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The impact of the UK aviation tax on carbon dioxide emissions and visitor numbers

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Abstract

We use a model of domestic and international tourist numbers and flows to estimate the impact of the recent and proposed changes in the Air Passenger Duty (APD) of the United Kingdom. We look at four different scenarios (abolishing the APD, keeping the 2001 APD level, the 2007 APD and the Conservative Party's "Green Miles" proposal) using base, high and very high elasticity levels as well as assumptions about the substitutability between domestic and international holidays and the effects of a carbon tax. We find that the recent doubling of the APD has the perverse effect of increasing carbon dioxide emissions, albeit only slightly, because it reduces the relative price difference between near and far holidays. Tourists arriving into the UK would fall slightly. The number of tourists travelling from the UK would fall in the countries near to the UK, and this drop would be only partly offset by displaced tourists from the UK. Tourists leaving the UK for countries further a field would increase. The proposal of the Conservative Party to exempt the first 2000 miles (for UK residents) would decrease emissions by roughly the same amount as abolishing the APD altogether—but the number of tourists arriving into the UK would not rise. These results are reversed if we assume that domestic holidays and foreign holidays are close substitutes. If the same revenue were raised with a carbon tax rather than a boarding tax, emissions would fall rather than rise.

Keywords: International tourism; Carbon dioxide emissions; Boarding tax; United kingdom

1. Introduction

The contribution of aviation to global greenhouse gas emissions is small but fast growing. According to the Conservatives (2007), aviation currently contributes just 5.5% of the UK's CO_2 emissions. However, emissions from UK aviation increased by over 90% between 1990 and 2004 and industry growth is expected to continue. Bows and Anderson (2007) provide a thorough review of the evolution of climate and aviation policies in the UK as well as aviation growth patterns and their implications for climate change policy. Until recently, aviation emissions had been excluded from climate policy. However, the European Commission has announced that aviation emissions will be part of the European Union Emissions Trading System (EU ETS) for greenhouse gases. Chancellor Gordon Brown has doubled Air Passenger Duty (APD), and David Cameron, the Conservative Party leader, has put forward an alternative plan to reduce emissions. This study investigates the implications of these two proposals for emissions and for travel patterns.

This paper builds on Tol (2007) and FitzGerald and Tol (2007). The first paper was written when taxing aviation emissions was a remote prospect, and the policy scenarios considered differ from the current policy proposals—particularly, Tol (2007) studies a global tax. FitzGerald and Tol (2007) study the inclusion of aviation emissions in the European trading system for CO_2 permits. Earlier studies—Michaelis (1997), Olsthoorn (2001) and Wit et al. (2002)—similarly analyse different policies than what is currently being proposed in the UK.

This paper only considers *international* aviation *demand* by *tourists*. Domestic air travel is excluded, as is travel for business purposes. There is a global database of reasonable

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quality on international tourist travel—but there is nothing of the sort for domestic tourist travel or for business travel. As such, a choice has to be made between geographic comprehensiveness, and comprehensiveness in a travel sense. The current paper opts for the former, which of course does not make the latter less relevant. Note that business travellers are less likely to respond to price changes than tourists.

The paper only considers shifts in modelled demand induced by an increase in the price of air travel. The optimal policy for reducing emissions would be to tax emissions directly[1]—this would also induce changes in flight behaviour, aircraft technology, and fuel choice (Bates et al., 2000; Wit et al., 2002, 2005; Wulff and Hourmouziadis, 1997). However, emission taxes are not in place in the UK, nor are they being discussed.

Section 2 presents the model design and calibration. In Section 3 we discuss the results of the analysis and the impacts on passenger numbers and emissions. This is followed by a sensitivity analysis, which includes different elasticity scenarios, the effect of substitution between domestic and international holidays and the comparative effect of a carbon tax. Finally, Section 5 provides a discussion and conclusions.

