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# The implications of environmental costs on air passenger demand for different airline business models

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A B S T R A C T

Various environmental measures, including both regulations and fiscal instruments, have been used at airports globally to reduce the impacts of aircraft noise as well as aircraft engine emissions. Internationally, it is recognized that the costs of environmental and social externalities of air transport must be internalized and paid for by the aviation industry and its users. The use of noise related charges or taxes, which theoretically should be based on their respective social costs, has been proved to be effective at some European airports. This research aims to investigate the impacts of environmental costs, through environmental charges, on air passenger demand for different airline business models. The paper presents the mathematical models measuring the social costs of aircraft noise and engine emissions as a basis for setting up environmental charges. Six intra-European short-haul routes in two city pairs, namely London–Amsterdam and London–Paris, are selected for the empirical analysis. The environmental charges are then hypothetically applied to airlines with two different business models, full service carriers (British Airways and Air France-KLM) and low cost airlines (EasyJet). The results show that the potential percentages of demand reduction for both leisure and business passengers would be higher for Easyjet's markets, although with less environmental cost per passenger.


## 1. Introduction

Over the years, increasing attention has been paid to the sustainable development of the aviation sector (Caves, 1994a,b; Fawcett, 2000). Environmental and social concerns are gradually posing limitations to the growth of the air transport industry. Although the global economic downturn and political turmoil of increased global security has caused a decline in the number of flights and passengers over the past years, these environmental concerns still remain valid. Nevertheless, it is widely recognized now that the costs of these externalities must be internalized (European Commission, 1999, 2002). For this reason, the sustainable development of the environment is a significant issue that should be concerned immediately.

Two of the most important externalities generated from commercial flights are noise nuisance and aircraft engine and ground access vehicle emissions. Of these two, noise nuisance has the largest impact on the community surrounding airports, while engine emissions have both local and global impacts on air quality and greenhouse gases, respectively. Noise causes both annoyance (nuisance) and health effects, for instance sleep deprivation, (Franssen et al., 2004) stress and hypertension (Jarup et al., 2005).

More and more, airports in the world, often forced by governments, are applying different types of noise management measures that range from noise abatement procedures to limits on the total noise allowed (Lu and Morrell, 2006). Among these measures are night flight restrictions and curfews, night quotas, and noise charges and penalties. In 1999, only 14 countries in the world had some forms of noise charges; by 2007, 24 countries, including 18 European, 2 Asian and 2 North American countries, have applied noise related charges (Boeing Website, 2007). The schemes of noise related charges vary greatly from country to country, even differences at airports in one country. Table 1 summarizes the various charge schemes at different countries and airports.

Aircraft engine emissions have extensive impact on human health, vegetation, materials, ecosystem and the climate. Aircraft exhaust pollutants are emitted during landing and take-off (LTO), ground stages and during the cruise mode of flights. Damage is incurred from these pollutants at all flight stages and aircraft is unusual in their injection of pollutants into the upper troposphere and lower stratosphere, resulting in a higher level of global warming than is the case for similar ground level emissions. Compared to the introduction of noise management measures, there are fewer airports applying engine emissions mitigation measures. In 2007, engine emissions charges are in place only at some airports in Switzerland and Sweden, as well as at London-Heathrow Airport.

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**Table 1**
Comparison of noise related charges at various countries/airports.

