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## APPENDIX 1

Aviation and the Environment--A General Perspective

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# AVIATION AND THE ENVIRONMENT–A GENERAL PERSPECTIVE

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# AVIATION AND THE ENVIRONMENT–A GENERAL PERSPECTIVE

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## INTRODUCTION

The state of the natural environment is a continuing public concern in most countries. The impact of transport on the environment in general has received particular attention in recent years[1]. Transport has been the subject of major pieces of legislation at local, national and international levels as policy makers and those supplying transport services have acted to respond to this public concern.

The underlying difficulty is that, because of a number of intrinsic features that are associated with transport, it is seen to lead to particular environmental difficulties. These features include[2].

- It is a major sector in its own right;
- It is a growth sector;
- It is highly visible;
- Transport is demanded where people are;
- It is a mobile source of pollution (in the widest sense);
- It generates a diverse range of environmentally intrusive effects;
- It is a major contributor to many forms of environmental damage.

All transport modes combine these features and air transport is no exception. In 1994, for example, the sector operated some 15 thousand aircraft serving more than 10 thousand airports. It employed about 3.3 million people (some 1.4 million in the US) and carried 1.2 billion people and 23 million tonnes of freight.

In comparison with many other transport modes, however, air transport has been left largely outside of many of the recent mainstream environmental debates. Where there has been concern it has mainly been in relation to issues of local importance (most notably aircraft noise around airports and fears concerning safety for those under flight paths).

The situation is, however, now changing. Air transport is clearly growing in importance as a mode of transport. Existing markets are expanding and new ones are emerging. Air transport is becoming more visible than in the past, especially as urban sprawl leads to encroachment on

[1] K.J. Button, *Transport, the Environment and Economic Policy*, Edward Elgar, 1993

[2] These features have led to one commentator describing transport as "Industry on Wheels".

airports[3]. The forecasts provided by Boeing and others also indicate that this growth is likely to continue into the foreseeable future.

This growth is also taking place within a much less regulated market than in the past[4]. The trend is towards the privatization of airlines and air transport infrastructure and towards more commercially driven markets. This has raised public concern about how the wider social interests are to be represented in decision-making.

Aviation needs significant amounts of surface infrastructure to function effectively but many airports are now congested and there are also land access problems at some. Adding new airports or expanding existing ones imposes a variety of environmental costs on those living nearby but these may be costs that have to be borne if growth in air transport is to take place. There is amounting conflict between those living near airports and those who use them as a result[5].

The perception of trends in environmental problems is often compounded because, although many of the adverse effects of air transport and especially noise round airports, has been reduced for individual flights and the noise envelopes for many airports are now consequently smaller, people's expectations have risen, in part because of rising living standards.

Additionally, many of the concerns about the environmental degradation that are associated with surface modes of transport have been addressed (albeit with varying degrees of success) and one can perceive a feeling that there is now the need to move on and to look at other forms of transport.

This short paper initially sets out to outline the main environmental implications of modern air travel. In particular it seeks to set this in the more general context of environmental concerns. It then moves on to offer a brief consideration of how one can look at the underlying reasons why air transport does create these difficulties. It pays particular attention to the way economists tend to look at these types of problem rather than being driven by pure engineering considerations..

Finally, it pays attention to the policy tools that may be deployed to confront the worst of the difficulties. In tackling this last task, the aim is rather to look at the options that are available than to be prescriptive. This is for no other reasons than that the choices are often difficult and, in many respects, we still have limited knowledge concerning key parameters that underlie the adoption of a viable policy package. There is also the wider issue that air transport interacts with other transport modes and there is a need to review policy options in a broader context. This latter issue is outside of our remit.

## Air Transport and the Environment

Globally, air passenger traffic since 1960 has grown world wide at an average

[3] For example, the Air Transport Association recognized the increasing role that environmental concerns will play in air transport policy making in a statement in 1996.

[4] K.J. Button, W. Michalski, B. Stevens and P.Weiss, *The Future of International Air Transport Policy: Responding to Global Change*, OECD, 1997.