2. The model

Simulations are done with the Hamburg Tourism Model (HTM), version 1.3. Previous model versions focussed on climate change (Hamilton et al., 2005a, b; Bigano et al., 2005) while the current version is designed to analyse climate policy (Tol, 2007).

HTM predicts the number of domestic and international tourists from 207 countries, and traces the international tourists to their destinations. Tourism demand is primarily driven by per capita income. Destination choice in the model is driven by income, climate, length of coastline, and travel time and cost. Carbon pricing would increase the travel cost, but leave other factors unaffected. The model runs in time steps of 5 years, from 1980 to 2100, with 1995 as the base year. See Tol (2007) for details. Here, we only show results for 2010; and we only discuss *deviations* from the baseline. The assumed price elasticity—the crucial parameter—and the quality of the calibration are discussed below.

Data were primarily taken from WTO (2003) and EuroMonitor (2002). Distance and income elasticities were estimated for 1995 (the most recent year with reasonably complete data coverage), and used to interpolate the missing observations. Price and time elasticities (which replace the distance elasticities) were calibrated for 2006. Observations on travel time and travel cost are very limited. Here, travel time and cost are assumed to be linear in the distance between airports, using data for Heathrow, Europe's busiest airport. Heathrow is also a common point of departure for UK tourists, the focus of our analysis. Flying from different airports in the UK does not greatly affect travel time, while competition keeps prices reasonably similar.

The airfare elasticity of destination choice is $-1.50+0.14\ln y$, where y is the average per capita income in the country of origin. For UK travellers, this translates into an elasticity of -0.45, which compares well to the estimates of Crouch (1995), Witt and Witt (1995) and Wohlgemuth (1997) but is low compared to the elasticities found by Oum et al. (1990), Brons et al. (2002) and Gillen et al. (2004). We use these lower elasticities for three reasons. Firstly, our price elasticity falls with rising per capita income, and is therefore lower than in previous studies. Secondly, we include the duration of the flight as well as its cost; as the two are correlated, the price elasticity is obviously lower if duration is included. Thirdly, we consider trade-offs between *countries*. The higher estimates for the price elasticity of travel demand are found for alternative city destinations, which are closer substitutes than alternative country destinations, and for price competition on the same route.

The model was used to "predict" tourist numbers for 1980, 1985, and 1990, and shown to have a predictive power of over 70%. (For 1995, the model was calibrated to close to 100%.) More to the point, we compared model output for UK travellers for 2005 to the data of ONS (2006). The model predicts 57.8 million leisure travellers, while the ONS counted 57.9 million non-business travellers. The modelled pattern explains 62% of the observed pattern, but for individual countries there are substantial differences—see Fig. 1. Some of the differences are innocent model artefacts. For example, different Caribbean islands specialise in tourists from different countries: the British go to Barbados while the Dutch go to Aruba, as flight availability perpetuates historical ties. In the model, British tourists are spread over all Caribbean nations, which leads to large relative deviations in the baseline—but the bias in the policy scenarios is small, as tax reform affects all Caribbean destinations in the same way. However, the model also overlooks the ethnic ties between the UK and some large countries (e.g., the Indian subcontinent, Australasia). Again, because the tax reform relates to travel distance in only the crudest of ways, this does not lead to a substantial bias in the policy results.

Carbon dioxide emissions equal 6.5 kg C per passenger for take-off and landing, and 0.02 kg per passenger-kilometre (Pearce and Pearce, 2000).[2] It is assumed that no holidays of less than 500 km distance (one way) are taken by air, and that tourists travelling more than 5000 km, travel by air; in between, the fraction of tourists

[1]The Weitzman (1974) theorem states that price regulation (tax) is preferred to quantity regulation (caps) if the marginal abatement cost curve is steeper than the marginal damage cost curve, and vice versa. Pizer (1999) extends this argument to greenhouse gas emission reduction policy, showing that for highly uncertain stock pollutants (as is the case with greenhouse gas emissions), it is better to use taxes.

