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Indirect Taxes on International Aviation*

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Abstract

There has recently been much discussion of the possible use of internationally coordinated indirect taxes, or equivalent charges, on international aviation, whether as a source of finance for development or as part of a response to heightened concerns with climate change. This paper considers the strengths and weaknesses of the leading candidate instruments of this kind. It argues that, on both policy and administration grounds, the case for increasing indirect taxes on international aviation is strong: the indirect tax burden on international aviation is very low, yet aviation contributes significantly to border-crossing environmental damage, is just as proper an object of taxation as any other commodity, and incipient tax competition is likely to result in these taxes being set at inefficiently low levels. But the form(s) in which such taxes are levied matters: a tax on aviation fuel would address the key border-crossing externalities most directly; a tax on final ticket values would have greater revenue potential, and perhaps some distributional advantage; departure/arrival taxes face the least legal obstacles, but are much blunter instruments. Optimal policy, it is shown, typically requires deploying both a fuel tax and a ticket tax, and the

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paper explores, both in principle and by simulation, the key considerations and trade-offs involved in designing a suitable indirect tax regime for international aviation.

I. Introduction

The indirect tax treatment of international aviation has come to attract considerable and often heated attention in recent months. This interest comes from two distinct but largely convergent perspectives. One is a renewed interest in the potential use of global taxes – taxes adopted, that is, by some set of countries on a coordinated basis – as a source of additional finance for development: see in particular the Landau Report (2004), Quadripartite Group (2004) and Atkinson (2005). Prominent among the candidate taxes for such a role that have emerged is some form of indirect tax on international aviation. The second source of interest is an increased awareness, within the context of the heightened concern with climate change, of the distinctly favourable tax treatment of aviation fuel relative to other fossil fuels. Both sets of concerns have now generated policy initiatives. In March 2006, 14 countries[1] committed themselves to impose aviation departure taxes earmarked for development financing: for France, Chile and Norway, these are new taxes,[2] while the UK will allocate some fraction of existing departure taxes in this way.[3] And in December 2006, the European Commission published a proposal to include aviation within the Emission Trading System (ETS) of the EU.[4]

The public finance of indirect taxes on aviation,[5] however, has received little attention. This paper aims to start filling the gap. The analysis will, for the most part, abstract from the distinct issues arising from the prospective use of the revenue from such taxes (or equivalents, such as charges for

[1]Brazil, Chile, Côte d'Ivoire, Cyprus, Democratic Republic of Congo, France, Jordan, Luxembourg, Madagascar, Mauritius, Nicaragua, Norway, Republic of Korea and the United Kingdom.

[2]The tax in France, imposed from July 2006, is highly differentiated: for economy class, the maximum rates will be €1 per departure to destinations within Europe and €4 to elsewhere; for business- and first-class travellers, they will be €10 and €40 respectively. The tax in Chile, implemented from the start of 2006, is a US$2 departure tax on all international travellers. That in Norway is a new tax on aviation, but with a revenue-offsetting reduction in carbon taxes.

[3]One estimate is that these taxes will yield around US$260 million annually, to be earmarked to a new facility, UNITAID, for the purchase of drugs for developing-country users, mainly to counteract AIDS/HIV, malaria and tuberculosis; see http://www.unitaid.eu/EN-Inutaid-unis-pour-soigner.html.

[4]See European Commission (2006). The proposal is to include all intra-EU flights within the ETS by 2011, and all flights to or from third countries by 2012. Emissions would be capped at their average level in 2004–06.

[5]Airlines are subject to corporate tax on their earnings by standard rules of international taxation: typically, under reciprocal arrangements, they are taxed only in their country of residence. Direct taxes are not considered here, and for brevity the unqualified term 'aviation taxes' refers in what follows only to indirect taxes.

emission rights) to finance development rather than simply to augment national tax revenues, which are to a large degree independent of the source of finance itself.[6] The aim is to identify, analyse and assess the merits of various forms of aviation taxes as tax policy measures in their own right.

The central arguments in favour of enhanced taxation of aviation, especially international, are easily stated. Such taxes are currently low (as will be seen). Yet (as will also be seen) aviation causes significant border-crossing environmental damage, including in relation to global warming – and greenhouse gas emissions related to international aviation are, notably, excluded from the Kyoto protocol. Even apart from border-crossing environmental harm, moreover, taxes on international aviation may be inefficiently low as a result of tax competition, with countries acting independently choosing to set taxes lower than they would if they behaved in concert, so as to avoid jeopardising domestic carriers and/or tourist sectors.

These generalities leave many important issues of detail to address. One key issue is which of several possible forms such a tax might take. It might be levied, in particular, on fuel use, as a tax on tickets and/or as a departure/arrival tax on each trip. Should several of these indirect tax instruments be used or just one? If only one, which? What would be the appropriate rates of such taxes and how much revenue would they raise? Are they consistent with existing international aviation law and custom? Could they be administered and complied with at reasonable cost? Do the factors that have kept such taxes low in the past mean that it is unlikely to be possible to raise them in the future?

The plan of the paper is as follows. Section II takes a first look at the various forms of aviation tax and the main border-crossing externalities arising from international aviation. Section III develops basic principles for aviation taxes, formally in a stylised theoretical model and then considering informally the implications of other potential distortions. Section IV considers the appropriate rates of aviation taxes and the revenue they would yield. Section V considers practical issues of administration and compliance. Section VI concludes.

[6]There is, however, one point worth noting. A key question with any candidate global tax for development finance is that of additionality – the extent to which the additional finance from such a source would be offset by reductions in other forms of support. On this, see World Bank (2005), Boadway and Keen (2006) and Zee (2006). Broadly speaking, viewing foreign assistance as a Samuelsonian public good to those who finance it, there is additionality from a coordinated tax reform amongst them only in so far as this increases the overall efficiency of their tax systems (with its extent then depending on the degree to which the associated increase in real income generates an increase in giving). In this respect, the stronger is the case for expecting efficiency gains from increased indirect taxation of international aviation, the more likely that any development finance from this source would prove genuinely additional.

II. Background

This section outlines issues and experience with the main types of indirect taxes on aviation and reviews the cross-border environmental externalities associated with international aviation.

1. Types of aviation taxes

There are three main possible types of indirect tax on aviation:[7,8]

- An *excise tax* – meaning one that (unlike, in particular, the VAT) is not creditable or refundable to business users – *on aviation fuel*, which, for brevity, it is assumed throughout would be levied in specific form (that is, as a fixed amount per gallon).[9]

  A cap-and-trade system, as envisaged in the European Commission's proposals, would have effects equivalent to those of a fuel excise levied at a rate equal to the market-clearing price (leaving aside – consistent with the general focus of the present analysis – the difference that emission rights might, as these proposals envisage, in part be allocated without charge to current emitters). For brevity, we therefore take the excise instrument to include schemes of this sort.
- A *ticket tax*, by which will be meant an ad valorem charge on sales of passenger tickets and cargo waybills, whether as VAT or a non-creditable excise – there being, as will be seen, important differences between the two.
- A *trip tax*, meaning a charge that is levied as a fixed amount per passenger trip and at a common rate for all trips within some wide class; the familiar departure tax is the leading example.

There are important similarities between the three types of tax. Under perfect competition for a homogeneous product of unchanging characteristics, for instance, ad valorem and specific taxes have precisely the same effects: thus a ticket tax levied as a non-creditable excise would be equivalent to a trip tax levied in the same monetary amount. If, further, there

[7]Taxes might also be levied in relation to local air pollution, noise or the use of airspace. While well targeted to particular difficulties, they have not featured prominently in recent discussions and none appears to be currently in use (except for a noise tax at airports in Switzerland).

[8]Aviation is also subject to a wide range of fees and charges. Most – such as airport landing charges, passenger security charges, and route facility charges imposed by air navigation services – are essentially user fees.

[9]Specific taxation is the norm for fuel excises. This reflects a variety of considerations, including the relative constancy of revenues that it implies, given relatively inelastic demand, in the face of variable oil prices.

were no possibility of changing fuel efficiency, then they would also be equivalent to a tax on aviation fuel.

But there are also important differences between these instruments. Critically, aviation fuel is an intermediate input (as is business cargo and, at least to some degree, business travel). Under conditions that are strong but provide a useful first guide to policy formation, the Diamond and Mirrlees (1971a and 1971b) theorem on production efficiency implies that – in the absence of externalities – such items should not be taxed. Thus the fundamental rationale for taxing aviation fuel and business travel and freight is the environmental damage referred to above and explored more fully below. Passenger travel, in contrast, is a final consumption item and so is potentially a proper target for final commodity taxation. More generally, differences between these three types of aviation tax arise from the potential differentiation between business and final use (under a VAT-type ticket tax), from substitution possibilities in the use of fuel and from the heterogeneity of the product (both across flights – so that the ad valorem equivalent of a fixed trip charge will vary – and across classes of travel for a given flight).

With this in mind, the rest of this section looks at current practice in respect of these three forms of indirect tax.

Taxes on aviation fuel

Domestic aviation fuel is generally subject to VAT. However, since aviation fuel is typically a business input, this component of tax will (in principle at least) be fully credited to registered taxpayers, and so have little economic impact. More relevant to the concerns here, many countries also charge excises on aviation fuel used for domestic flights, sometimes at rates differentiated between propeller planes (which use aviation gasoline) and jets (which use kerosene).

Systematic information on aviation fuel taxes is hard to come by. Table 1 reports the rates, in both specific amount and ad valorem equivalent (though note that the latter relate to a period of lower fuel prices than at present), recently applied to domestic aviation fuel in a selection of countries. These rates are in many cases similar for aviation gasoline and jet fuel, but where they differ, the jet fuel tax (the more important in practice) is the lower. There is quite wide variation across countries, with Japan and the Netherlands imposing noticeably higher taxes on jet fuel than do others. In the US, domestic aviation fuel is taxed at the state level, with rates varying across states (and no tax in some);[10] the figure reported is an average.

[10]Some states provide airlines with guarantees as to the maximum amount of fuel tax they will pay.