[5] K.J. Button, "Environmental factors in airport competition", paper to the Les Aeroports de Demain Conference, Lyon, 1997.

yearly rate of 9% and freight and mail traffic by some 11% and 7% respectively. In 1995, for example, some 1.3 billion passengers were carried by the world's airlines. Civil aviation has become a major service industry contributing to both domestic and international transport systems. It facilitates wider business communications and is a key component in the growth of tourism, now one of the world's major employment sectors. In addition to passenger transport, aviation is an important form of freight transport, with some estimates suggesting it carries up to 60% of world trade by value and forecast to rise 80% by 2014.

It is fairly safe to say that as a sector, aviation will continue expanding into the foreseeable future, albeit at differential rates, in various geographical sub-markets. A number of international agencies, aircraft manufacturers and airlines regularly produce forecasts of aviation traffic. While forecasting remains an art rather than a science, it seems likely that passenger traffic will grow at a rate between 5% and 7% into the foreseeable future, much of it in the Asian-Pacific region (up to 9% a year). Forecasts have also foreseen slower growth in the more mature US and European markets.

This economic success, however, has been accompanied by increasing concerns about the longer term and the wider implications of air transport for society. While environmental matters have not been at the forefront of air transport policy concerns in the past they are now attracting increasing attention.

While most people concur that environmental preservation is important, what constitutes an environmental concern is not always agreed upon. At the macro-level, notions of sustainability and sustainable development have gained a widespread general acceptance following the publication of the Brundtland Report in 1987[6].

While the notion that current generations should leave as a legacy a natural resource base for future generations comparable with the one it inherited itself has an intuitive appeal, operationalizing this at a global level has proved problematic. At the level of individual sectors such as transport it is even more difficult and becomes even more so at the level of the individual industry[7]. There are simply too many possible trade-offs that could potentially lead to a sustainable path.

More traditional approaches to looking at environmental protection focus upon micro-concerns, on particular issues and on individual environmental problems. These approaches, while less holistic in their basis, do provide a framework of analysis that is more consistent with normal policy making. Thus, while not intellectually ideal they offer tractable tools of immediate use in such areas as project appraisal, regulation and pricing.

In this context, aviation can be seen to have environmental effects at various levels[8]. Some of these are local and concern such things as noise, land-take and soil contamination at airports

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[6] World Commission on Environment and Development, *Our Common Future*, Oxford University Press, 1987.

[7] See papers in D. Banister and K.J. Button (eds.) *Transport, the Environment and Sustainable Development* E & FN Spon, 1993.

[8] Space precludes a detailed outline of the implications of these types of emissions for health, etc. For details see papers in A.J. McMichael and A.C. Fletcher (eds.) *Health at the Crossroads – Transport Policy and Urban Health*, John Wiley and Sons, 1997.

and emissions of pollutants into the air by aircraft while at airports or during the landing and take-off cycle. Among these emissions are those of VOC due to fueling of aircraft and fuel handling in general, and CO emissions of aircraft due to incomplete combustion while being in the idle and taxi mode. For these pollutants the shares emitted at altitudes lower than 1.5 kilometers are dominant (from 50% to 80%).

At a larger spatial scale the emissions stemming from climbing, approaching and cruising take the form of $CO_2$, $NO_X$, $SO_2$, CO, CH, and VOC. At a global scale emissions are important that take place in the stratosphere (i.e. the layer above 12 kilometers where the Ozone layer is located). Since many aircraft cruise at about 10 to 12 kilometers, a non-negligible part of the aircraft effluent is emitted in the stratosphere.

In terms of what is actually taking place regarding empirical and applied research, this traditional approach has mainly manifested itself in studies concerned with noise and pollution at airports and with certain aspects of safety[9]. A recent small scale survey by Morrissette looking at the activities of consultancy firms specializing in environmental work in relation to airports, for example, found that issues concerning wetland damage was of most importance followed by air quality, noise and storm water pollution work[10].