[2]These figures correspond to emissions from the European aircraft fleet.

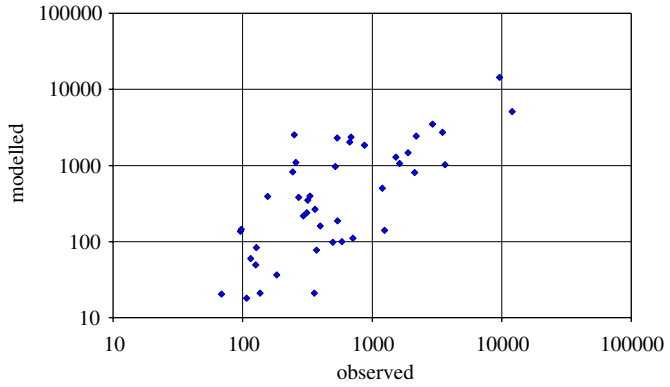

Fig. 1. Observed versus modelled number of arrivals (in thousands) from the United Kingdom in all countries for which data are available.

travelling by air increases proportionally to distance travelled. These two thresholds are based on anecdotal evidence only. Under 500 km, travelling by car or train is usually cheaper and faster while weight constraints do not apply. Large and poor families do drive great distances for their annual holiday, particularly ethnic minorities visiting their country of origin. Tol (2007) presents a sensitivity analysis on these assumptions, showing that they are not too important for the results. As the UK is an island, we assume that all trips over 500 km to and from the UK are taken by plane, and a fraction of trips below 500 km. This assumption also applies to the other island nations in the model. Modelled global emissions in 2000 are 140 million metric tonnes of carbon, which is 2.1% of global emissions from fossil fuels. This is from tourism only. Total international aviation is responsible for some 3% of global emissions.[3] There are no published numbers on the share of tourism in total international travel.

3. Scenarios and results

3.1. Scenarios

The model was calibrated for 1995, and that is the baseline year. Observed data for population and economic growth from 1995 to 2004 are used. We discussed the 2005 baseline results above. Between 2005 and 2020, growth rates gradually converge to the SRES A1 scenario (Nakicenovic and Swart, 2001). The price of oil is kept constant at the price in September 2006 (approximately 36$ per barrel).[4] Results are presented for 2010 only and in deviations from the baseline.

We analyse four different taxes. The first case is one in which all charges are abolished ("no tax"). The second scenario is the original APD (essentially a boarding tax), which was valid from 2001 to 2007, at a rate of £5.50 on flights from the UK to elsewhere in the European Union and the European Economic Area; and £22.00 for other flights.[5] Thirdly, we also show the new tax (valid from February 2007), which doubled these charges. Finally, we investigate the tax proposed by the Conservative Party which would involve the introduction of a "Green Air Miles Allowance" whereby people would get an allowance of one short-haul trip a year (first 2000 miles flown) and would then pay a higher rate of tax on the rest of their flights.[6] According to the Department for Transport (2003) 50% of the UK population does not use air travel and as the HTM uses a representative tourist, this is the equivalent of a tax rate reduction of 50% on short-haul flights out of the UK if flown by a UK resident. Non-residents do not receive *Green Miles*, so the Conservatives essentially propose to shift the tax burden abroad.

3.2. Results

Fig. 2 shows the impact of the four different taxes on carbon dioxide emissions. The top panel reveals that the overall effect is minimal. For all the rhetoric and discussion about climate change, a boarding tax is effective as a revenue-raising instrument, but not necessarily as a means to reduce emissions. If significant falls in emissions are being sought, a more radical approach must be taken. Indeed, there is no visible difference in the level of emissions under the different tax proposals investigated using the model.