TABLE 1

Tax rates on domestic aviation fuel (selected countries, various years)

	Aviation gasoline		Jet fuel	
	US$ per gallon	*Per cent*[a]	*US$ per gallon*	*Per cent*[a]
Australia (2004)	0.09	8.0	0.09	8.0
Bolivia (2000)	0.21	9.3	0.21	17.4
Brazil (2002)	1.57	40.4	0.06	4.9
Canada (2004)	0.06	6.0	0.06	6.0
Costa Rica (2003)	0.96	38.7	0.58	38.4
Ecuador (2000)	0.36	15.8	0.16	15.4
Indonesia (2001)	0.02	7.7	0.16	13.2
Japan (2004)	1.10	96.0	1.10	96.0
Netherlands (2004)	0.92	81.0	0.92	81.0
Nicaragua (2003)	0.91	21.7	0.01	0.7
Norway (2004)[b]	0.16	14.0	0.16	14.0
Paraguay (2000)	0.32	9.2	0.01	1.1
Peru (2003)	0.58	15.9	0.25	16.1
Philippines (2004)	n.a.	n.a.	0.30	27.5
Taiwan (2000)	0.89	39.4	0.06	3.3
Uruguay (2004)	0.09	5.0	0.09	5.0
US (2004)	0.19	18.1	0.22	21.0
Venezuela (2001)	0.05	4.4	0.04	5.0

[a]Percentage of average fuel prices in the respective year (US$1 per gallon worldwide for 2000–03, US$1.50 per gallon for 2004).
[b]Also international flights.
Source: Energy Détente, various issues.

Under the VAT, items related to international transport are generally zero-rated (meaning that no tax is charged on sales, and any tax paid on inputs is refunded). In sharp contrast to the high excise rates that are often charged on other fuels, no country appears to levy either an excise or VAT on fuel used for international flights.

This exemption of international aviation fuel is to a large degree enshrined in the legal framework of international aviation:

- Article 24 of the 1944 Convention on International Civil Aviation (the 'Chicago Convention'),[11] which provides the legal framework for international civil aviation, requires that 'Fuel, lubricating oils [and other items] on board an aircraft of a contracting State, on arrival in the territory of another contracting State and retained on board on leaving the territory of that State, shall be exempt from customs duty, inspection fees or similar national or local duties and charges'. This prevents

[11]The Convention, which establishes the International Civil Aviation Organisation (ICAO), now has 188 signatories, including those countries most prominent in civil aviation.

countries from undoing any incentive for carriers to fuel flights from that country by tanking in lower-tax jurisdictions.

- Bilateral air service agreements typically go further, in also providing for reciprocal exemption of fuels uplifted in signatory countries: the International Civil Aviation Organisation (1998) reports that 97 per cent of agreements contain such provisions. Within the EU, there is now no legal impediment to Member States amending their bilateral agreements to allow the taxation of aviation fuel used in travel between them;[12] but this would apply only to their national carriers, and so would convey a competitive advantage on carriers from other countries enjoying a 'fifth freedom' right to transport traffic between the two – and in the EU, carriers from all other Member States have such a right. No EU member appears to have taken up this option.

The rationale for these legal undertakings is by no means clear. They may reflect a sense, perhaps especially strong in the early days of the industry, that international air travel conveys beneficial externalities through the fostering of international contacts and ought to be positively encouraged. In any event, they place significant obstacles to the taxation of international aviation fuel.[13] Renegotiating the Chicago Convention seems out of the question. Air service agreements could be renegotiated bilaterally, and are to that extent perhaps a lesser obstacle. The EU is indeed seeking to amend its agreements with third countries so as to allow the possibility of taxing aviation fuel used in travel between them, but the sheer number of these agreements (around 1,500 worldwide) would make their wholesale revision a painstaking and lengthy process.

Importantly, there are fewer legal obstacles to international emission trading schemes or charges, even though these have essentially equivalent economic effects to fuel taxes. (Indeed, the International Civil Aviation Organisation, for example, has endorsed the possibility of including aviation in a wider emissions trading scheme.) Within the EU, emissions trading has the further advantage that it can be adopted without the unanimity required for common tax measures.

Ticket taxes

Ad valorem taxes – proportional to the price charged – may be levied on tickets issued to passengers and on prices charged for cargo (waybills). These too may take the form of either a VAT or a non-creditable excise. Here, the role of the VAT is rather different from, and potentially more

[12]Article 14.2 of Directive 2003/96.

[13]For further discussion, see Sledsens (1998), for instance.

TABLE 2

Domestic ad valorem ticket taxes (selected high-income countries, April 2005)

Per cent

	VAT	*Other ticket taxes*
Australia	10	0
Austria	10	0
Belgium	6	0
Canada	0	7
Finland	8	0
France	5.5	0
Germany	16	0
Greece	8	0
Italy	10	0
Japan	0	5
Netherlands	6	0
New Zealand	12.5	0
Norway	7	0
Spain	7	0
Sweden	6	0
Switzerland	7	0
US	0	7.5

Notes: Tax-exclusive rates. None of these countries charges ticket taxes on international flights.
Source: International Air Transport Association, 2005a.

TABLE 3

Ad valorem ticket taxes
(selected emerging-market and developing economies, April 2005)

Per cent

	Value added tax		Other ticket taxes	
	Domestic flights	*International flights*	*Domestic flights*	*International flights*
Argentina	10.5	0	14	5
Brazil	0	0	3	0
Colombia	16	8–16	0	0
India	0	0	10	0
Korea	10	0	0	0
Mexico	2.5–10	2.5–4	0	0
Pakistan	0	0	20	1
Peru	19	19	0	0
Poland	7	0	0	0
South Africa	14	0	0	0
Taiwan	5	0	0	0
Thailand	10	7	0	0
Venezuela	0	0	9	1

Note: Tax-exclusive rates.
Source: International Air Transport Association, 2005a.

significant than, in the case of aviation fuel: although the tax will typically be credited when charged on business-related travel, it will be final for purchases by final consumers.

Treatment again commonly differs between domestic and international travel.

Domestic air travel is quite widely subject to VAT, as shown in the first column of Table 2 for selected high-income countries and the first column of Table 3 for selected developing and emerging-market economies. In the EU, all Member States except Denmark, Ireland and the UK charge VAT on domestic aviation services, although (except for Germany and the Netherlands) they do so at a rate lower than their standard.

Tables 2 and 3 also show non-creditable ad valorem ticket taxes imposed on domestic aviation. These are quite rare in high-income countries, being charged only by a few that do not levy VAT. The 7.5 per cent charge in the US is an earmarked security charge.

International travel, on the other hand, is typically zero-rated under the VAT.[14] This is the case for all high-income countries in Table 2; a few developing and emerging-market countries, however – notably in Latin America – do impose VAT on international travel. Ad valorem ticket taxes on international travel are also largely confined to developing and emerging-market countries, and where levied they are generally at lower rates than apply domestically. None of the countries for which we have information levies both VAT and an ad valorem ticket tax on international travel. Note also that in the rather few cases in which international ticket taxes are levied, this is typically only for tickets sold in the country.[15]

Many countries[16] simply have no ticket taxes.

Departure and other trip charges

Tables 4 and 5 report per-passenger charges for selected high-income and developing/emerging-market economies respectively. While the data used in them distinguish between airport charges (which usually accrue to the airport authority) and arrival/departure taxes (which usually accrue to government), it is in many cases unclear to which of these two categories the charge should be allocated. Attention is thus best focused on the sum of the two, shown in the rightmost pair of columns.

[14]All EU members except Sweden zero-rate international aviation activity, including flights among members. Sweden has an option to tax intra-EU flights, as a derogation from the Sixth VAT Directive.

[15]In Argentina and Costa Rica, which have the most significant taxes of this kind, travel beginning abroad is exempt, as are tickets sold outside Argentina to non-Argentines.

[16]Including, for example, Brazil, China, Denmark, Hong Kong, Indonesia, Ireland, Israel, Russia, Singapore and Turkey.

TABLE 4

Airport and trip charges (selected high-income countries)

US$ per traveller

	Airport charges		Trip charges		Total passenger charges	
	Domestic	*International*	*Domestic*	*International*	*Domestic*	*International*
Australia	6–22	11–19	30	30	36–52	41–49
Austria	16	16	0	16–17	16	32–33
Belgium	0	0	0	12–25	0	12–25
Canada	16–20	22–26	0	0	16–20	22–26
Denmark	8–16	20	12	12	20–28	32
Finland	3	3	7	6–12	10	9–15
France	15	9–16	0	0	15	9–16
Germany	13–22	11–19	0	0	13–22	11–19
Greece	29	44	0	0	29	44
Hong Kong	0	0	0	15	0	15
Ireland	4–6	4–6	10	10	14–16	14–16
Israel	12	12	0	8–55	12	20–67
Italy	6	6	7–11	7–11	13–17	13–17
Japan	1–2	11–28	0	0	1–2	11–28
Netherlands	40–42	40–42	0	0	40–42	40–42
New Zealand	4	11	0	14–18	4	25–29
Norway	12	17	0	0	12	17
Singapore	0	0	0	10–13	0	10–13
Spain	1	1	4–5	5–8	5–6	6–9
Sweden	11–18	12–25	0	0	11–18	12–25
Switzerland	0	0	6–28[a]	6–28[a]	6–28[a]	6–28
UK[b]	15–27	18–36	11	9–73[c]	26–38	27–109
US	3	3	19	31	22	34

Notes: Trip charges include departure charges and in some instances also arrival charges. All charges are as of April 2005; exchange rates are as of June 2005.
[a]Includes a specific noise tax, differentiated by airport.
[b]Air passenger duty has subsequently (February 2007) been doubled.
[c]Rate differentiated by class of travel and by destination (EU/non-EU).
Source: International Air Transport Association, 2005a.