[9] Safety is often not considered an environmental issue and this is sensible for many aspects of the topic. However, there is the issue of the whether people living close to airports have their quality of life reduced through the fear of a plane crashing on them. In the broad definition favored here this aspect of safety is seen as an environmental concern as much as something such as noise nuisance.

[10] S.E. Morrissette, "A survey of environmental issues in the civilian aviation industry", *Journal of Air Transportation World Wide,* (1996) Vol. 1, pp. 22-35.

**Table 1** Estimates of the implications of noise nuisance effects on property values (percentage change per decibel increase).

| Study | Year | % of house price | Country | Data |
|---|---|---|---|---|
| Abelson | 1979 | 0.45 | Australia | Disaggregate |
| Collins& Evans | 1994 | 0.45 | UK | Disaggregate |
| De Vany | 1976 | 0.80 | USA | Aggregate |
| Dygert | 1973 | 0.60 | USA | Aggregate |
| Emerson | 1969 | 0.57 | USA | Disaggregate |
| Gautrin | 1975 | 0.35 | UK | Disaggregate |
| Levesque | 1994 | 1.30 | Canada | Disaggregate |
| Maser | 1977 | 0.62 | USA | Aggregate |
| McMillan | 1978 | 0.50 | Canada | Disaggregate |
| McMillan | 1980 | 0.87 | Canada | Disaggregate |
| Mieszkowski | 1978 | 0.40 | Canada | Disaggregate |
| Nelson | 1979 | 1.10 | USA | Aggregate |
| O'Byrne *et al* | 1985 | 0.52 | USA | Aggregate |
| O'Byrne *et al* | 1985 | 0.57 | USA | Disaggregate |
| Paik | 1972 | 0.65 | USA | Disaggregate |
| Pennington *et al* | 1990 | 0.60 | UK | Disaggregate |
| Price | 1974 | 0.83 | USA | Aggregate |
| Uyeno *et al* | 1993 | 1.13 | Canada | Disaggregate |

A considerable amount of work by academic and government economists, has been done on the social costs of noise nuisance. A variety of techniques have been developed in order to place a monetary valuation of such nuisances so that they may be traded off-against the more narrowly defined economic benefits of air transport. Generally, this has involved efforts to express noise nuisance in terms of the financial implications of living near a major noise source, such as an airport, on house prices (e.g. see Table 1 for a summary of some of these values[11]).

More recently researchers have concerned themselves with trying to gain more direct valuations through sophisticated questioning of those affected[12]. These studies indicate that noise nuisance costs may have been under estimated in earlier work. Feitelson, Hurd and Mudge's work implies the valuation per decibel to be up to 4.1% of property values[13].

[11] K. Johnson and K.J. Button, 'Benefit transfers: are they a satisfactory input to benefit cost analysis? An airport noise nuisance case study' *Transportation Research Series D* (1997), Vol 2D, pp 223-31.

[12] Technically, these two approaches are refereed to by economists as the revealed preference and the stated preference methodologies.

[13] E. Feitelson, R. Hurd and R. Mudge, "The impact of airport noise on willingness to pay for residences", *Transportation Research Series D*, (1996), Vol. 1, pp.1-14.

In terms of atmospheric pollution, air transport also imposes adverse effects. The evidence on this, and in particular the particular implications of individual pollutants however, is still not always solid. It does contribute $No_X$ to the atmosphere and is, thus, contributing to acid rain, but the evidence indicates this contribution is very small. At altitudes between 1 and 12 kilometers, aircraft emissions would seem to impact on the creation of global warming gases and at higher altitudes (where there is supersonic flight) to ozone depletion.

As a mode of passenger transport, air transport is slightly less fuel efficient than the auto but offers significant benefits in terms of time savings over longer distances (See column 2 of Table 2 although care must be exercised in the way this type of data is handled.). In aggregate, air transport is responsible for about 5% of the world oil consumption and 12% of that consumed by the transport sector. The International Civil Aviation Organization estimates that civil aviation consumed about 138 million tonnes of aviation fuel in 1990 and that this will rise, given existing policies but allowing for improved technology, to about 220 million tonnes by 2020.