In fact, the bottom panel of Fig. 2 shows that a higher tax actually implies higher emissions according to the model's forecasts. For UK travellers, this is because destination choice is determined by relative prices. A boarding tax raises the price of flights to the near abroad relatively more than the price of flights to the far abroad. For instance, as the price difference between France and Italy falls, more people opt for Italy. The result is that the number of *flights* an individual will make over a year stays the same (by assumption) but the number of *miles* flown by that individual on any one trip will increase as she maximises her utility under the new higher cost of travel. Note that this result crucially depends on the assumption that the number of foreign holidays taken is not sensitive to the price of flights; we present a sensitivity analysis below.

Fig. 3 shows this effect. As there are different tax regimes for the EU and elsewhere, the results on the graph are split accordingly. Within a 1000 km zone around the UK, the model predicts that EU countries welcome less UK visitors; outside that zone, more UK residents travel. Similarly, within a 5000 km zone, non-EU countries receive less visits from the UK, while outside that zone, more UK visitors can be expected. This implies that regardless of whether

[3]See http://themes.eea.europa.eu/Environmental_issues/climate/indicators.

[4]http://findarticles.com/p/articles/mi_m2744/is_1997_Feb/ai_19511950.

[5]These are weighted averages of the taxes for Economy (90%) and Higher (10%) tickets, which were respectively £5 and £10 for the EU and EEA and £20 and £40 for the rest of the world.

[6]The proposal does not detail what these tax levels would be (Conservatives, 2007). For the purposes of this analysis, the higher rate of tax is assumed to be the newly doubled level of APD.

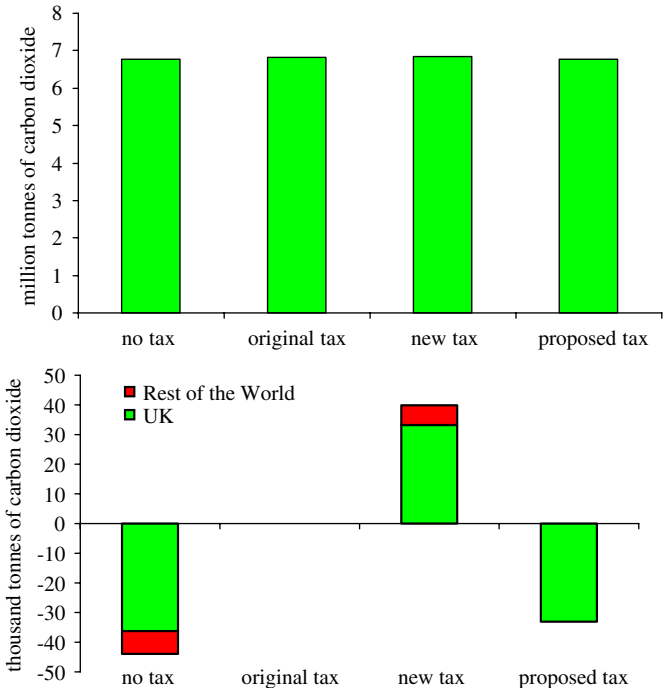

Fig. 2. The impact of four alternative boarding taxes on carbon dioxide emissions. In the top panel, total aviation emissions for UK travellers are shown. In the bottom panel, the changes in emissions for UK travellers and travellers from the rest of the world are shown. Four cases are shown, the "no tax" scenario where the APD is abolished, the "original tax" scenario corresponding to the 2001 APD (£5.5 for EU flights and £22 for non-EU flights), the "new tax" case which corresponds to the 2007 APD (double the 2001 APD, i.e. £11 and £44) and the "proposed tax" which corresponds to the "Green Miles" proposal (for one EU flight a year, UK residents are not taxed and then all passengers are taxed £11 and £44 for EU and non-EU flights, respectively).