Per-passenger charges are evidently commonplace, though the detail varies (some are differentiated by citizenship, for example, and some by class of travel). In some high-income countries, charges are substantial: they are highest in the UK, at US$109 for first-class travellers to destinations outside the EU (and this before the recent doubling of air passenger duty). Most important for present concerns, charges are typically higher for international than for domestic travel.[17] In some emerging-market and

[17]Interestingly, this pattern in trip taxes runs counter to the impression formed above that the ticket taxes levied in low-income countries are commonly higher for domestic than for international travel. It

TABLE 5

Airport and trip charges (selected emerging-market and developing economies)

US$ per traveller

	Airport charges		Trip charges		Total passenger charges	
	Domestic	*International*	*Domestic*	*International*	*Domestic*	*International*
Argentina	1	12	2	18	3	30
Brazil	0	0	2–4	12–36	2–4	12–36
Chile	3–8	8	0	20/50[a]	3–8	8
China	6	11	0	0	6	11
Colombia	0	0	1–4	60–66	1–4	60–66
Costa Rica	1	7	0	26	1	33
India	5.50	5.50	0	3–12	5.50	8.50–17.50
Indonesia	2–10	5–10	0	10	2–10	15–20
Korea	4–5	23–27	0	0	4–5	23–27
Malaysia	0	0	2	5–12	2	5–12
Mexico	10	10	15	39	25	49
Nigeria	3	35	0	0	3	35
Pakistan	2	12–25[b]	0	27	2	39–52
Peru	0	0	5	43	5	43
Philippines	2	10	0	23–32[c]	2	33–42
Poland	5–8	10–16	0	0	5–8	10–16
Russia	6	6–14.50	0	15	6	21–29.50
Saudi Arabia	0	0	0	9	0	9
South Africa	7–16	19–21	0	10	7–16	29–31
Taiwan	0	0	0	10	0	10
Thailand	0	0	1–10	12	1–10	12
Turkey	1–3	7–18	0	0	1–3	7–18
Ukraine	1	1–5	2–3	10–15	3–4	11–20
Venezuela	1	0	0	30–37	1	30–37

Notes: Trip charges include departure charges and in some instances also arrival charges. All charges are as of April 2005; exchange rates are as of June 2005.
[a]The two figures apply, respectively, to US and Canadian citizens only (and are not included in the rightmost column).
[b]Rate differentiated by class of travel.
[c]Applies to domestic citizens only.
Source: International Air Transport Association, 2005a.

developing countries (such as Colombia, Mexico, Pakistan and Peru), charges for international travellers are near the highest levels found in high-income countries.

This differentially heavier taxation of international trips will tend to offset, particularly for shorter journeys and at the top end of the rates currently charged, the inefficiencies implied by the relatively advantageous

may be that trip taxes are a better-targeted way of taxing non-residents likely to have bought their tickets abroad.

treatment of international aviation in respect of ticket taxes and aviation fuel. Clearly, though, trip taxes will have very different incentive effects.[18]

All these instruments, it should be noted, encounter potential problems of international tax competition. To the extent that planes are technically able to do so (a Boeing 747, for example, can travel from New York to London and back on a single tank of fuel) – and to the extent that safety rules allow them to do so – high fuel taxes in any country could be avoided by tanking in lower-tax jurisdictions. Even if legal obstacles to explicit fuel taxes were overcome, incipient tax competition might thus lead to their being set at inefficiently low levels. Countries may also fear that a unilateral increase in any of these aviation taxes would jeopardise their attractiveness as a tourist destination. Collective action in rate-setting may then be appropriate.

2. Environmental externalities

A key argument in favour of taxing aviation is that it generates adverse environmental externalities, creating a case for purely corrective taxation. Since the concern here is with taxing international aviation, it is only border-crossing externalities that are at issue: purely domestic damage from domestic aviation can in principle be dealt with, at least for the most part, by countries unilaterally, even given the legal obligations described above.

Air pollution

The main pollutants in the emissions from burning aviation fuel are NO_x, carbon monoxide, hydrocarbons, sulphates and soot aerosols. A complicating factor is that some of these emissions, such as NO_x, also affect the concentrations of other substances such as ozone and methane (pollutants and greenhouse gases) through complex chemical processes. And while NO_x increases ozone, other aviation emissions reduce it, so that the net effect is uncertain. Air pollution effects from aircraft are more damaging in more populated areas, and emissions relative to distance travelled are greater in the vicinity of airports. Since many more international than domestic flights are long and over sea or deserted land areas, international aviation on average involves less air pollution (per unit of burned fuel) than domestic.

[18]As a rough indication of orders of magnitude, a 747 flying from London to New York with 24 business- and 281 economy-class passengers (see Table 7 below) would generate departure tax revenue to the UK of £13,160. It would use about 17,300 gallons of fuel, so that a fuel tax of $0.40 (see discussion below) would raise, at current exchange rates, £3,650. In this case, the departure tax thus raises considerably more revenue than would a fuel tax. (Other countries, it should be remembered, set far lower departure taxes than does the UK.)

Global warming

Aviation fuels contribute to global warming through greenhouse effects due to emission of carbon dioxide.[19] At present, aviation accounts for only 3–4 per cent of global carbon emissions, but the share is growing: on one assessment,[20] this figure will rise by 2050 to at least 5 and perhaps as much as 15 per cent, with absolute effect 3.8 times that of the 1992 value. Other pollutants emitted by airplanes (nitrogen oxides, methane, water vapour, sulphates and soot) may also contribute to global warming, although the effects – and often even their signs – are uncertain.

Noise

Most aviation noise arises at or near airports, with damage varying greatly by airport location and nearby population density. Noise problems far from airports are small, at least for (subsonic) jet flight at 10–12 km (Pearce and Pearce, 2002).[21] Noise pollution is thus essentially local, which implies that it can in general be dealt with at country level.

Pollution and congestion at airports

Pollution at airports (apart from that caused by fuels) includes local and groundwater contamination due to use of de-icing fluids, local oil spills, and other substances used for clearing or cleaning runways. Congestion at airports has two components. First, the air transport system may be congested, in runways and airspace. Second, there may be congestion in terminals, road and airport transport systems and parking. Congestion is usually of a peak-load character, and may be particularly serious when it is difficult to scale-up airport size (in terms of terminal, parking and runway space). With a single monopoly provider of air services, congestion externalities will tend to be fully internalised.[22] When several airlines operate at a given airport, however, inefficiency is liable to remain, so that congestion charges should be levied, typically at higher rates the more intense is the competition.[23] In practice, there are relatively few cases in which a single provider (or cooperating provider group) is fully dominant, so that internalisation cannot generally be presumed. Again, however, this is generally a domestic rather than border-crossing matter.

[19]NO_x also has greenhouse gas effects, through its interaction with ozone, when emitted at high altitudes. This effect is less well studied than that of CO_2, but likely to be relatively minor.

[20]This estimate is from Intergovernmental Panel on Climate Change (1999).

[21]Supersonic transport creates local noise problems similar to those of subsonic transport, but far greater non-local noise problems over populated land areas.

[22]Acemoglu and Ozdaglar, 2007; Brueckner, 2002.

[23]In Brueckner (2002), with airlines operating as Cournot oligopolists, the optimal toll equals the congestion cost from an extra flight multiplied by one minus the carrier's flight share at the airport.

Congestion due to passenger overcrowding at or near airports is also of little relevance to the case for international aviation taxes, since it can be corrected by purely domestic means, such as road user charges. In principle, local airport administrations should deal with externality costs arising at airports by charging such costs to users (airlines and/or passengers) through take-off and landing fees (preferably graduated by airplane size, fuel consumption and local noise created by airplanes) and other congestion-related charges (such as fees for local parking and for the use of terminals charged to passengers, and peak-load fees charged to airlines). Most airports do indeed charge substantial fees. Only the fees in excess of costs of constructing and operating airports, however, can serve to correct for externalities: it is unclear whether these are set at such a level, and this may vary across countries and airports.

Estimates of environmental harm from aviation

There have been few attempts to quantify the external damages associated with aviation. A careful study by Pearce and Pearce (2002) estimates overall marginal air and noise externalities from aviation in the UK to be about £0.07 per litre of aviation fuel, or about US$0.45 per gallon (varying somewhat across aircraft types): see Table 6. The great bulk of this comes, in about equal parts, from air pollution and CO_2 emissions (with a central estimate for the latter, quite widely used, of US$50 per ton, or about 20 US cents per gallon of aviation fuel).

TABLE 6

Estimated aviation fuel externality costs: UK, 2000

US cents per gallon

Airplane type	*Noise*	*Air pollution*[a]	*Total externality cost*
A310	7	35	42
A340	7	40	47
Bae146	0	35	35
B737-100	42	27	69
B737-400	0	35	35
B747-400	7	44	51
B757	6	38	44
B767-300	6	36	42
B777	0	40	40
F100	0	35	35
MD82	7	38	45
Average	7	38	45

[a]Including carbon emissions.
Source: Pearce and Pearce, 2002.

Externalities from aviation may be higher in the UK than elsewhere, since incomes and population densities are relatively high. And noise pollution is more a matter for local and national policy, as noted above, than for international. On the other hand, the Pearce and Pearce estimates exclude the cost of some air pollution compounds (notably carbon monoxide and volatile organic compounds).[24]

In the discussion below, we therefore focus for brevity on three illustrative values of marginal environmental damage: US$0.4 per gallon, as a plausible estimate for higher-income countries, and particularly within Europe; US$0.2 per gallon, effectively valuing only carbon emissions; and zero, which must be a lower bound.

III. Optimal indirect taxes on aviation

This section explores a simple model – capturing the key distinction between taxes on aviation fuel inputs and ticket (or trip) taxes on final consumption – that enables a basic analysis and, later, simulation of optimal indirect taxes on aviation.

1. No cross-border damage

For clarity, we start with the case in which environmental damage does not cross borders and in which there is no international mobility of the tax base. This means that the optimal policy of each country can be examined in isolation.

Denote output of the aviation sector – thought of as passenger miles travelled – by X. This is taxed at a specific (per unit) rate of τ; the market is assumed to be perfectly competitive (we return to this below), so that this is equivalent to (but algebraically less messy than) an ad valorem tax. For brevity, τ is referred to as a ticket tax, though in the present simple setting – with only one, fixed type of journey and the competitiveness assumption meaning that specific taxation is equivalent to ad valorem – it is equivalent to a trip tax. There are constant returns, with unit cost denoted by $c(p+t)$, where p denotes the tax-exclusive price of fuel (taken to be exogenous) and t a fuel tax in specific form; though not made explicit, there is also some other input, assumed to be untaxed and unchanging in price. By standard results, the cost function c is convex, and the use of fuel per unit output, f, is given by

[24]Looking forward, it is not clear whether marginal damage is likely to be higher or lower in the future: greater population densities and incomes will tend to increase it, while more fuel-efficient and quiet aircraft will tend to reduce it.

(1) $$c'(p+t) = f\ ,$$

with the curvature $c'' \leq 0$ indicating the ease of substitution between fuel and the other input. The consumer price of the final output is $Q \equiv \tau + c(p+t)$.

