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THE ENVIRONMENTAL COSTS OF AVIATION

The Government's policies for the future of UK air transport will be set out in a White Paper in late 2003. This will also put forward initial proposals for making the aviation industry and its users pay for their environmental costs. This briefing examines the basis for the Government's cost estimates and how these could be used in policy decisions related to airport expansion and environmental regulation for aviation.

Background

Aviation gives rise to a range of environmental impacts, including global warming, noise, air pollution and other local impacts such as landtake, habitat loss and impacts on water.[1] In addition to conventional regulation and mitigation measures, the Government has stated that the aviation industry ought to take responsibility for these impacts and has consulted on using economic instruments (such as an environmental tax or emissions trading scheme) as a possible way to achieve this.

To this end, Department for Transport (DfT) and HM Treasury (HMT) published estimates of the values of three types of environmental effects arising from UK aviation (other impacts were not valued):[2]

- global warming – valued at £1.4b for emissions in 2000, and forecast to increase to £4.8b by 2030
- local air quality – valued at £119-236m for 2000; no figures were quoted for 2030
- noise – valued at £25m in 2000; again, no figures were quoted for 2030.

Economic valuation of the environment

Principles

Public concerns about environmental changes can be expressed in both monetary and non-monetary terms. The methods available for placing monetary values on the environment are outlined in the box above. Although valuation is an economic technique, it does not imply that the environment is valued solely through its impact on the economy or its practical use to individuals. For example, there are techniques available that attempt to measure people's values related to the loss of a rare species of plant in a remote forest, even if there is no known use for it. It may be that the plant is valued as a potential medicine, or purely for its existence.

Economic valuation methods

A range of methods can be used:

- valuation from market prices, such as the value of crops lost due to air pollution
- where no market exists, 'stated preference' techniques can be used to elicit valuations, such as surveys of 'willingness to pay' to preserve a rare species or 'willingness to accept' compensation for damage
- alternatively, valuations may be estimated from people's behaviour using 'revealed preference' techniques, such as measuring the differences in house prices between areas subjected to differing levels of noise
- derived valuations based on research elsewhere, such as using valuations of the impacts of air pollution in other countries to estimate the value in the UK.

The strengths and weaknesses of these approaches vary, and none is entirely straightforward. For example, asking people about their 'willingness to accept' tends to yield significantly higher valuations than asking them about their 'willingness to pay'. Also, applying locally-derived values to other locations calls for complex adjustments, and may not always be reliable.

Uses of valuation

Essentially, valuation has two uses:

- to aid decision-making, environmental impacts can be valued alongside economic and social impacts in

cost-benefit analyses of policy decisions such as airport capacity expansion
- to help set values for economic instruments (such as environmental taxes) to implement the 'polluter pays principle'. This is the aim of the Government's valuation of aviation's environmental costs.

Environmental costs of aviation

Global warming

The global warming impacts of aviation arise mainly from emissions of carbon dioxide (CO_2) and other gases high in the atmosphere. The Government estimated that each tonne of carbon emitted in 2000 will over time cause damage valued at £70, rising to £100 for emissions in 2030. These estimates were multiplied by a conversion factor, to reflect the effects of emissions other than CO_2. The resulting damage costs were £1.4b for 2000 emissions and £4.8b for 2030 emissions.

Valuing the effects of a tonne of carbon is subject to considerable uncertainty due to:
- complexities in how emissions of greenhouse gases translate into impacts and how people respond
- differences between how costs and benefits are shared between rich and poor countries, and between current and future generations[3]
- differing values of risks to life (see box opposite).

Taken together, these uncertainties mean that valuations of the effect of a tonne of carbon range from significant damage costs estimated at several hundred pounds per tonne (although most estimates are much lower) to a few pounds of benefit per tonne.[4] The figures used by the Government (£70 in 2000; £100 in 2030) are towards the higher end of most estimates, and are viewed by some commentators as too high. They are, however, under review and interim findings are due in late 2003.