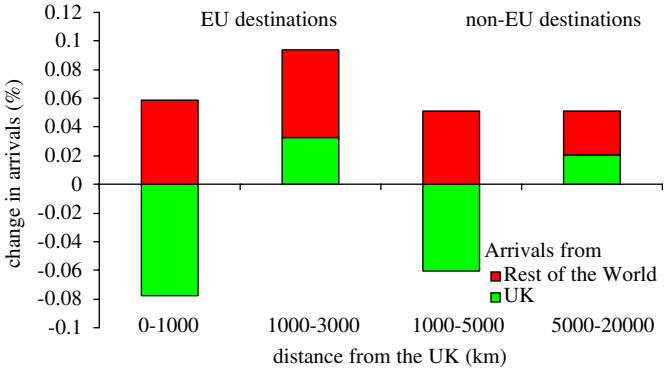

Fig. 3. The change, due to the doubling of the Air Passenger Duty, from £5.5 and £22 to £11 and £44 for EU and non-EU flights, respectively, in international arrivals in the EU and elsewhere, from the UK and the rest of the world, as a percentage of total arrivals with the original APD, and as a function of the distance from the UK.

UK travellers are travelling to the EU or not, their travel destinations choices will shift from close countries to countries further away as they spread the cost of the tax over more miles flown.

Faced with a higher level of tax, travellers from the rest of the world would fly less to the UK, but would fly to other destinations instead. The result again depends on the assumption that the number of holidays taken does not respond to price; see below for a sensitivity analysis. Fig. 3 shows that this replacement is rather uniform in space, i.e. the travel patterns of the rest of the world would remain largely the same (the UK apart).

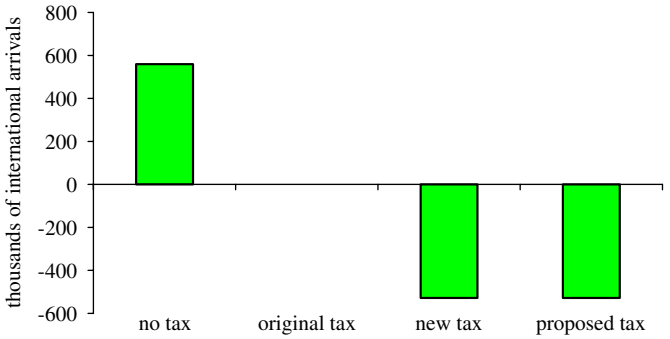

Fig. 4. The change in international arrivals in the UK as a function of the tax. Four cases are shown, the "no tax" scenario where the APD is abolished, the "original tax" scenario corresponding to the 2001 APD (£5.5 for EU flights and £22 for non-EU flights), the "new tax" case which corresponds to the 2007 APD (double the 2001 APD, i.e. £11 and £44) and the "proposed tax" which corresponds to the "Green Miles" proposal (for one EU flight a year, UK residents are not taxed and then all passengers are taxed £11 and £44 for EU and non-EU flights, respectively).

Following this logic, if doubling the boarding tax increases emissions, abolishing it should reduce emissions. Fig. 2 confirms that this is the case. Abolishing the tax results in a fall in emissions from the UK and the rest of the world compared to the base case scenario (i.e. the 2001 tax level), as the price of short-haul flights falls relative to the price of long-haul flights, and the number of trips is assumed not to respond. Fig. 2 also shows the effect on emissions of the "Green Miles" proposal of the Conservative Party. The latter has roughly the same effect on emissions as the abolition of APD and emissions from the UK will fall compared to the original tax scenario. However, in this case there will still be a small increase in emissions from the rest of the world. This is because the Green Miles proposal only exempts UK residents from the tax and non-UK travellers will face an unchanged situation.

Fig. 4 shows the impact of the four different taxes on international arrivals in the UK. The recent doubling of the boarding tax will reduce arrivals by some 528,800 people in 2010; this is a 1.3% reduction, while the number of airline passengers globally is growing by some 4% per year.[7] The voiced objective of the tax—to reduce emissions by curbing international airline travel—is manifestly not being accomplished with this policy. The "Green Miles" proposal only exempts UK residents, and therefore does not affect international arrivals in the UK. Abolishing the boarding tax would increase international tourist numbers by some 559,500 people per year.

