through to higher fares or a CO_2 surcharge. Merrill Lynch expects that operators will try to pass on "as much as possible of the cost of emissions allowances to customers." (reference)

UK Defra (2007) concluded that 'the rate of cost pass through is likely to be around 100%, for aviation as a whole, with variations by sub-market'. The variations ranged 'from 90% to 120% for most aviation services.' This was based on a largely theoretical analysis by a consultancy, Vivid Economics, depending on the nature of demand, competition, and whether firms seek to maximise profits, market share or sales.

Some studies differentiated between flights to/from congested airports, where none of the additional costs would be passed on, and uncongested airports where all of the costs would be added to fares (Oxera, 2003). Frontier Economics (2006) calculated a differential impact on low-cost and network carriers, suggesting that not all of any increase in costs due to ETS would be passed on in higher prices by the LCC: "the impact of ETS on aviation prices in general and in any particular market would in practice depend on the elasticity of demand (and supply) in the relevant market." This study assumed a price elasticity of demand of -0.8 for the network carrier's short/medium haul network, and -1.5 for the LCC. This gave a 2-3% reduction in demand for the network carrier as a result of passing through all of the EUR4 per passenger ETS cost, but a 7.5-12% drop for the LCC. The network carrier could pass on all of the EUR4 per passenger increase with no fall in revenues, but the LCC would suffer a revenue decline of 2.5-4% if it did so. This analysis ignores the more price elastic passengers carried by airlines such as British Airways (a large part of its non-premium leisure passengers which accounted for

58% of total traffic in 2007[vi]), and the less price sensitive traffic on LCCs (eg foreign property owners).

Other studies took the more realistic line that ETS costs might be passed on to certain markets or market segments. This is cross-subsidisation which occurs where an airline uses profits it makes in one market or market segment where it has market power, to support low prices in other markets or segments which are subject to greater competition. Markets are usually defined on a city or airport pair basis. However, they could also be the various market segments travelling on the same city-pair, often simplified to premium and economy passengers. Cargo is another segment carried on the same flight but often disregarded.

Premium passengers are generally thought to be price inelastic and economy price elastic, although there are sub-groups within each category that behave differently. Increasing premium prices and reducing economy fares would thus be expected to increase revenues, other things being equal. Some commentators think that this has been exploited to the full and that premium or business passengers are becoming more price elastic. Airlines are also keen to increase their share of premium passengers on competitive routes because they are generally more profitable (apart from those travelling first class). In Europe, this is likely to take the form of discounting premium transfer passengers (those connecting at their hubs) but not non-stop markets to/from their hubs.

In the context of the EU ETS, the routes in question will involve all airlines (EU and non-EU) incurring additional costs from the need to purchase emissions permits. These costs would lead initially to lower profits. All carriers could pass on the additional costs to the passengers in higher fares in the same way as fuel surcharges, but in highly competitive markets they may prefer to absorb the costs in lower profits or take steps to reduce other costs (such as labour) further to compensate. In this context, airlines appeared much more successful in reducing non-fuel costs during periods of very high fuel prices. Reduced profits would also lead to a higher cost of borrowing, less ability to invest in more fuel efficient aircraft and more competitive products. This would reduce their ability to compete with non-EU carriers in the future. Non-EU carriers could take a hit on profitability much more easily, since the markets in question will probably account for a small part of their total revenues. They could also much more easily absorb the costs across the rest of their network.

Some of the previous studies have discussed 'profit maximisation' and an 'equilibrium situation' but this is likely to be an oversimplification, and in reality, airlines are responding to many changes in both demand and supply as the date of departure of the flight approaches. In the short term, airlines tend to try to maximise revenues, with costs relatively fixed. This amounts to profit maximisation but on a dynamic and network basis. Each market's revenues are spread over a number of sectors such that profit maximisation can only be viewed on a network basis; this offers considerable scope for cross-subsidisation that has nothing to do with ETS (e.g., short-haul feeder routes from profits from long-hauls).

The market segment that this is likely to focus on is the premium traffic, since the marginal revenue gained from attracting these passengers far exceeds marginal costs. However, price is only one of a number of important factors governing premium traffic purchase decisions, the ticket for which is usually purchased by the company rather than the individual (Brons *et al.*, 2002). Others include:

- Frequent flyer programmes
- Corporate agent and travel manager incentives
- Product features (flight timings, service levels, frequency, etc.)

The last is difficult to adjust on a shorter term basis, and one carrier may have a marked advantage that is already reflected in market share and yield. The first two factors are also very

important and give the home carrier a built-in advantage that small price changes would not easily shift (*e.g.* British Airways in the markets with UK origin or destination). This applies to home market sales, and explains why premium sales in adjacent markets (British Airways' sales in, for example, Germany connecting with their long-haul flights to/from London) are much less dependent on the first two bullet points above and easier to attract. Thus, cross price elasticity in the non-stop home markets is relatively low and in the multi-stop (hub-feed) markets much higher.

This example needs to be expanded to include non-EU carriers. They will be competing in the non-stop flights to/from EU carrier hubs, but efforts to attract home market sales will be limited for the above reasons. The home carrier might also defend its premium point-to-point passengers by allocating more of the flight's ETS costs to other segments. On the other hand, the non-EU carrier will be able to cross-subsidise in all multi-stop markets travelling on the flight between its hub and the EU carrier hub, and also the non-stop market sold in its home country, although this may be quite small (*e.g,* Dubai and Singapore).