While one can always question these types of calculation, translating this into damaging emissions, the Air Transport Action Group in Geneva finds that air transport only contributes about 2-3% of $CO_2$ emissions that are, in turn, responsible for about 1% of any global warming effect. Even more tentative are the estimates of the monetary costs of air pollution. A US study by Hansson and Markham estimated this to be about 1.08 cents per passenger ton kilometer, Kagerson' work in Scandinavia puts it at 0.70 cents while German analysis by INFRAS/IWW offers arrange between 0.18 and 1.09 cents.

There have also been efforts to place a larger set of values on the social costs of air transport and, in particular, to set these costs in the context of alternative modes. These studies rely on a combination of syntheses of previous work with new findings. The results of one recent study by Levinson, Gillen and Kanafani[14] generated the estimates found in Table 3. The difficulties with such work are numerous and the findings, although helpful in a general sense, should be treated with some care.

Measuring many other environmental effects, let alone attempting to place a monetary value on them is even more difficult than with items such as noise and air pollution. Airports, for example, despite often innovative design are not normally seen as visible delights. There are problems of drainage at and near airports as work courses are diverted and fuel seepage from storage tanks can take place.

## The Economic Issues

Economists have long had an interest in the environment, although the focus of their thinking had changed over time as new issues have evolved and new policy debates have taken the stage.

The economic perspective is that at the margin any additional activity should generate benefits at least as great as the costs that are imposed. In standard accounting terms this would just mean weighing up the financial pros and cons

[14] D.M. Levinson, D. Gillen and A. Kanafani "The social costs of intercity transport: a review and comparison of air and highway", *Transport Reviews* (1998) Vol. 18, pp. 215-240.

of options. The welfare economic view that underlies public policy making takes a much broader perspective and embraces a full range of social costs. There is a trade-off between the different effects of any action that is multi-dimensional in its nature and this should be allowed for. What it does not mean, however, is that all environmental degradation is intrinsically undesirable; if the benefits to society exceed the costs then they are justified.

At the most basic level, economists view the underlying problem of excessive environmental degradation in terms of there being a market failure. In the very strictest terms this stems from the lack of adequate 'property right' allocations. In other words, there is no clear ownership of environmental attributes and, as a consequence, there is excessive consumption of them. They are called 'Commons' in the environmental economics literature. they would be used efficiently.

**Table 2** Relative fuel consumption of air transport

| | Energy per pkm (MJ/pkm) | Average Speed (km/hour) | Energy use per travel hour (MJ/hour) |
|---|---|---|---|
| Aviation | 2.2 | 500 | 1100 |
| HSR | 0.7 | 150 | 106 |
| Intercity train | 0.7 | 80 | 56 |
| Car | 1.5 | 50 | 75 |

The environmental attributes are, therefore, external to the market process and to ensure their appropriate and efficient use they need to be brought within the market.. As obvious as this may seem, it was not really until the work of the Nobel Prize winner Ronald Coase in the 1960s that this became generally accepted.

If every environmental attribute were owned then there would be a market for them and Of course, there may be good reasons why property rights are not allocated. It may be difficult to define exactly what they are and to police a market system. There may be wider social reasons why is felt the market process may prove inefficient (e.g. due to monopoly elements) or to be socially undesirable for income distribution reasons. Nevertheless, a lack of property right allocation is the underlying cause of excessive environmental degradation.

Ideally, techniques such as cost-benefit analysis, therefore, include the environmental costs of activities as well as those immediately evident from the market. This is not, however, always straightforward to put into practice. There are, for instance, problems of valuation, it may not be possible for practical or political reasons to pursue some policy approaches and there are normally knock-on effects elsewhere in the system that are difficult to foresee.

One simple way of looking at the more pragmatic economic approach to environmental matters favored by practitioners rather than pure theoreticians, be it to do with air transport or some other activity, is to think in terms of a chain effect. Figure 1 provides a simple outline of what is meant by this.