| Country | Airport | Code | Landing as a basis | | | Landing fee according to aircraft acoustic categories | | Based on noise levels | Aircraft noise categorization | Based on aircraft weight | Charge per passenger |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | % Increase | % Discount | Night surcharge | Surcharge | Night surcharge | | | | |
| Australia | Sydney | SYD | | | | | | ✓ | | | |
| Austria | Vienna | VIE | | | | | | | | | ✓ |
| Belgium | Brussels | BRU | | | | ✓ | ✓ | | ✓ | ✓ | |
| Canada | Toronto | YYZ | | | ✓ | | | | | | |
| Croatia | Split | SPU | ✓ | | | | | | | | |
| Cyprus | Pafos | PFO | | | ✓ | | | | | | |
| Czech Republic | Prague | PRG | | | | | | | ✓ | ✓ | |
| Finland | Helsinki | HEL | | | | | | ✓ | | | |
| France * | Charles de G. | CDG | ✓ | ✓ | ✓ | | | | ✓ | ✓ | |
| Germany | Frankfurt | FRA | | | | | | | ✓ | | |
| | Munich | MUC | | | | | | | ✓ | | |
| | Dusseldorf | DUS | | | | ✓ | ✓ | | | | |
| | Hamburg | HAM | | | | | | | ✓ | | |
| Hungary | Budapest | BUD | | | | | | | ✓ | | |
| Italy | Major airports | | | | | | | | ✓ | ✓ | |
| Japan | Narita | NRT | | | | ✓ | | ✓ | | | |
| | Haneda | HND | | | | | | ✓ | | | |
| | Osaka | OSA | | | | | | ✓ | | | |
| Luxembourg | Luxembourg | | | | | ✓ | ✓ | | | | |
| Netherlands** | Schiphol | SPL | ✓ | ✓ | ✓ | | | ✓ | | | |
| Norway | Bodø | BOO | | | ✓ | | | | | | |
| Poland | Okecie | WAW | | | | ✓ | ✓ | | | | |
| South Korea | Gimpo | GMPL | ✓ | | | | | | | | |
| Sweden | Stockholm-Arl. | ARN | | | | | | ✓ | | | |
| Switzerland | Zurich | ZRH | | | | | | | ✓ | | |
| Taiwan | 11 airports | | | | | | | ✓ | | ✓ | |
| United Kingdom | London-Heathrow | LHR | | | | ✓ | ✓ | | | | |
| | London-Gatwick | LGW | | | | ✓ | | | | | |
| USA | Palm Beach | | | | | | | | ✓ | | |

Note: * In addition to the landing fee related to aircraft acoustic categories, the noise tax is also applied at 10 French airports.
** In addition to the landing fee related to aircraft acoustic categories, the Dutch Governmental Noise Charge is applied.

For governments and airports, environmental charges are seen as one of the most effective ways in mitigating the impacts from aircraft operations. However, the subsequent impacts of charges on airline costs, air fares, and passenger demand should be investigated before applying. Hence, the implications of various environmental charge scenarios on different kinds of airline business models and passenger demand are then discussed and measured in this study.

This paper has chosen two European city pairs, which have flight services both from full service carriers and low cost carriers. The analysis focuses on the potential passenger demand reduction for these two types of airline business models, if environmental charges are added to air fares. However, the extent to which airlines might adapt their pricing strategies will not be explored.

The next section presents the mathematical models and the evaluation techniques used for estimating the environmental costs of flights, and the review of passenger demand elasticities. This is then followed by the results of the modeling and case studies, concluding with their implications for airlines and policy makers.

## 2. The approach

### 2.1. Noise social cost model

The hedonic price method (HPM) is the most commonly used technique for estimating noise damage costs (Morrell and Lu, 2007). This method extracts the implicit prices of certain characteristics that determine property values, such as location, attributes of the neighbourhood and environmental quality. By applying the HPM, the annual total noise social cost $C_n$ could be derived from the following formula:

$$C_n = \sum_i I_{NDI} P_v (N_{ai} - N_0) H_i \quad (1)$$

where $I_{NDI}$ is the noise depreciation index expressed as a percentage; $P_v$ is the annual average house rent in the vicinity of the airport; and therefore, $I_{NDI}P_v$ is the annual noise social cost per residence per dB(A). The noise level above the ambient level is $(N_{ai} - N_0)$, where $N_{ai}$ is the average noise for the $i$th section of the noise contour; $N_0$ is the background noise or the ambient noise. This is finally multiplied by $H_i$, the number of residences within the $i$th zone of the noise contour.

The annual house rent $P_v$ could be converted from the average house value in the vicinity of the airport, $P$, by the following capital

**Table 2**
Social costs of each exhaust pollutant.

| Pollutant | Average (2005 euros/kg)* | Rural | Urban |
|---|---|---|---|
| HC | 4.5 | 2.8–5.2 | 2.8–9.0 |
| CO | 0.1 | 0.02–0.20 | |
| $NO_X$ | 10.1 | 4.2–13.3 | 7.2–25.3 |
| PM | 167.8 | 18.2–202.0 | 85.5–2,005.0 |
| SO2 | 6.8 | 3.2–8.8 | 3.5–52.0 |
| $CO_2$ | 0.03** | 0.01–0.04 | |

Source: Pearce and Pearce (2000), Dings et al. (2003), and Lu and Morrell (2006).
Note: * The figures are inflated to 2005 values by applying the euro area inflation rates.
** The figure of 0.038, used in the calculation, has been rounded to two decimal places.