The object of policy is then to choose the two tax rates, τ and t, to maximise welfare, given by[25]

(2) $$W \equiv V(Q) + \delta\left[\tau X(Q) + tX(Q)c'(p+t)\right] - E\left[X(Q)c'(p+t)\right]$$

where the indirect utility function, V, captures utility from private consumption, environmental damage, E, is taken to be increasing and convex in aviation fuel use, Xc', and the parameter δ represents the marginal social cost of raising revenue (to which the marginal benefit of public expenditure will optimally be equated). The last of these captures, in convenient summary form, the extent of the deadweight losses associated with a wider tax system that is not explicitly modelled.[26] With lump-sum taxation, there are no such distortions and $\delta = 1$. More generally, to the extent that distorting taxes must be used, $\delta > 1$: if this were not the case, it would be socially preferable to raise no tax revenue at all.

It is straightforward to show[27] from the necessary conditions for this problem that, so long as $c'' < 0$, so that there is some substitution between fuel and other inputs (without which the ticket and fuel tax are equivalent), the optimal fuel[28] and ticket taxes (both expressed as tax-inclusive ad valorem equivalents) are characterised by

(3) $$\frac{t}{p+t} = \frac{E'}{\delta(p+t)}$$

(4) $$\frac{\tau}{Q} = \left(\frac{\delta - 1}{\delta}\right)\frac{1}{\varepsilon(Q)}$$

[25]There is in the background a numeraire good taken (by normalisation) to be untaxed. Preferences are quasi-linear, with all income effects concentrated on the numeraire. Note too that it is assumed throughout that each country may tax only the travel of its own citizens (which abstracts from a range of issues in tax exporting and tax competition likely to be significant to some tourist destinations) and that the load factor is 100 per cent (abstracting from some issues of convenience and peak loading).

[26]For present purposes (since we shall be more concerned with characterising tax policies than with their comparative statics), there is no real loss in treating the marginal value of public expenditure as a constant: the same characterisations would apply if revenue were valued by an increasing concave function with marginal value $\delta(.)$.

[27]Further details of this and other claims to follow can be found in Keen and Strand (2006).

[28]Here and elsewhere, characterisations of the optimal fuel tax can, of course, be translated into characterisations of an optimal quantity restriction, allocated by auctioning.

where $\varepsilon(Q) \equiv -X'Q/X > 0$ denotes the price elasticity of final demand (assumed throughout to be strictly positive in absolute value).

The importance of (3) and (4) is in showing a clear separation in the roles of the two types of tax: environmental damage enters only the characterisation of the fuel tax, and revenue considerations drive the ticket tax (which has the standard form of a Ramsey tax in the absence of externalities). To see this separation most clearly, note that if $\delta = 1$, so that there is no revenue-raising motive, then it is optimal to set the fuel tax at the Pigovian level and not to tax tickets at all. At the opposite extreme, when there is no environmental damage ($E' = 0$), it is optimal to use only the ticket tax, setting the fuel tax to zero. The intuition behind these observations is straightforward. Aviation fuel is an intermediate input. As noted earlier, the Diamond–Mirrlees theorem then implies that in the absence of externalities, it should not be taxed at all if there are no constraints on the taxation (through the ticket tax) of final consumption.[29] When there is no environmental damage, the distortion of input choices caused by a fuel tax would serve no socially useful purpose, and indeed would create an inefficiency in input choice that erodes potential tax revenues.

There is an important trade-off to be faced between environmental and revenue concerns. This emerges clearly on noting that, as is easily shown, it is always possible to raise more revenue with a ticket tax than with a fuel tax.[30] By the same token, whenever $\delta > 1$, the (second-best efficient) correction of the externality is in an important sense incomplete: unless lump-sum taxation is available, the environmental charge is set below the Pigovian level. This is a standard result in the literature on environmental taxation – discussed at length, for instance, in Bovenberg and Goulder (2002) – with a straightforward intuition: increasing the fuel tax towards the Pigovian level would lead to a reduction in the tax base, and hence revenues, that more than offsets the benefit derived from a reduction in external damage. Thus the optimal fuel tax tends to be lower, and the ticket tax higher, the greater is the need for revenue (that is, the higher is δ).[31]

Given the evident difficulty of implementing any indirect tax on international aviation, let alone two, the case in which only one can be levied is of natural interest. The optimal levels of each tax when used in isolation are readily shown to be

[29]More generally, the result requires that there be no constraints on the ability to tax pure profits or to deploy a full range of distorting tax instruments.

[30]This follows from noting that the necessary conditions for maximising revenue $T = \tau X(Q)+tX(Q)c'(p+t)$ are $X+\tau X'+tX'c' = 0$ and $\tau c'X'+c'X+t(c')^2X'+tc''X' = 0$, which together imply $tc''X' = 0$, and therefore that $t = 0$ so long as $c'' < 0$.

[31]It is assumed in this informal discussion, but not in the algebra, that marginal environmental damage and the elasticity of demand are both constants.

$$(5) \qquad \frac{\tau}{Q} = \left(\frac{\delta - 1}{\delta}\right)\frac{1}{\varepsilon} + \frac{E'c'}{\delta Q}$$

for the ticket tax and

$$(6) \qquad \frac{t}{p+t} = \left(\frac{\delta - 1}{\delta}\right)\frac{1}{(1-\alpha)\sigma + \alpha\varepsilon} + \frac{E'}{\delta(p+t)}$$

for the fuel tax, where $\sigma \equiv (p+t)c.c''/\{c'.[c-c'(p+t)]\}$ denotes the elasticity of substitution in production between fuel and the composite other input, and α denotes the share of fuel in total costs. As one would expect, the neat separation of roles found when both tax instruments can be used is lost when only one can be used: each is then shaped by both revenue and environmental concerns, with their characterisations having the same additive structure.[32] The key structural difference is that whereas the optimal stand-alone ticket tax depends on the elasticity of demand, the optimal stand-alone fuel tax depends on a weighted average of that elasticity and the elasticity of substitution in production. If there is no possibility of substituting away from fuel use ($\sigma = 0$), then the optimal stand-alone fuel tax (per unit of final output), tc', is identical to the stand-alone ticket tax, τ. In contrast, when $\sigma > 0$, the fuel tax is lower, by an extent that increases with the strength of substitution in production and decreases with the elasticity of final demand.

If then only one of these tax instruments can be used – a ticket tax or a fuel tax – which should it be? Clearly, the answer hinges on the relative importance of environmental and revenue concerns. All else equal, the ticket tax is more likely to be preferred, the greater is the need for revenue and the lower is marginal environmental damage. The practical significance of this point, and of others raised by the formal analysis in this section, is explored by simulation in Section IV.

2. Implications of cross-border environmental damage

A large part of the interest in indirect taxes on international aviation stems from the perception that it causes significant and at present largely uncorrected border-crossing environmental damage, as discussed above. So suppose now that there are (for simplicity, only) two countries, with the harm suffered by country $i = 1,2$ being, in obvious notation, $E_i(X_1 f_1 + X_2 f_2)$. Welfare in country i thus becomes

[32]This echoes Sandmo's (1975) result on the additivity of Ramsey and environmental terms in optimal tax formulae for final products.

$$(7) \qquad W_i \equiv V_i(Q_i) + \delta_i\left[\tau_i X_i(Q_i) + t_i X_i(Q_i) c_i'(p+t_i)\right] \\ - E_i\left[X_1(Q_1)c_1'(p+t_1) + X_2(Q_2)c_2'(p+t_2)\right]$$

where, note, the countries may differ in preferences, susceptibility to environmental damage and/or technology.

Cooperative taxation

Consider first the case in which countries cooperate in setting their tax rates, in the sense that each seeks to maximise W_1+W_2. Each thus takes account of the impact of its tax choices on the environmental harm suffered by the other. Optimally coordinated taxes are then given by[33]

$$(8) \qquad \frac{t_i}{p+t_i} = \frac{E'}{\delta_i(p+t_i)}$$

$$(9) \qquad \frac{\tau_i}{Q_i} = \left(\frac{\delta_i - 1}{\delta_i}\right)\frac{1}{\varepsilon_i}$$

where $E' \equiv E_1' + E_2'$ denotes the global damage from a small increase in international travel.

As one might expect, the ticket tax optimally differs across countries, reflecting differences in both the elasticity of demand and the strength of the need for revenue. Rather less obviously – and running counter to the notion that efficiency requires taxes on items that damage the collective commons to be uniform across countries – the optimal fuel tax also typically varies across countries.[34] The point here is that even though the Pigovian marginal social damage that enters the optimal fuel tax expression is the same in the two countries – because it reflects their collective harm – the second-best considerations discussed above mean that the optimal fuel tax is typically lower in the country with the higher marginal cost of public funds: when δ_i is high, the environmental component is lower in order to mitigate the impact through pre-existing distortions, with the greater need for revenue reflected instead in a higher tax on the final product.

Thus even when countries cooperate fully – and even in the absence of explicit concerns with international distribution of real income – it will typically be optimal for them to set different taxes, on both tickets and fuel,

[33]We abstract from considerations of cross-country equity by taking the marginal utility of income (normalised to unity) to be the same in each.

[34]A little-remarked limitation of an international cap-and-trade system is that it cannot in itself replicate such an optimally differentiated tax structure, since it faces all emitters with the same charge.

both to exploit differences in elasticity of demand and in reflection of their differing needs for government revenue.

Non-cooperative taxation

Now suppose – more plausibly, at least at present – that countries do not cooperate in tax-setting but rather look to their own national interest: country i simply maximises W_i. With each country taking as given the tax rates set by others, the Nash equilibrium non-cooperative tax rates are

$$(10) \qquad \frac{t_i}{p+t_i} = \frac{E_i'}{\delta_i(p+t_i)}$$

$$(11) \qquad \frac{\tau_i}{Q_i} = \left(\frac{\delta_i - 1}{\delta_i}\right)\frac{1}{\varepsilon_i}.$$

When both taxes are used in the pursuit of national rather than collective interest, equilibrium fuel taxes thus reflect only the harm that each country perceives for itself, and so are set lower than in the cooperative outcome. The characterisation of the ticket tax, on the other hand, remains exactly as in the cooperative case.[35]

That the neglect of harm suffered abroad leads to fuel taxes being set at inefficiently low levels is evident enough, and easily verified: starting from a non-cooperative equilibrium, both countries would benefit from a coordinated increase in fuel taxes.[36] It is also readily shown that, less obviously, ticket taxes tend to be set too low in non-cooperative equilibrium.[37] The existence of this inefficiency in ticket taxes may seem strange, given that the characterisation of these taxes in the non-cooperative equilibrium (equation (11)) is exactly the same as in the cooperative solution (9) – indeed, if the elasticity of demand is constant, the numerical level of the ticket tax is precisely the same in the non-cooperative equilibrium as under full cooperation. The key point, however, is that unless fuel taxes are set to deal appropriately with environmental damage, moving ticket taxes away from the cooperative rule (or even level) may be desirable as a second-best means of reducing emissions.