Other uncertainties relate to the relative impact of CO_2 and other emissions. Scientific uncertainties suggest that a broader range of conversion factors should be used rather than the precise figure of 2.7 used by HMT/DfT. There is also uncertainty over the regional impacts and timing of these effects. Last, there are uncertainties relating to the pace and direction of technological innovation and forecasts of the demand for aviation.

Noise

House prices are often used as a way of valuing attitudes to noise. This is based on the idea that, of two similar properties, the one exposed to higher noise levels will tend to be cheaper. Research suggests that for each unit (dBA L_{eq}) of noise, a reduction in house prices of 0.5-1.0% can be expected.

The house price method has a number of advantages and disadvantages. On the plus side, it is based on actual behaviour in a market, so it is less likely to be distorted by biases in willingness to pay surveys (where local residents may, for example overstate the nuisance incurred to extract a higher level of compensation). Also, the house-price method overcomes the discrepancy between 'willingness to pay' and 'willingness to accept' surveys (see box on page 1).

Valuing risks to human life

To value the risk of mortality, economists estimate the value which people place on changes in the risk of premature death (e.g. as revealed by the wage premium for relatively unsafe occupations). The costs to the economy (mainly through lost output) are then added to this figure to derive the 'value of a statistical life' (VSL). Using this technique, DfT estimates the cost of a fatal road accident to be £1.2m, of which around one third is the direct economic cost.

VSL is most appropriate for valuing acute risks. There is an argument that it is less useful for valuing chronic risks such as long-term air quality. Also, DfT's valuation assumes that people are of average age and life expectancy, and so it may exaggerate the willingness to pay of groups most at risk from episodes of low air quality (the elderly and terminally ill).

On the other hand, there are uncertainties in the house price method which mean that the relationship between house prices and noise can only be approximated within a range. For example, the positive value placed on access to airports may confuse the relationship. In addition, noise may have effects that are not captured by the house price method. These include:
- impacts on physical and mental health, sleep patterns and educational achievements
- costs to the wider economy in terms of health care and lost productivity
- impacts on non-residential property, e.g. hospitals and open spaces, or on visitors and tourists
- any difference in valuation of noise at different times of the day and night
- the impacts of frequent, but low-level noise.

The Government's tentative valuation of the impact of aviation noise in the UK (£25m in 2000) is based on the house price method, using a price reduction of 0.6% per decibel for houses exposed to noise greater than 57 dBA L_{eq} (the Government's suggested threshold for the onset of 'significant community annoyance').[5] The valuation is lower than found in other studies using similar methods - academics have estimated noise damage to be £37-66m at Heathrow alone.[6] Although the discrepancy may be explained by differences in assumptions, wider questions are raised by the omissions noted above. DfT is updating research on attitudes to aircraft noise (including stated preference valuation), with results expected late 2004.

Local air quality

Aircraft produce a range of emissions that may affect the quality of air surrounding an airport. The focus has been on the health impacts of nitrogen oxides (NO_x) and particulates (PM_{10}). The Government has quoted a cost of £119-236m for 2000. This figure includes costs for impacts on health, damage to crops and buildings, and some allowance for damage to biodiversity. There are, however, a number of uncertainties in this valuation:
- modelling emissions, how these contribute to air quality, the dose-response relationship, and the effects of mixtures of different emissions

- identifying which emissions come from different sources around an airport (aircraft, traffic to the airport, passing traffic and local factories)
- how to value impacts on biodiversity and human life (see box on page 2)
- lack of valuation specific to UK airports: most research is based on other European countries.

Other environmental impacts
Aviation gives rise to other predominantly local impacts, including on landtake, heritage, landscape, wildlife habitat, water and waste. While various methods exist for valuing such impacts, DfT argues they are not yet well developed and so these effects were not valued as part of its consultation exercise. Some academics counter that such methods are well developed and that the main issue is the paucity of studies based on them.

Further, aviation creates indirect environmental impacts such as from fuel production, aircraft production, tourism and housing and commercial development around airports. These were not valued in the consultation.

Issues in valuation

The Government's valuations of the environmental costs of aviation illustrate key issues related to valuation itself and its use in making policy.