4.3. Price elasticities of demand

Previous studies have tried to estimate the impact of price increases or ETS surcharges on demand. Some have gone a step further in attempting to gauge the supply response and resultant changes in profitability. Price elasticities have been determined in past studies using econometric techniques over given historical periods of time. These have encompassed periods of economic growth and downturns. The estimates are shown separately for business travel and leisure travel, since these would be expected to show different reactions to price increases or reductions. They are often based on business and economy class or cabin passengers and this is used as a proxy for purpose of trip data that is not reported on any regular basis.

UK Defra (2007) highlighted the range of elasticites determined in previous studies, while Brons *et al.* (2002) distilled some key findings from a survey of 37 studies and examined the impact on the estimates of such variables as class of travel, distance and level of income. Omitting income from the estimation resulted in an overestimation of price sensitivity. This seems to be supported by a more rigorous pass through of fuel surcharges by airlines during periods of strong economic growth.

Long-haul markets might be expected to show less price sensitivity since there are fewer substitutes and this was apparent from the Brons *et al.* data. On the other hand, Defra (2007) concluded that there is "no evidence that long and short haul flights have different price elasticities." (reference)Some feel that LCC passengers should be treated differently from leisure traffic in general; this was the view of the Defra study, but Frontier Economics (2006) disagreed. Some LCCs carry up to 20% of passengers on business trips in contrast to European charter flights which have almost none. LCCs differ from network carrier short-haul flights that also carry a mix of business and leisure passengers in having only one fare available at any point in time. This means that they cannot take advantage of price differentiation based on the difference in price elasticities confirmed by previous studies.

The impact on demand resulting from ETS induced price increased will vary depending on the elasticity used. Most previous estimates of the impact on demand are small and insufficient to prevent aviation emissions from continuing to rise in the future. For this reason, an open trading scheme is crucial in allowing aviation to pay for emissions reductions in more polluting industries or to encourage alternative technology energy. Anger *et al*. (2008) concluded that 100% pass through of aviation allowances would result in its emissions being 7.5% lower in 2020 than without the ETS.

5. CONCLUSIONS

The failure to get agreement for a global Emissions Trading Scheme for air transport through ICAO led the EU to finalise its own scheme. An emissions or fuel tax is ruled out given the hundreds of international aviation agreements that would have to be re-negotiated. Thus? the first international aviation ETS will start in 2012 and be applied to all flights arriving in and departing from EU airports. Most of the details of the scheme have now been published, although not yet totally incorporated into EU member states' legislation. The most important decision remaining is whether the percentage of allowance that is auctioned will increase from 2013 onwards and, if so, by how much. For the first year of operation, it is now possible to make good guesses as to how it might impact various airlines, although the baseline emissions total for all airlines in 2004-06 has not yet been published, and the traffic data for the benchmarking (2010) can only be forecast.

Most studies of the impact of the EU ETS on airlines show a modest increase in cost per passenger even assuming all their allowance value is passed on in full. This cost is well below recent fuel cost surcharges, and may have a limited impact on air traffic growth. The degree to which these costs are passed on and which market segment takes the brunt of this will depend on the position in the economic cycle and the pricing strategies of the airlines involved. Given that many airlines take a network-wide approach to pricing, it will also depend on the size of the costs in relation to their system-wide revenues. Almost none of the previous studies assumed any pass through of ETS costs to cargo shippers, even though they can account for almost 40% of payload on long-haul flights.

The assumption on the cost of acquiring additional EUAAs or EUAs though auctioning or in the market has tended to be based on past market trends determined by the existing ground based emitters. These may increase significantly as a result of a tighter scheme for ground based emitters and the addition of airlines as net purchasers.

The approach to passing on ETS costs may be similar to fuel surcharges, which network airlines showed as a separate add-on (although some LCCs absorbed them in the underlying fares offered). This might be attractive to some passengers in confirming that the polluter is paying (and to the airline in withdrawing its voluntary offset mechanism). Previous studies also looked at the likely impact on demand of possible price increases. As expected, there was a large range of elasticities used, and differing views on the differential impact on leisure versus business, long-haul versus short-haul and LCC versus other types of airline. None of them considered the economic context in which the airlines find themselves, or ETS cost increases acting as a driver to reduce other non-fuel costs.

Any scheme that uses benchmarking for allocation of free allowance will produce some distortions and the EU approach tends to favour longer haul carriers and LCCs. The regional coverage of the EU scheme penalises EU hub carriers and favours those with hubs outside the EU but this impact on not large. The extra fuel needed to carry passengers on indirect routings via non-EU hubs may more than outweigh any ETS costs avoided, and the EU carrier could market its competing service as the more environmentally friendly.

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NOTES

[i] The gain would be far higher if the long-haul aircraft were designed for a maximum range of, say, 7,500km, since weight would be saved from lighter structures.

[ii] Both based on a passenger load of 360 in identical B747-400 aircrafts.

[iii] http://www.greenaviation.org/ 24 June 2009

[iv] British Airways Press Release, 29 May 2008

[v] As was the case with fuel surcharges.

[vi] British Airways Investor Day 2008, www.bashares.com