[7] http://www.ippr.org.uk/pressreleases/?id=2488.

4. Sensitivity analysis

In this section, we conduct four sensitivity analyses and examine the effects of different assumptions on aviation emissions attributed to UK travellers. The first two analyses relate to the assumed price elasticity, we then look at the effects of substitution between domestic and foreign holidays and finally we examine the effect on emissions of a carbon tax which is set at a level that would raise the same amount of revenue as the original APD. The assumed price elasticity is evidently important. It is also very uncertain. The survey of Brons et al. (2002) reveals a wide range of estimates. The price elasticity used here is a result of calibration rather than estimation. In the calibration, it is assumed that, for the UK, the travel cost elasticity and the travel time elasticity have the same value. This is arbitrary. The model was recalibrated so that the price elasticity equals twice and four times the time elasticity. The price elasticity then falls from −0.45 (base case) to −0.58 (twice) and −0.68 (four times) for the UK.[8] The impact on emissions is shown in Fig. 5. A greater sensitivity to price strengthens the effect of a tax increase, and emissions increase accordingly—but still by only a small amount.

Above, we assume that a boarding tax induces substitution between foreign holiday destinations, but not between domestic and international holidays. The reason is that foreign holidays are considered very different from domestic ones if one hails from a relatively small, relatively homogenous island. However, if more UK tourists took their holidays in their own country because of the boarding tax, then aviation emissions would fall. To test for this, we assume that the (base case) price elasticity of substitution between foreign destinations also governs the substitution between domestic and international holidays. Fig. 5 shows the results. The domestic/international substitution dominates the near-abroad/far-abroad substitution: carbon dioxide emissions from aviation would fall.

Chancellor Brown justified the increase in the boarding tax by referring to the issues of climate policy and greenhouse gas emission reduction. Any textbook in environmental economics shows that, if emissions are of concern, then emissions should be taxed. A boarding tax is a bad approximation of an emissions tax. Indeed, most of the analyses above show that emissions would *increase* as a result of higher boarding taxes. We therefore replaced the boarding tax with an emissions tax, to be levied on any flight leaving the UK. The level of the emissions tax is such that the total tax revenue of the emissions tax equals the revenue of the boarding tax. Fig. 5 shows this result. If the tax were levied on emissions rather than boarding, the change in emissions would be about the same size (i.e., very small), but of the opposite sign. That is, an emissions tax would reduce aviation emissions compared to a boarding tax, yet generate the same amount of revenue.

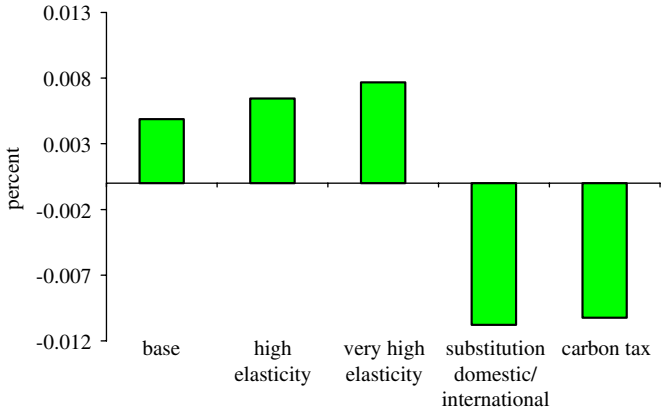

Fig. 5. The change in aviation emissions attributed to UK travellers for alternative model and tax specifications.

5. Discussion and conclusion

We use a model of international flows of tourists to estimate the effect of changes in the Air Passenger Duty in the UK, which is essentially a boarding tax. We looked at four different scenarios corresponding to taxes that have been introduced or have been proposed in the UK. The current Air Passenger Duty was introduced in 2007 and is simply double the previous 2001 APD. We also look at the effects of abolishing APD altogether and the effects of the Conservative Party's "Green Miles" proposal.