Uncertainty
The above discussion shows that environmental valuation is subject to considerable uncertainty, both scientific (e.g. the response of the climate to emissions), economic (methodological difficulties in capturing valuations of environmental harm) and ethical (such as fairness issues between different countries and generations). In each of these areas, the uncertainties are likely to be greater for impacts which are global, long-term and irreversible (such as climate change) than those which are local and temporary (e.g. noise). The level of uncertainty may reduce over time, as further research is undertaken, but it is unlikely that uncertainties will ever be fully removed.

The implication of these uncertainties is that the 'wrong' values could be adopted, which could lead to poor policy decisions. For example, the state of scientific knowledge on climate change may mean that the damage caused is undervalued. If so, then policies may be adopted that encourage aviation beyond acceptable levels of damage.

In view of such uncertainties (and their consequences), a question arises over how far economic valuation should be used as the basis for policy decisions. Alternatively, other tools which do not seek to place monetary values on different types of impact may be more appropriate, such as multi-criteria analysis (see later). Economists defend valuation on a number of grounds:

- other analytical methods are subject to the same scientific uncertainties as economic valuation
- even if impacts are not prioritised in the analysis, prioritisation is inevitable in decision-making
- explicit valuation leads to greater consistency and transparency in decision making
- valuation does not necessarily require precision, and can be subjected to 'sensitivity analysis' and other techniques for dealing with uncertainty.

Ethical issues
Policies maximising economic efficiency do not necessarily lead to a fair outcome. For example, if a tax on noise were introduced alongside an airport expansion programme, and were set at a level equal to the value of noise damage, it is possible that an airline might simply pay the tax (and pass it on to customers through airfares, as competitive pressures permit) without modifying its behaviour. This does nothing to reduce the exposure to increased noise of people in the vicinity of the airport, and therefore presents an issue of fairness. Some groups argue that setting a tax at a level designed to reach an environmental target (e.g. no extra noise) represents a fairer approach.

Economists counter that valuation can be used to determine the level of compensation which would, in theory, keep the affected population indifferent to the additional noise generated. If compensation costs less than suppressing the extra noise, then it would be both efficient and fair to permit the greater level of noise and pay compensation to residents. If compensation were more expensive, then the logical outcome would be to suppress or mitigate the additional noise. However, in either case, it is almost inevitable that there will be 'winners and losers' in such a process.

Valuation in policy-making
For appraising policies and investment decisions, HMT recommends quantification of costs and benefits, where possible. HMT recognises that there are impacts whose values are not revealed directly by markets and suggests ways to derive the values, similar to those described on the previous pages. HMT also advocates the use of weighting techniques to take account of fairness issues (such as impacts on lower income groups).

Nevertheless, HMT also recognises that there may be costs and benefits that cannot readily be valued in monetary terms. It puts forward a number of options for presenting them alongside monetised impacts in evaluation. Mirroring this approach, the DfT's has adopted a form of multi-criteria analysis, in which all impacts are presented to Ministers side by side on a single page. This requires a political judgement based on information presented on a range of costs and benefits expressed in a number of ways. For instance, monetary valuations are required for some factors (cost of building the road, value of lives saved, etc.), while numerical and descriptive information is necessary for other factors (e.g. the area land lost of that is important for wildlife).

In the light of HMT guidance, DfT proposes to gradually extend the range of environmental impacts to be valued in monetary terms, although it is cautious of the prospects for reliable valuations of certain impacts. Economic valuation is now an established tool in decision-making, but questions remain over how

valuation can be used alongside other decision-making tools, and whether monetary values are, in practice, given more weight against other information during the process of decision-making.

Economic instruments for aviation

Valuation and economic instruments

Making polluters pay their environmental costs should give them an incentive to reduce the damage caused. If a noise tax were high relative to overall costs, airlines would have an incentive buy quieter aircraft. Also, customers would have an incentive to pay less by flying from airports where fewer residents are disturbed. The question then arises whether economic instruments should be set at a level which simply makes the polluter pay the environmental cost or whether they should be set with specific environmental targets in mind (e.g. a certain level of air quality). In theory, the distinction drops away if targets are set at a level aimed to maximise economic efficiency. In practice, targets are not always based on economic analysis and may be constrained by political factors such as issues of fairness and also by factors beyond the Government's control (such as the requirement to meet EU air quality standards by 2010).