[35]The precise value will generally differ, reflecting the impact of the different level of the fuel tax on producer prices and hence, in principle, on the elasticity of demand.

[36]For example, a small increase in t_1 from the non-cooperative equilibrium has no effect on W_1 (as an envelope property) but increases W_2 by $-E_2'\left[X_1'(c_1')^2 + X_1 c_1''\right]dt_1 > 0$.

[37]Along similar lines to the preceding footnote, a small increase in country 1's ticket tax, τ_1, for example, has no first-order effect on welfare in country 1 but increases welfare in country 2 by $-E_2' X_1' c_1' d\tau_1 > 0$.

While the analysis thus points to potential coordination gains, in the presence of border-crossing environmental damage, in respect of both fuel and ticket taxes, those in respect of the former are in an important sense more fundamental and a more appropriate focus of policy: increasing ticket taxes from their non-cooperative level may convey a mutual benefit for the reason just noted, but is also likely to move those taxes away from their appropriate cooperative levels. Increasing fuel taxes from their non-cooperative levels, on the other hand, is likely to bring them closer to their cooperative levels, in the process eliminating any gain from ticket tax coordination and moving the combination of instruments towards the efficient outcome.

The magnitude of the coordination gains will depend on the nature and extent of asymmetries between the countries. It is likely to be greater the more similar are the countries: for if, in contrast, one country causes a large share of overall externalities, then it will to a large degree internalise these in its own decision-making.

3. Treatment of business and economy travel

The analysis above treats air travellers as a homogeneous group. In reality, the aviation market is highly segmented, between (and within) first, business and economy class. Since it makes no sense to differentiate a fuel tax by passenger class, the question is whether, and if so in which direction, it is desirable to differentiate ticket or trip taxes.

Clearly, the elasticity of demand ε is likely to differ between these groups, and hence so too are optimal ticket and trip tax rates. A recent survey[38] confirms the natural presumption that business travel is indeed typically far less price-sensitive than economy or tourist travel: central estimates of the demand elasticity for business travel are around 0.25 for long-haul international travel and around 0.6 for short-haul domestic travel; for economy-class travel they are around 1.0 and 1.3 respectively (all in absolute value).[39] The analysis above would thus point to substantially higher ticket or trip taxes on business- than on economy-class travel.

There are, though, other considerations that may serve to modify this conclusion. In particular:

- Interactions with the wider tax system are potentially important. When this leads consumers to take excessive leisure (in the broad sense of time

[38]Gillen, Morrison and Stewart, 2004.

[39]European Commission (2005a and 2005b) takes a central estimate of –0.5. Earlier work by the International Civil Aviation Organisation (1985) implies a demand elasticity for leisure trips of –1.1 for short-haul and –0.8 for long-haul.

out of the labour market), optimal tax design involves counteracting this effect by taxing more heavily items that are more complementary with leisure. To the extent that economy travel tends to be for leisure and business travel for business, this points to a lower tax on business- than economy-class travel.[40] One might also suspect, however, that at least some business travel is in part a tax-favoured fringe benefit – deductible to the employer but inadequately taxed to the recipient – pointing again towards heavier taxation of business use in order to counteract an implicit tax subsidy.

- To the extent that business-class travel is a production input, the Diamond–Mirrlees theorem implies that it should be untaxed, so long as fuel is properly taxed. Even if fuel is not appropriately taxed, the point has potential force: taxing business travel may lead to such a reduction in aggregate output that any revenue gained by the tax itself would be more than offset by a reduction in the revenue that could be raised by other taxes (such as those on salaries, profits or final sales).

Where the balance of these considerations lies is not clear-cut. In the absence of evidence on their relative importance, the most reasonable conclusion appears to be that there is no overwhelming reason to differentiate between business and economy travel, and that the best form of ticket tax would in principle be a VAT, creditable to registered taxpayers (and, of course, subject to controls intended to deny credit for private use).

4. International tax competition

Countries are likely to be unwilling unilaterally to levy aviation taxes at levels that they fear will reduce their competitiveness – the market share of their own airlines and airports, or of their tourism industries – given the taxes charged by others. It is possible, for example, for route and hub structures to be altered in response to tax differentials across countries and individual airports. In the case of fuel taxes, bunkering in lower-tax jurisdictions could emerge as a significant problem when fuel tax rates differ substantially. All this again points – for reasons familiar, for example, in relation to the taxation of internationally mobile capital[41] – to non-cooperative taxes on international aviation being set at inefficiently low levels, with scope for mutually beneficial gains from a coordinated increase. This, it should be stressed, is a source of gain from cooperative taxation quite distinct from that relating to border-crossing environmental externalities discussed above.

[40]Strand (2005) develops this argument in detail.
[41]A classic reference is Zodrow and Mieszkowski (1986).

There are some qualifications to this presumption of mutual gain from coordination. First, there may be countervailing incentives to set tax rates higher than is in the collective interest, in order to exploit power in world markets. Countries with strong appeal to tourists, or with major airports serving as hubs, may to some degree exploit these advantages by 'tax exporting', imposing high taxes on foreigners, whose welfare is presumably valued less than that of domestic residents. Indeed, that is presumably to some degree the rationale for the heavier departure taxes on international travel described in Section II, at least for some lower-income countries.

Second, the interests of countries diverge, and it is possible that coordinated tax increases can be made beneficial to all only if some of the revenue raised is used to compensate those who would otherwise lose. Indeed, coordinated tax increases by a subset of countries may increase the benefits of non-cooperation to other countries.[42]

Third, strategic international fuel tanking seems likely to be a significant problem only with aviation fuel taxes above the fairly moderate levels currently under discussion: arbitraging fuel tax differentials can involve quite substantial costs, not least in adding to aircraft weight. In Norway, for example, when an aviation fuel tax at a rate of 16 US cents per gallon was first proposed, major airlines threatened to purchase substantial amounts of aviation fuel abroad. Such a fuel tax was enacted in 1999, and has since been increased moderately, to about 18 US cents per gallon. But little or no such excess fuelling has taken place. ECON (2005) concludes that the tax was low enough to make excess tanking abroad uneconomical, due to resulting increased plane weight. Nevertheless, experience in relation to tanking of commercial diesel fuel in the EU – for which there is significant evidence of tax competition (Evers, de Mooij and Vollebergh, 2004) – suggests that this could become a real issue at the higher levels of international fuel tax that might be envisaged.[43]

5. Distortions in competing modes of transport

Distortions in transport markets that provide substitutes for air travel may also affect the optimal structure of aviation taxes. In particular, since short-haul air travel often competes with road or rail transport, any over- or under-

[42]On these points – not specific to the aviation context – see Kanbur and Keen (1993) on the possibility of Pareto gains from harmonisation or the adoption of a minimum tax rate, and Konrad and Schjelderup (1998) on the possibility of a subset of countries gaining from coordination in which others do not participate.

[43]For a fuel tax at the (high) rate of US$1 per gallon, Edmondson et al. (2005) calculate that 50 per cent or more of the fuel tax base may be lost for inter-EU air traffic. European Commission (1999), however, concludes that the loss of the aviation fuel tax base would be only in the range 5–10 per cent for tax rates in this range.

pricing in these sectors should in principle – to the extent that it cannot be addressed directly – be factored into aviation tax design. The extent of the proper adjustment depends on both the cross-elasticity of demand between aviation and these other modes and the direction of the distortion in the latter. To the extent that a competing mode is inappropriately subsidised, for example (and the subsidies cannot be removed), the optimal aviation tax will be lower than otherwise, in order to counteract the tendency towards socially excessive use of the alternative.

This consideration is potentially important in both North America and Europe. In much of North America, short-haul air transport competes mainly with car travel (though there are cases, notably on the eastern seaboard, in which it competes with rail); in Europe, air transport competes with both cars and rail. Recent work suggests that road transport is under-taxed in the US and other countries in which road vehicle fuel taxes are low (at least in urban areas where most airports are located).[44] If higher road traffic taxes in the US are ruled out, perhaps as a matter of political reality, then second-best aviation taxes will be lower there relative to the benchmark Pigovian case (though this is, of course, a matter for domestic tax policy rather than internationally coordinated taxes). In some European countries, on the other hand, fuel taxes may be too high,[45] in which case second-best considerations point to higher aviation taxes than would otherwise be the case (including on international flights within the region). Pointing in the opposite direction, however, rail transport is heavily subsidised in some European countries, such as France, Germany, the UK and the Benelux.[46] There is thus no clear-cut conclusion, with the appropriate pattern of aviation taxes on intra-EU flights dependent on the strength of substitutability between road, rail and air transport and the extent of taxes/subsidies on the alternatives to air travel. Indeed, the implications for aviation taxation might well, in principle, be route-specific. In the absence of firmer quantitative evidence, and given too that the better response is to address directly any inefficiencies related to the alternative modes, the safest position for the moment – and this is clearly an area that will merit closer study if aviation taxation continues to move up the policy agenda – seems to be to consider aviation taxes independently of potential interactions across competing modes.

[44]See Parry (2002), Parry and Bento (2001) and Parry and Small (2005).

[45]Parry and Small (2005) argue that fuel taxes are too high in the UK and Newbery (2005) argues that they are about right.

[46]International Air Transport Association (2005b) documents substantial rail subsidies for Britain, France and Germany.

6. Other considerations

There are several additional considerations that are in principle relevant for aviation tax design, but on which direct evidence is at present again scant. One is possible imperfect competition in the aviation sector. With homogeneous product monopoly or Cournot competition, first-best policy – leaving revenue and environmental considerations aside for the present – is an output subsidy set so as to induce marginal cost pricing, together with lump-sum transfers to firms, if necessary, to ensure non-zero profits. Combined with revenue and environmental concerns, the implication is that optimal taxes will be lower than would otherwise be the case.[47] Assessing the extent of imperfect competition in the aviation industry is not easy, however.