If the market does not work then government has a responsibility for trying to rectify the situation[15]. If it cannot create an appropriate market to internalize the underlying issue because property rights cannot viably be allocated then it can act at a second level to attain a level of environmental intrusion nearer the optimum. It has the ability to impose various forms of regulation, adjust prices, provide subsidies and to influence complementary activities (e.g. in the case of airlines, investments in infrastructure such as airports). These are all measures that can directly or indirectly be aimed at the environmental problem.

The long-standing standard micro-economic position is that 'Pigouvian taxes' can be imposed on

[15] In some cases government interventions may actually make the situation worse or lead to excessive environmental damage when none would have occurred without it, see, K.J. Button, *Market and Government Failures in Environmental Policy: The Case of Transport*, OECD, 1992.

those generating the adverse environmental externality to bring it more nearly to the socially desirable level. Those causing the environmental damage are charged by the authorities for so doing. This is not, however, strictly a market measure but rather a method for attaining a particular environmental standard - it is rather a fiscal instrument. Whether such taxes, or indeed subsidies in some cases, are preferable to other measures such as regulations on emissions has long been debated.

In any case, the underlying economic issue is one of externalities. These externalities manifest, however, themselves on the way air transport is provided (Link 2 in Figure 1). If the full costs of air transport are not made transparent to suppliers of air transport services then they will make decisions that are environmentally detrimental.

**Table 3.** Comparison of long-run average social costs of passenger transport

| Cost Category | Air System ($/pkt) | Highways ($/pkt) |
|---|---|---|
| Noise | 0.0043 | 0.00045 |
| Air Pollution | | |
| CO | 0.0000018 | 0.000033 |
| VOC | 0.0001530 | 0.0026 |
| $NO_X$ | 0.0001700 | 0.00067 |
| $SO_2$ | – | 0.00021 |
| PM10 | – | 0.000057 |
| Carbon | 0.0005800 | 0.00017 |
| Accidents | 0.0005 | 0.0200 |
| Congestion | 0.0017 | 0.0069 |

If the social costs of noise imposed on people around airports is not taken into account then there will be excessive aircraft movements and their timing will not allowing for possible differing temporal sensitivities of local people to noise. Inadequate allowance for the atmospheric pollution effects of air travel will influence the fleet composition of carriers and their route choices. On the ground, traffic to and from airports causes a particular set of environmental problems and if this is not reflected in the prices that are paid for surface transport use them airport planning will fall short of environmental requirements.

These distortions to the air transport market then have effects for the environment (Link 3). In general, the existence of negative environmental activities in transport leads to an excess in the total supply of transport services; there is no exception to this in air transport. It also leads to sub-optimal modal splits with excessive traffic being

carried by modes that exhibit the highest relative external costs. The overall impact of these, and other industrial distortions, are the atmospheric, noise, land-use take and other environmental costs that cause social concern.

The final link in the chain is the impact of environmental degradation on society. After all, it is generally the social well-being of this and future generations that is the concern of people. An excessively degraded environment has immediate health implications (e.g. high levels of noise causes stress) and can reduce traditional economic output (again, noise can affect sleep and this is reflected in lower levels of labor productivity). In many cases there is the simple loss of welfare in knowing that the environment has been damaged and irreplaceable resources have been lost..