Estimating the level of tax required to achieve a target may not be easy, since long-term responses are not always predictable. If the target is an overriding imperative (such as a legal obligation), then it may be appropriate to adopt more conventional regulatory instruments or adopt economic instruments which limit emissions (such as tradable permits).[7]

Options for aviation

Potential economic instruments on aviation include taxes (e.g. on fuel), charges (e.g. noise-related landing charges, which already apply at some airports) and tradable permits (on CO_2 emissions). Voluntary mechanisms (e.g. disclosure of emissions) can also be an economic instrument, as they affect a firm's market perception.

For maximum impact at minimum cost, instruments should address the damage as directly as possible and provide incentives to suppliers as well as consumers. It is widely acknowledged that the present Air Passenger Duty (APD) meets neither of these objectives. The APD charged on different journeys is not related to the relative amounts of damage and gives little incentive for airlines to reduce damage. In the case of global warming, a tax on fuel would create a more direct incentive for airlines to reduce greenhouse gas emissions than APD. However, this raises legal issues (see box opposite) and creates little incentive to reduce emissions (such as NO_x) which are related to aircraft design and operations, and not just fuel consumption. Instruments targeting global warming would be most effective if adopted internationally.

Feedback from the HMT/DfT consultations suggests that the airport and airline industries are receptive to economic instruments which enable them to take account of their environmental costs, provided they are structured so as not to prejudice competitive interests.

International agreements on economic instruments

Fuel used on international flights is exempted from taxation under more than 2,000 bilateral agreements. The EU is committed to ending this anomaly. However, while such agreements remain in place, there would be a competitive disadvantage in taxing fuel used by EU airlines only. No such restrictions apply to domestic flights. The EU is considering the possibility of *en route* charges covering European airspace. CO_2 emissions from international flights (unlike domestic flights) are not covered under the Kyoto Protocol. They could be brought into the Protocol after 2012 and/or the EU Emissions Trading Scheme from 2008.

Industry generally favours tradable permits over taxes, as they offer the 'carrot' of revenues if reductions are achieved beyond targets. They also favour 'recycling' of tax revenues, e.g. for funding research and development.

Others (including environmental groups) are also generally positive towards economic instruments, although their views on preferred instruments are more mixed. These groups argue for a greater emphasis on target-based rather than valuation-based approaches. Some academic economists are less in favour of recycling of revenues from taxes than other groups, on the grounds that hypothecation of taxes is inefficient.

Overview

A range of techniques for valuing environmental impacts can be used for appraising policy options such as airport expansion and setting levels of environmental taxation. Using such techniques, the Government has valued UK aviation damage at around £1.6 billion for the year 2000 (rising to nearly £5 billion by 2030). Although economic techniques and underlying science are constantly improving, valuation remains prone to uncertainties. The forthcoming air transport White Paper is expected to set out preliminary proposals for economic instruments on aviation. The proposals will also be influenced by considerations of UK economic competitiveness and also initiatives undertaken at an international level.

Endnotes

1 *Aviation and the Environment*, POST report 195, Parliamentary Office of Science and Technology, April 2003.
2 *Aviation and the Environment: Using Economic Instruments*, HM Treasury and Department for Transport 2003.
3 *Estimating the Social Cost of Carbon Emissions*, Government Economic Service Working Paper 140, 2002.
4 Benefits may include improved agricultural yields and reductions in heating energy requirements, mainly in northern latitudes.
5 *Aircraft Noise,* POSTnote 197, Parliamentary Office of Science and Technology, June 2003.
6 *Budget 2003 and Aviation: Ninth Report of Session 2002-03*, House of Commons Environmental Audit Committee, 2003.
7 Tradable permits work by one person, who exceeds their target, selling their 'excess' to another, who cannot meet their target.

POST is an office of both Houses of Parliament, charged with providing independent and balanced analysis of public policy issues that have a basis in science and technology. POST is grateful to Mark Davis and Imperial College for assisting in the preparation of this briefing note. A report on the economic costs of the global warming impacts of aviation is available on the POST web site.

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