A key issue is whether there is free entry and exit. This has been studied widely for domestic US aviation, the general conclusion being that net long-run profits tend to zero and entry/exit is relatively free, at least in the economy-class segments.[48] Both formal and informal barriers (due, for example, to national airline subsidies) have also been substantially reduced since the 1980s, at least in North America and Europe.[49] Ease of entry/exit has been less studied for international aviation. Stronger legal restrictions on entry suggest that – while there is clearly considerable variation by route – monopolistic output restrictions are here more likely. It seems, however, that private international carriers do not systematically earn supernormal profits.[50]

Analysis of this and other aspects of the airline industry is complicated too by the heterogeneity of its products, notably as between economy, business and first-class travel. These products are differentiated by flexibility of booking, availability at short notice, travel and airport comfort, food and entertainment service, connection availability, and timing. The potential importance of such differentiation is illustrated by the pricing structure of a fairly typical trans-Atlantic flight, shown in Table 7. Only 9 per cent of passengers were in first or club (business) class, but they accounted for about half of revenues. There was wide price differentiation even within the traveller (economy) class segment. Differentiation has likely increased since then, by place of ticket issue, by whether the ticket is sold

[47]See, for instance, Kolstad (2000, pp. 129–32).

[48]See, for instance, Transportation Research Board (1999), Hanlon (1999), Borenstein (1989, 1991 and 1992), Borenstein and Rose (1994), Evans and Kessides (1993), Hurdle et al. (1989), Mayer and Sinai (2003), Morrison (2001) and Whinston and Collins (1992).

[49]See Transportation Research Board (1999). Government-controlled European airlines received more than US$11 billion in (accumulated) subsidies in the 1990s, and private airlines more than US$3 billion.

[50]Pearce (2006) shows that airline industry profits over the last 10 years have generally been small.

TABLE 7

Illustrative seat prices by type of ticket
(British Airways 747, London–New York, November 1998)

Travel class	*Ticket price round trip (£)*	*Number of seats*	*Average capacity utilisation (%)*	*Average share of passengers (%)*	*Average share of revenue (%)*
First class	5,234	18	50	3	25
Club class	2,954	25	60	5	24
Unrestricted traveller class	844	49	80	13	18
APEX class	357	124	85	35	19
Promotion class[a]	187	132	100	44	13
Total	186,813[b]	348	75		

[a]This is a particular low-price ticket sold as part of a time-limited promotion scheme; the capacity utilisation rate of 100 per cent is assumed.
[b]Total revenue per flight.
Source: Hanlon (1999), with some inaccuracies corrected.

through a travel agency, via the internet or directly from the airline. Some part of these differentials reflects cost differences, but others are clearly due to price discrimination between passenger segments.

Imperfect competition and product heterogeneity could also affect the choice between specific and ad valorem forms of aviation taxes. With perfect competition and homogeneous products, ad valorem and specific taxes are equivalent; under imperfect competition, they are not, and it is a fairly robust result that ad valorem taxes are then socially preferable.[51] Further complications and ambiguities arise, however, from the heterogeneity and endogeneity of product characteristics. Ad valorem taxation, for example, tends to induce airlines to compete in part by offering lower-quality products, since recovering the cost of a quality improvement that costs, say, US$1 will require increasing the consumer price by more than US$1. Thus heavy reliance on ad valorem ticket taxes (rather than, say, per-passenger charges) is likely to imply, for example, reduced in-flight service, and fewer flights with higher load factors (and hence less flexibility in booking). What this implies for the optimal balance between specific and ad valorem taxation depends on how quality enters consumers' preferences, the general principle being that it should be chosen to minimise the distortion of quality decisions.[52] This may point to a preference for specific

[51]See, for instance, Delipalla and Keen (1992); Keen (1998) shows that this is also true in the Dixit–Stiglitz (1977) model of horizontal quality competition.
[52]Delipalla and Keen, 2006.

ticket taxes, though this may be more than offset by the distributional appeal of ad valorem taxation.[53]

Network externalities – the beneficial 'Mohring effect' that arises from access to more frequent flights to a wider set of destinations[54] – might also affect the appropriate indirect taxation of aviation. Betancor and Nombela (2002) find that the average travel time between two European capitals fell between 1990 and 1998 by 20 minutes, due to more extensive and frequent flights. The time reduction was largest for the routes with the lowest initial densities, with no gains for routes with traffic exceeding 150,000 passengers per year. Most airlines, however, limit own ticket issues to routes covered by the airline (including in some cases a limited range of cooperating partners), and effectively exclude other airlines operating on the same airport. This serves to limit the scope for positive network externalities from greater traffic loads. In principle, the presence of Mohring effects for airports of smaller sizes might indicate a case for lower-than-otherwise aviation taxes for traffic to and from such airports; but not for traffic at major airports. But the empirical significance of such externalities in international air travel, and the balance between these effects and the potential intensification of airport congestion problems discussed earlier, is uncertain.

Optimal aviation taxes may also be affected by input price distortions when aircraft production and operation are subsidised by producing and operating countries' governments. To the extent that such subsidies are significant – a continued matter of contention between Airbus and Boeing – they point to relatively high aviation taxes. Implicit taxes or subsidies also arise when airport fees and charges differ from appropriate marginal cost levels. The limited evidence suggests, tentatively and with exceptions, a broad tendency for high-income countries to subsidise such activities – pointing to higher aviation taxes – and for lower-income countries to tax them. To the extent that this is the case, it is an argument for generally lighter aviation taxation in low-income countries than in high-income ones.

A final set of considerations arises from the possibility of endogenous technical change, generating gains not fully appropriated by the developer and hence tending to be underprovided in the absence of public intervention. In the aviation context, this might apply to improvements in fuel efficiency through, for example, aircraft body and engine design. Along the same lines as argued by Goulder and Mathai (2000) for carbon taxes, there may then be

[53]Product quality and distributional concerns are less of an issue with aviation fuel; given too the revenue stability concern noted earlier, the established preference for specific taxation is in this case uncontentious.

[54]See Mohring (1972).

a case for taxing aviation fuel in order to correct underinvestment in research activities.

With these various considerations pointing in different directions and very little evidence on their quantitative importance, the safest approach for policy design seems, at least for the moment, to be to suppose that they net out to zero.

IV. Tax rates, revenues and incidence

This section reports illustrative calculations of the rates at which internationally coordinated aviation taxes might optimally be set, the revenue they could raise and who would bear the burden they would impose.

1. Optimal tax rates

The conceptual framework for these calculations is that of Section III.1, in which there is assumed to be no cross-border spillover of environmental harm. The analysis is thus best thought of as corresponding to the case of globally coordinated tax design, with all countries assumed to be identical (and abstracts too – as we argued may well be appropriate for practical purposes – from the range of further considerations in Sections III.4–III.6). The analysis of further and perhaps more interesting cases is left to future work.

For the purposes of these calculations, the elasticity of demand, ε, is assumed to be constant, taking alternative values of unity and 0.5 that broadly reflect the estimates for leisure and business travel reported above. The elasticity of substitution in production, σ, is also taken to be constant, with values of unity or 0.5,[55] and the factor share for aviation fuel, α, is assumed to be 0.25 in the absence of aviation taxes (corresponding broadly to its global factor share in 2005).[56] The marginal cost of public funds, δ, ranges from unity (corresponding to the case in which lump-sum taxation is available) to a fairly moderate 1.5. The appropriate value of marginal environmental damage, E', remains an open question, but the discussion

[55]We know of no estimates of the strength of substitution between fuel and other inputs, but there is certainly evidence that it can be quite marked, even in the short term: for instance, a 16 per cent increase in aviation fuel prices in 2002–03 was associated with a 3 per cent reduction in fuel use per passenger mile travelled (International Air Transport Association, 2004). Margins on which aviation fuel efficiency can be improved include closing routes with low average load factors and/or reducing seat space (or even eliminating seating (*New York Times*, 2006)). For the longer term, Sledsens (1998), for example, discusses how more efficient airplane design is phased in when fuel prices increase.

[56]IATA figures for 2005 are not yet available, but the *Economist* (2005) reports fuel expenses at US$97 billion, implying a fuel share of about 25 per cent.

TABLE 8

Optimal tax rates with ε = *1*[a]

	Both taxes available		Only one tax available[b]		
Parameters	*Ticket tax*	*Fuel tax*	*Ticket tax*	*Fuel tax,* σ = *1*	*Fuel tax,* σ = *0.5*
E′ = *0*					
$\delta = 1$	0	0	0	0	0
$\delta = 1.1$	0.09	0	**0.09**	0.20	0.34
$\delta = 1.25$	0.20	0	**0.20**	0.50	0.94
$\delta = 1.5$	0.33	0	**0.33**	0.75	2.28
E′ = *0.40*					
$\delta = 1$	0	0.40	0.05	**0.40**	**0.40**
$\delta = 1.1$	0.09	0.36	**0.13**[c]	0.60	**0.77**
$\delta = 1.25$	0.20	0.32	**0.23**	0.90	1.41
$\delta = 1.5$	0.33	0.27	**0.35**	1.40	2.86

[a]Ticket tax in tax-inclusive form, per cent. Fuel tax in US$ per gallon.
[b]Bold type indicates optimal single tax.
[c]Ticket tax optimal when $\sigma = 1$; fuel tax optimal when $\sigma = 0.5$.

above suggested a reasonable order of magnitude, particularly in contexts like the European, to be US$0.40 per gallon of aviation fuel.

Table 8 reports optimal (tax-inclusive, ad valorem) ticket tax rates, and fuel tax rates (in US$ per gallon), for the case in which the elasticity of demand is unity. The first two columns show ticket and fuel tax rates when both instruments are optimally deployed. In this case, the calculations are straightforward: recalling (3) and (4), the optimal fuel tax is E'/δ while the optimal ticket tax is in this case simply $(\delta - 1)/\delta$. The results are thus easily anticipated, but provide a useful reminder that the optimal fuel tax decreases with the marginal cost of public funds: taking the central case in which E' = 0.40, it decreases from around 20 per cent when δ is unity to 13 per cent at δ = 1.5. Perhaps more interestingly, the last three columns in Table 8 show optimal tax rates when only one tax instrument may be deployed (as in (5) and (6)), recognising too that in this case the optimal fuel tax depends on the elasticity of substitution in production. As one would expect, each tax in isolation is now optimally set higher than it would be if the other tax were also available; and the optimal stand-alone fuel tax is higher at the lower elasticity of substitution. Beyond this, three points stand out. First, the optimal stand-alone fuel tax increases with the marginal cost of public funds, reflecting the impact of an intensified revenue need. Second, the optimal ticket tax becomes highly sensitive to the marginal social cost of public funds: again taking the central case in which E' = 0.40, it increases from 5 per cent when lump-sum taxes are available – in which case the ticket tax is being used only as an inferior corrective device – to 35 per cent when δ = 1.5. Third, the elasticity of substitution in production matters: halving it more than doubles the optimal stand-alone fuel tax at the highest level of δ. The intuition, evident from (6), is that at higher levels of δ, the revenue motive becomes more dominant, further emphasising the role that the elasticity of substitution plays (analogous to that of the demand elasticity in the Ramsey rule).