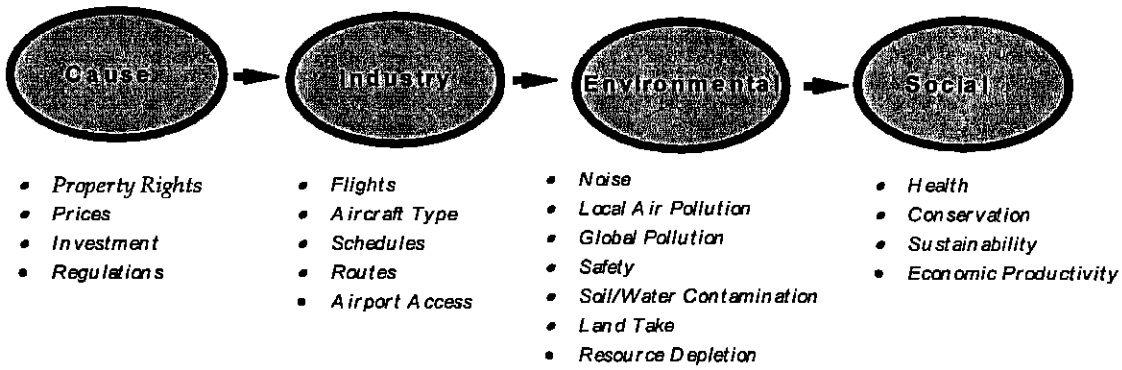


**Figure 1.** The stages of the environmental chain.

In the longer term there are the much wider question concerning sustainability and whether it is possible for the global ecosystem to provide the resources necessary for future generations if current levels of utilization continue. This can be extended to the consideration of whether current political, social and institutional structures can be sustained as the resource base is reduced.

## Policy Approaches

It is often taken for granted that there are few private sector reasons for taking account of environmental costs in decision-making other than that government policy requires this or that government action will follow if private sector management does not act itself. This is not always the situation, however, in practice. Airline managers may well have incentives to take at least some account of their actions on the environment when making commercial decisions.

One way slightly different way of looking at air transport and environmental policy is to consider it in terms of incentives that influence the actions of those providing air transport services. We continue to focus on the airlines but parallel arguments are applicable to airports and other key actors in the game.

Essentially, the function takes the form:

$$S = f(E, G, I) + \varepsilon$$

where:

- *S* reflects the environmental standard level adopted by an airline;
- *E* reflects the private economic incentive to be adopt an environmentally sensitive approach (e.g. retention of reputation);
- *G* represents government environmental codes and policies (e.g. aircraft design features, maintenance standards taxation); and
- *I* represents air transport infrastructure considerations (e.g. airport design and air traffic control priorities).

There is an additional random element in the function ε, indicating the risk of something else that can unexpectedly influence the environmental attitude of an airline (e.g. a war).

The equation is set out in this way to emphasize that airlines themselves sometimes have an incentive to contain the environmental costs of their activities. At one level, there is the pure public relations side. The public is not insensitive to what airlines do regarding the environment and this is reflected in some of the action taken by carriers. The UK carrier, British Airways, for example, has a senior official responsible for environmental matters and regularly produces and environmental report.

In other cases the market itself acts to rein in some environmental costs. Fuel use is, for example, highly correlated with many elements of atmospheric pollution but it is also a major cost of supplying airline services. There is a natural commercial incentive to seek more fuel efficient technologies in a competitive, market driven airline industry.

When there is the need for official action, policy makers have a variety of instruments that may be used. In broad terms policy interventions can be made at any of the four stages of the chain set out in Figure 1. The government also has a wide portfolio of potential policy instruments at its disposal that can be applied at the various stages. Table 5 offers a taxonomy of some of the possible measures that are available to policy makers. The dividing lines being drawn according to whether they act directly on the environmental source or are of a less direct nature.

**Table 5.** Taxonomy of policy instruments

| | Market Based Incentives | | Command and Control Regulations | |
|---|---|---|---|---|
| | Direct | Indirect | Direct | Indirect |
| Plane | • Emission fees<br>• Tax allowances | • Tradable permits<br>• Feebates | • Emissions standards | • Inspection and maintenance<br>• Compulsory scrappage |
| Fuel | | • Fuel taxation | • Fuel composition | • Fuel economy standards<br>• Flying speeds |
| Traffic | | • Slot pricing<br>• Airport access pricing | • Routing<br>• Timing<br>• Aircraft type<br>• Airport design<br>• Noise insulation | • Flight limitations |

Ideally, but also probably unrealistically, from an economic perspective property right allocations could be made more comprehensive but failing that other remedial problems relating to pricing or directly regulating the use of environmental resources could be initiated. In fact, there are effect ways of making use of some of the features inherent in property rights. The use of tradable permits, whereby actors are allocated rights to make use of a predetermined quantity of from their allocations has proved effective in related areas such as the reduction of lead in gasoline.