We find that the effects of all the proposals are small and partly perverse. Because tourist destination choice is driven by relative prices, a boarding tax makes far-flung destinations more appealing, not less, and UK aviation emissions increase as a result, albeit by only a fraction. Countries near the UK would see a small drop in visitor numbers, and the UK itself would see a larger drop (1.2%)—which is small compared to the annual 4% growth of the tourism industry. At its current and past levels, a boarding tax does not curb people's travel habits and as a result does not have a significant impact on emissions.

The Green Miles proposal of the Conservative Party is almost equivalent to revoking the boarding tax paid by UK residents, while keeping the tax for other travellers. This is a reverse form of mercantilism, helping UK tourists and the environment, at the expense of foreign tourists and UK business. Emissions would fall—and by about the same amount as abolishing the APD altogether. The reason is that the price of short-haul flights falls relative to the price of long-haul flights. Although the Green Miles proposal does result in a fall in emissions compared to the present situation it also involves the following problems. Firstly, in addition to the administrative costs of levying the duty, there are the costs of administering and monitoring the

[8]Note that the studies in Oum et al. (1990) typically do not include travel time. This implies an upward bias in the price elasticity. Note also that tourists are likely to judge a holiday based on its total cost, another reason why the price elasticity of a single holiday component is limited.

"Green Miles" allowances which could be substantial considering the scale of the scheme. Secondly, there may be legal implications of treating UK residents, other EU residents, and non-EU residents differently. Thirdly, compared to simply abolishing the APD, the emissions are the same while visitor numbers to the UK are lower.

The results presented here are uncertain and require substantial caveats. The sensitivity analysis presented here is limited. Tol (2007) presents a more extensive sensitivity analysis, which reveals that the main result obtained here is unlikely to be reversed: At their current level, aviation taxes are unlikely to substantially change aviation emissions. The sensitivity analysis does reveal a crucial assumption; if we assume that domestic holidays and foreign holidays are not substitutes for one another, then a boarding tax would have a perverse effect on emissions. That is, the higher the tax, the higher the emissions. However, if domestic and foreign holidays are substitutes, then a boarding tax may reduce emissions. It is hardly conceivable that UK tourists would consider a domestic holiday as a substitute for a foreign holiday—with the possible exception of Ireland. As Great Britain is an island, the distinction between "domestic" and "abroad" is much sharper than, say, on the European continent. Low substitutability implies low price elasticity which implies a minimal response to tax reform.

We also find, not unexpectedly, that an emissions tax would have the desired result of reducing emissions, even if domestic and foreign holidays are not substitutes. An emissions tax thus has the desired impact, and can be designed to raise the same revenue as the boarding taxes currently under discussion.

We did not look at other instruments for reducing aviation emissions. These include accelerating the development and diffusion of fuel-efficient planes and alternative aviation fuels; and faster deployment of high-speed trains—although little progress can be expected in terms of emission reduction over the next decades. In the short run, changes in taxing, take-off and landing could reduce emissions, as could changes in flight routes. This would require reform of airport and air control regulations, rather than regulation of airlines and travellers.

As argued by Pearce (2006), rhetoric and reality do not always match in UK climate policy. The APD reform of Chancellor Brown is a revenue-raising tax reform, promoted under the guise of climate policy. The counter-proposal by the Conservative Party is ill-considered populism. A simple carbon tax, as proposed in any textbook, would be far superior. The APD reform is therefore another sign that UK politicians are keen to be seen to be doing something about climate change, but not able or not interested in doing the right thing (Helm, 2005). Unfortunately, the UK civil service seems unable to prevent such basic mistakes (Helm, 2005; Pearce, 2006) and may even encourage them (e.g., Tol and Yohe, 2006).

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