Table 9 repeats the exercise for a demand elasticity of 0.5. Broadly the same qualitative pattern emerges, with the tendency towards a higher rate associated with the Ramsey component being evident – except in the case of the fuel tax when both instruments are optimally deployed, since that instrument is then independent of the elasticity of demand.

The final columns of Tables 8 and 9 explore which of the two taxes is preferred (indicated in bold) when only one can be used. As the discussion in Section III indicated, the fuel tax is more likely to be preferred the lower is the marginal cost of public funds, δ, and the higher is the marginal environmental damage, E'. Less obviously, the calculations also show that the issue is a real one, in that neither tax dominates the other within the plausible range of parameter values: at E' = 0.40, for example, the fuel tax, which is evidently preferred when lump-sum taxes are available, becomes inferior to the ticket tax when δ rises to the quite moderate level of 1.25. It also emerges that the choice between the instruments is potentially quite sensitive to the elasticity of substitution, with the fuel tax more likely to be preferred the lower it is – for the lower is σ, the less is the erosion of the tax base, and hence the jeopardy to the revenue objective, from taxing fuel.

TABLE 9

Optimal tax rates with ε = *0.5*[a]

	Both taxes available		Only one tax available[b]		
Parameters	*Ticket tax*	*Fuel tax*	*Ticket tax*	*Fuel tax,* $\sigma = 1$	*Fuel tax,* $\sigma = 0.5$
$E' = 0$					
$\delta = 1$	0	0	0	0	0
$\delta = 1.1$	0.18	0	**0.18**	0.34	0.44
$\delta = 1.25$	0.40	0	**0.40**	0.94	1.33
$\delta = 1.5$	0.67	0	**0.67**	2.29	4.00
$E' = 0.40$					
$\delta = 1$	0	0.40	0.05	**0.40**	**0.40**
$\delta = 1.1$	0.18	0.36	**0.22**	0.76	0.89
$\delta = 1.25$	0.40	0.32	**0.42**	1.41	1.87
$\delta = 1.5$	0.67	0.27	**0.68**	2.86	4.80

[a]Ticket tax in tax-inclusive form, per cent. Fuel tax in US$ per gallon.
[b]Bold type indicates optimal single tax.

TABLE 10

Policy gains (with ε = 1) from using both instruments and from ticket versus fuel tax

Per cent of total aviation turnover

Parameters	*Two taxes over best single tax*		*Ticket tax over fuel tax*	
	$\sigma = 1$	$\sigma = 0.5$	$\sigma = 1$	$\sigma = 0.5$
$E' = 0$				
$\delta = 1$	0	0	0	0
$\delta = 1.1$	0	0	0.35	0.22
$\delta = 1.25$	0	0	2.01	1.60
$\delta = 1.5$	0	0	6.84	5.05
$E' = 0.40$				
$\delta = 1$	0	0	–0.42	–0.19
$\delta = 1.1$	0.01	0.01	0.02	–0.02
$\delta = 1.25$	0.21	0.15	1.80	1.15
$\delta = 1.5$	0.25	0.20	6.94	4.85

Table 10 provides some sense of the likely welfare losses in using only one instrument rather than two, and in then choosing the wrong one. The first two columns suggest that there may be relatively little gain in using both instruments rather than only the better of the two: the largest policy gain is under 1 per cent of turnover. (It is greater, as one would expect, the higher is the elasticity of substitution in production: in the limiting case in which $\sigma = 0$, recall that the two instruments are equivalent.) The gain in choosing the better of the single instruments tends to be somewhat larger, but is still relatively modest: when there is no environmental damage, for example, inappropriately deploying a fuel tax leads to a welfare loss of about 2 per cent of expenditure. These calculations thus suggest that there may be relatively little loss in using one instrument, even if not the best choice available, rather than two.

2. The revenue potential of aviation taxes

As a natural benchmark, consider first the case in which a fuel tax alone is deployed, and set at its average worldwide Pigovian level. This level is unknown, but the considerations discussed at the end of Section II suggest it may be lower than the benchmark of $E' = 0.40$ taken in the simulations above. Suppose instead that the fuel tax were set at half this level, corresponding roughly, as noted earlier, to the damage from carbon emissions alone, and so something of a lower bound. With worldwide aviation fuel consumption of 50 billion gallons in 2003 (the latest year for which data are available: International Air Transport Association (2004)), this would raise – assuming for the moment no behavioural response to imposition of the tax – around US$10 billion per annum. Given aviation sector turnover of US$400 billion, such a fuel tax would be roughly equivalent to a modest 2.5 per cent non-creditable ticket tax,[57] and would add roughly US$6 to an average air fare (about US$25 for business/first-class tickets, and US$4 for economy tickets). This is a fairly modest price increase: recall, for instance, that the homeland security charge in the US is 7.5 per cent. With about 1.7 billion passengers carried in 2005 (about 1.5 billion of them in economy class), the same tax revenue would be collected through a US$5 departure tax on economy-class passengers, and a US$15 departure tax on business- and first-class passengers, applied both internationally and domestically.

Applied only to international aviation – which accounted for about two-thirds of aviation fuel use in 2003[58] – a fuel tax of US$0.2 would raise about US$6.5 billion. Applied only in Europe (encompassing the EU and current non-EU members in Western and Eastern Europe, including Russia, and covering both domestic and international flights), it would raise about US$3 billion. Revenue patterns under a ticket tax of about 2.5 per cent would be similar.[59]

Behavioural responses are potentially important, of course, tending to reduce the revenue raised from any combination of ticket and fuel tax through an induced reduction in final demand and/or increase in fuel efficiency. And of course the fuel tax may not be the only, or best, tax instrument to be deployed. To provide some sense of the likely importance of these further considerations, Table 11 reports the revenue associated with the welfare-maximising tax rates reported in Table 8, in US dollars. For brevity, we consider only the case of unitary demand elasticity.[60] These figures are based on the percentage rates for ticket taxes and the per-gallon rates for fuel taxes derived in Table 8, and considering overall aviation sector turnover and fuel consumption. As a rough calibration, in 2003 global airline revenues were US$400 billion, while aviation fuel consumption was 50 billion gallons (International Air Transport Association, 2004).

[57]It is assumed throughout this section that any ticket tax would function as an excise, rather than a VAT, so that the revenue raised would not be diminished by refund to registered taxpayers.

[58]This is the proportionate usage for airlines that reported the breakdown to IATA (International Air Transport Association, 2004).

[59]These sums, it is worth noting, are substantially more than departure taxes of the kind recently discussed and implemented are likely to raise: a uniform departure tax raising US$10 billion, for example, would require a charge of about US$6 per trip if applied worldwide. A uniform departure tax levied in Europe alone would need, in order to raise US$10 billion, to be set at US$20, or about €16.

[60]A lower demand elasticity would, of course, be associated with higher levels of revenue.

TABLE 11

Tax revenues (with ε = 1), and revenue gain from using both taxes

US$ billion

	Both taxes		Only one tax available[a]			Revenue from using two taxes[b]	
			Ticket tax	*Fuel tax*			
	σ = *1*	σ = *0.5*		σ = *1*	σ = *0.5*	σ = *1*	σ = *0.5*
E′ = *0*							
$\delta = 1$	0	0	0	0	0	0	0
$\delta = 1.1$	36.4	36.4	**36.4**	9.2	15.6	0	0
$\delta = 1.25$	80.0	80.0	**80.0**	16.8	31.6	0	0
$\delta = 1.5$	133.2	133.2	**133.2**	25.2	48.0	0	0
E′ = *0.40*							
$\delta = 1$	16.8	18.4	19.2	**16.8**	**18.4**	0	0
$\delta = 1.1$	50.4	51.6	**52.0**[c]	23.2	**27.6**	–1.6	24.0
$\delta = 1.25$	91.2	92.0	**92.4**	31.2	43.2	–1.2	–0.4
$\delta = 1.5$	141.2	141.6	**142.0**	41.2	63.2	–0.8	–0.4

[a]Bold type indicates the welfare-maximising single tax.
[b]Relative to welfare-maximising single tax.
[c]Ticket tax optimal when $\sigma = 1$; fuel tax optimal when $\sigma = 0.5$.

With a fuel tax set at the higher level of US$0.40 per gallon – roughly the level of external damage in the UK – the possibility of substituting away from fuel use reduces the revenue yield to US$16.8–18.4 billion (being lower, as one would expect, the greater is the ease of substitution; and of course lower than the US$20 billion that would be raised in the absence of any behavioural response).

The aggregate revenue associated with optimal policy naturally becomes higher once a revenue-raising motive is also recognised, and increases with both the marginal cost of public funds and the extent of marginal environmental damage. More to the point, the amounts raised can plausibly be substantial. When, for instance, $\delta = 1.25$ and $E' = 0.4$, global tax revenues are around 23 per cent of sector turnover, or US$92 billion. The bulk of this revenue – around US$80 billion – comes from the ticket tax (reflecting the revenue motive). When applied only to international traffic, the figures would be roughly two-thirds of these, corresponding to the fraction of international air traffic in total activity.

Two other points emerge from the revenue calculations. First, and perhaps surprisingly, the revenue associated with optimal policy is not necessarily higher when both taxes can be deployed than when only one is available. Second, revenue is in all cases higher – in some cases, very substantially so – when only the ticket tax may be deployed than when only the fuel tax can be used;[61] and this is true, strikingly, even when there is no revenue-raising concern, so that the sole purpose of taxation is corrective. Indeed, in all cases revenue when only the ticket tax is used is higher than when both can be deployed, while revenue from a stand-alone fuel tax is always lower. While these results are not fully general,[62] the implications and underlying intuition may be of some importance. At one level, they reiterate the feature of the fuel tax that the distortion of production that it implies – however desirable on environmental grounds – erodes the tax base. They also make the point that using an ill-targeted tax on final consumption (in this case, the ticket tax) to address externality problems arising in production may actually lead to more revenue being raised, rather than less, since the imperfect targeting may call for heavy taxation to choke back the demand for the input generating the problem.