Government interventions can come through a variety of other direct channels[16]. Since full property right allocation is difficult, many economists favor the use of pollution charges of various kinds as mechanisms for reducing the environmental intrusion of air transport. They are seen, because of their flexibility and because they equalize the marginal costs of abatement, as being the best way of attaining an administratively established level of pollution.

Besides the need to have a fairly good idea of how sensitive users are to various levels of charge, there is the political difficult that without some form of pay-back, these charges extract revenue from the sector in a way that fully allocated property rights would not. They essentially take resources from airlines and give them to government. A property right structure involves trade between airlines and those adversely affected with the automatic outcome that there are measures of compensation for those who are still adversely affected and penalties for those who continue to inflict damage on the environment. Further, it yields an optimal level of abatement rather than simply resulting in some level

[16] K.J. Button, "Overview of internalising the social costs of transport", in *Internalising the Social Costs of Transport*, ECMT/OECD, 1994.

that has been deemed appropriate (albeit often with expert advice) by the authorities.

At the second stage seen in Figure 1, the way the industry operates and its scale could be controlled, again to reduce the environmental intrusion of air transport if this is felt excessive. In practice this is often the chosen approach of policy makers. Instruments of direct regulation abound. Examples include; airport curfews, designated flight paths around airports, safety regulations, airport planning requirements, and regulations over destinations served (e.g. the Perimeter Rules in the US). Fuel taxation may also be seen as important in this context as can airport charging regimes.

The problem with acting at this stage in the chain is that air transport policy itself has more than an environmental dimension to it. Acting indirectly on the environmental problems by influencing market conditions can affect and potentially adversely affect the competitive environment in which air services are provided. While this may be done in a purely incidental way, there is always the underlying danger that actions purporting to be environmentally desirable in their orientation can be driven by secondary considerations to favor a particular carrier or airport.

At the third stage is direct remedial action on environmental damage. In terms of noise, reductions in environmental intrusion is often achieved by insulating certain aspects of the environment (e.g. the construction of noise barriers) or by fitting aircraft with mufflers. The global warming problems associated with $CO_2$ emission can mitigated by remedial measures such as the creation of 'carbon sinks'. Essentially, the air transport sector would be left to its own devices but measures taken to adapt the environment to it.

The main objections to this type of strategy are mainly to do with distribution considerations. The problem is that the costs of insulating the environment are not directly borne by the air transport industry. There are also questions of effectiveness. Most of these types of measure only partially reduce the adverse effects and may themselves have secondary out comes that are undesirable (e.g. most noise barriers are not aesthetically pleasing.

Finally, society could be 'treat' itself to overcome the adverse environmental effects of air transport. This may be in the form of compensation or it may be more direct, for example better medical care for those affected by nosier induced stress or for the effects of VOC on chest ailments. While theoretically this is a possible option it is generally treated very much as a last resort. the full social costs of many forms of environmental pollution individuals is not known and many treatments for those that are understood are far from satisfactory.

## Conclusions

Air transport is a major growth sector in the global economy. It brings with it not only improved communication for those in business but has opened up a whole range of leisure possibilities. At the same time it is bringing with it increased concern about the implications that this rise in air transport activity may have on the environment.

The sector has, to-date, been reactive in a number of ways to meet these concerns, some of the reactions the result of market pressures and others the outcome of policy initiatives by governments. Compared to surface modes of transport, however, the environmental debate has been relatively subdued regarding aviation. This may continue to be the case but even if this is so there is still a social need to ensure that air transport does not cause excessive environmental damage.

Policy makers have a variety of policy instruments that can be used to help ensure that air transport conforms to the longer term needs of sustainable development, but there are problems. Information on the monetary equivalent costs of many forms of environmental damage is still scant and this makes comparisons of policy instruments difficult. There is still relatively little information concerning the effectiveness of many of the policy instruments. A problem here is not only that individual instruments are often still largely untried but also in practice policies have a multidimensional nature involving a number of tools applied simultaneously with consequential interactive effects. Further, most policy instruments have impacts other than those purely on the environment and the magnitude and nature of these are generally not fully know in advance.