3. Incidence

Who would ultimately bear the burden of aviation taxes depends on details of market structure and adjustment. No detailed study of these issues will be offered here. Instead, and as first pass at the issue, it will simply be assumed that airlines are competitive and operate under constant returns and (massively simplifying a complex reality) that oil supply is elastic in the long run. A tax on aviation fuel will then be fully passed on into airlines' input prices, and the consequent increase in ticket prices fully borne by travellers. Ticket and trip taxes too would be fully passed on.

The incidence of ticket taxes by travel class will then depend on airline revenues from travellers in different classes and the class-specific tax rates. For departure taxes, it will depend on class-related traffic volumes and tax rates. Since fuel can best be considered a fixed cost for each flight, ascribing fuel cost shares to travel classes is somewhat arbitrary, although airlines may tend to recuperate their increased fuel costs from different passenger segments according to the segment-specific demand elasticities.

Table 12 provides worldwide data on traffic volumes by passenger category and region. About 90 per cent of all air travel (in passenger numbers or miles) is in economy, about 9 per cent in business and only about 1 per cent in first class. In terms of airline revenues, however, the shares for business and first class are much higher: about 30 per cent. About

[61]Note that this is not implied by the earlier general result that maximised revenue is higher under the ticket tax than under the fuel tax, since here it is welfare that is being maximised, not revenue.

[62]The finding that revenue is higher under a ticket tax than under a fuel tax when only the corrective motive is present, for example, is readily shown to be model-specific: relative revenues in the two cases depend on the curvatures of the cost function and the slope of the demand function.

TABLE 12

Aviation traffic by travel class and region, 2003

Traffic category	*Economy class (% of traffic)*[a]	*Business class (% of traffic)*[a]	*First class (% of traffic)*[a]	*Percentage of total traffic*[b]
Originating in Europe	85.0	14.6	0.4	28.4
Originating in North America	89.0	9.3	1.7	35.5
Originating in Latin America	91.1	7.3	1.6	5.0
Originating in East Asia and Pacific	90.5	8.7	0.8	23.9
Other regions[c]	92.5	7.0	0.5	7.2
Total traffic[a]	89.6	9.6	0.8	100
Share of total traffic[b]	90.4	8.2	1.4	100
Share of airline revenue	73.1	20.1	6.7	100

[a]Number of passengers.
[b]In terms of passenger kilometres.
[c]Includes Africa and the Middle and Near East.
Sources: International Air Transport Association (2004); Brian Pearce, IATA, personal communication.

90 per cent of the burden of a departure tax invariant to distance and class of travel, or a fuel tax, would then fall on economy-class travellers. For a uniform ad valorem ticket tax, by contrast, almost 30 per cent would fall on premium travellers.

Incidence by region has several aspects. The impact on any country's welfare is likely to depend on the direct effect on its own residents (regardless of carrier), on its national carriers (whatever the residence of their passengers) and, for tourist destinations, on the volume of all leisure traffic. And the pattern of regional effects will also potentially differ by type of tax. The available data allow only a few broad statements:

- Allocating the impact of aviation fuel taxes in proportion to passenger kilometres flown,[63] about 36 per cent of the burden would fall on North America, 28 per cent on Europe, 24 per cent on East Asia and the Pacific, and 12 per cent on the other regions (South and Central America, Africa, the Middle East, and South and Central Asia).

[63]International Air Transport Association (2004) data indicate that the three main regions – North America, Europe, and East Asia and the Pacific – have broadly similar fuel consumption per passenger kilometre, so that passenger kilometre counts are reasonably good proxies for regional aviation fuel use. (Fuel efficiency is slightly lower in North America and slightly higher in East Asia and the Pacific, compared with Europe, mainly reflecting lower average age of aircraft fleets in East Asia and the Pacific.)

- Since ticket prices per kilometre flown are typically lower for long-haul than for short-haul flights, the burden of ticket taxes would be tilted, compared with fuel taxes, towards regions (such as Europe) in which flights are relatively short and fares high.[64] A ticket tax would also tend to fall more heavily on premium-class use. This also increases the average burden on European compared with other travellers, due to the larger fraction of business-class travellers in Europe (Table 12).
- For departure taxes, the allocation would be proportional to the number of departing passengers, so that the burden would fall rather more on Europe and Asia-Pacific regions and rather less on North America.
- Concern about harm to tourism – important for many low-income countries – has prompted the suggestion of excluding all flights connecting low-income countries. Exempting Latin America, the Caribbean, Africa and Asia (except Japan and other high-income countries) would eliminate approximately 25 per cent of the global tax base (somewhat less for ticket taxes, and somewhat more for fuel taxes). Alternatively, one might exempt only economy-class travel within and from such destinations, with a tax base reduction of about 15 per cent. This may have some distributional appeal, but is, of course, unwarranted from an environmental perspective.

V. Administration and compliance

There is little technical difficulty in collecting taxes on aviation fuel, on tickets and/or on departures.

Well-developed procedures for imposing excises on fuels are already in place in almost all countries, with the relatively small number of companies involved in importing and/or refining greatly facilitating control.[65] Indeed, levying tax on fuel for international aviation might well facilitate administration, since narrowing the tax differential between fuels used internationally and domestically would reduce the need to identify the use to which fuel is to be put. Ticket and departure taxes are both already commonplace.

More difficult than these technicalities is ensuring appropriate incentives for their collection if – as recent proponents of aviation taxes have in mind[66] – proceeds do not accrue to the collecting country. Collection is in practice

[64]Kesharwani (2001) notes that in 2000 the worldwide average fare per kilometre for 16,000-kilometre trips was only 20 per cent of that for 250-kilometre trips, while average fares in Europe were three times those in Asia and the Pacific for 250-kilometre trips (almost all domestic). Shorter flights, however, are only slightly more fuel-consuming per kilometre.

[65]The close monitoring to which international commercial air traffic is subject might also be used to support implementation, providing some potential check on fuel usage.

[66]See Quadripartite Group (2004) and the Landau Report (2004).

likely to be entrusted to participating countries rather than vested in a new supranational tax administration. Incentives to devote scarce resources to the collection of such taxes are then clearly blunted. This effect can be mitigated, but not eliminated, by allowing the collecting authorities to retain some proportion of the receipts (just as members of the EU retain part of the revenue from the common external tariff that they collect). Moreover, the same considerations of national self-interest that are likely to lead countries to set inefficiently low levels of taxation in the absence of coordination give them a reason to enforce these taxes less intensively than otherwise. Countries that fear disadvantaging national carriers may be inclined to allow for lengthier payment periods, for example, or delay inflation-adjusting specific taxes.

Participation in such schemes may require that countries be assured that other participants will comply with the commonly agreed rules. This has two implications. First, agreement may need to be reached on quite detailed aspects of design and implementation, concerning not only the rate of the tax but also its precise base, the definition of taxpayers subject to it, and rules on such matters as payment periods, interest and penalties. Second, countries may wish to have some direct means of verifying implementation by others. This might take a number of forms, such as participation in joint audit activities or the monitoring of aviation activity so as to derive independent estimates of the tax due. The pressures for some such mutual oversight are likely to increase as the set of participating countries widens, since weaker relations of bilateral trust may be involved and the possibilities for directly observing each others' actions reduced.

VI. Conclusions

On pure tax policy grounds, the case for increased indirect taxes (or equivalent charges) on international aviation is strong. The present low rates stand in marked contrast to the quite persuasive evidence of significant cross-border damage from international air travel, which in any event is just as proper an object of indirect taxation as any other commodity, and – even leaving aside environmental issues – there is potentially a coordination problem leading to inefficiently low taxes. In practical terms, such taxes are similar to ones that tax administrations and taxpayers are already well accustomed to. Certainly, a novel set of practical issues would arise if the revenue were devoted to other than national purposes; but these are qualitatively no different from (and may be less than) those that any global tax would raise.

Optimal aviation taxation is likely to involve a combination of both an excise on the use of aviation fuel or equivalent emissions charges (addressing the principal and most clearly established source of cross-border environmental harm associated with aviation), and a ticket tax (focused on the objective of raising revenue), with the latter best taking the form of a VAT (so as to exclude business use, including through cargo). Which of the two is to be preferred, if only one can be used, is in general unclear for plausible parameter values, but depends on the relative strengths of environmental and revenue concerns. Somewhat reassuringly, however, simulations suggest that there may be little loss in using only one instrument, or in then choosing the wrong one between the two. Trip charges, such as the departure taxes that have been the subject of recent policy initiatives, are a much blunter instrument, being less capable of variation according to fuel use or the extent of consumption of aviation services.

There are legal obstacles to aviation fuel taxation, in the Chicago Convention and, especially, under bilateral air service agreements. One might argue that such restrictions, dating from a time when encouraging international aviation travel was an object of policy, have outlived their usefulness. Emissions trading schemes, however, face few legal difficulties. If, nevertheless, international aviation fuel taxes, or equivalent, are ruled out, the case for ticket taxes clearly becomes stronger. To ensure that environmental costs are reflected in all travel decisions, including business travel and cargo, these should be in the form of a non-creditable excise rather than – or in addition to – a VAT that is better suited to raising revenue.

Even if legal impediments were overcome, however, prospective tax competition between countries concerned to protect their national carriers, tourist industries and revenues would likely lead to inefficiently low tax rates. Some degree of coordination in the design and setting of aviation taxes would be required, though since the tax base is less than perfectly mobile – bunkering fuel in low-tax jurisdictions is costly, and many destinations have elements of uniqueness – such taxes can clearly have effect even if levied on a regional basis rather than universally.

The calculations reported here suggest that fuel taxes set at US$0.20 per gallon, or 2.5 per cent as a ticket tax – corresponding to a fairly conservative estimate of the typical marginal environmental cost of international aviation – would raise a little under US$10 billion if levied worldwide, and a little under US$3 billion if levied in Europe alone. Considerably more could be raised if aviation taxes were set not only with environmental concerns in mind but also with a view to the distortionary impact of the wider tax system.

Many countries, including high-income countries with large shares of the aviation market and smaller, low-income countries heavily reliant on tourism, have expressed strong opposition to indirect taxes on international aviation. And clearly the present circumstance of high and uncertain future fuel prices, with many airlines financially pressed, do not make this the easiest moment to press the case.[67] Nevertheless, the case for strengthening indirect taxation of international aviation is strong enough to warrant continued attention and closer analysis.

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