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## The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers

**Karen Mayor and Richard S.J. Tol**

*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 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. Tourist arrivals in the UK would fall slightly. Tourist arrivals 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. Tourist numbers in countries far from the UK would increase. The proposal of the Conservative Party to exempt the first 2,000 miles (for UK residents) would decrease emissions by roughly the same amount as abolishing the APD altogether – but tourist arrivals in 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 with higher taxes.

### **Key words**

International tourism, carbon dioxide emissions, boarding tax, United Kingdom

# **The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers**

## **1. Introduction**

The contribution of aviation to global greenhouse gas emissions is small but fast-growing. 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 Trading System (ETS) for carbon dioxide. Chancellor Gordon Brown has doubled Air Passenger Duty (APD), and David Cameron, the Tory 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 (forthcoming). 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 (forthcoming) study the inclusion of aviation emissions in the European trading system for CO<sub>2</sub> 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 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 demand induced by an increase in the price of air travel. The optimal policy for reducing emissions would be to tax emissions directly – 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. Section 3 discusses the results. Section 4 shows a sensitivity analysis. Section 5 concludes.

## **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 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. See Tol (2007) for details. Here, we only show results for 2010.

Data were primarily taken from WTO (2003) and EuroMonitor (2002). Behavioural relationships were estimated for 1995 (the most recent year with reasonably complete data coverage), and used to interpolate the missing observations. 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. 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, the elasticity is  $-0.45$ , which compares well to the estimates of Oum *et al.* (1990), Crouch (1995), Witt and Witt (1995) and Wohlgemuth (1997).

The model was used to "predict" tourist numbers for 1980, 1985, and 1990, and shown to have a predictive power of over 70%.

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). 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 increases linearly with distance. For tourists travelling from island nations like the UK, the respective distances are 0 and 500 km. Total modelled emissions in 2000 are 140 million metric tonnes of carbon, which is 2.1% of total emissions from fossil fuels. This is from tourism only. Total international aviation is responsible for some 3% of global

emissions.<sup>1</sup> 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. Observed data for population and economic growth from 1995 to 2004 is used. 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. Results are presented for 2010 only, and in deviations from the baseline, so that the baseline details are largely irrelevant.

We analyse four different taxes. The first 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.<sup>2</sup> The second scenario is the new tax (valid from February 2007), which doubled these charges. Thirdly, we also show the case in which these charges are abolished (“no tax”). 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 2,000 miles flown) and would then pay a higher rate of tax on the rest of their flights.<sup>3</sup> 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 Tories essentially propose to shift the tax burden abroad.

#### 3.2. Results

Figure 1 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

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<sup>1</sup> See [http://themes.eea.europa.eu/Environmental\\_issues/climate/indicators](http://themes.eea.europa.eu/Environmental_issues/climate/indicators).

<sup>2</sup> 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.

<sup>3</sup> 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.

instrument, but not necessarily as a means to reduce emissions. Indeed, there is no visible difference in the level of emissions under the different tax proposals.

In fact, the bottom panel of Figure 1 shows that a higher tax actually implies higher emissions. 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 might stay the same but the number of *miles* flown by that individual on any one trip will increase as she maximizes her utility under the new higher cost of travel.

Figure 2 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, 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 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. Figure 2 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). Furthermore, Figure 2 shows that the decrease in UK visitors is not offset by an increase in visitors from elsewhere.

Following this logic, if doubling the boarding tax increases emissions, abolishing it should reduce emissions. Figure 1 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. Figure 1 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 abolition of APD and emissions from the UK will fall compared to the original tax scenario. However, in this case there will still be an 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.

Figure 3 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 163,000

people in 2010; this is a 0.4% reduction, in a market growing by some 4% per year. 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 169,000 people per year.

#### **4. Sensitivity Analysis**

The assumed price elasticity is evidently important. It is also very uncertain. The survey of Oum *et al.* (1980) 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.<sup>4</sup> The impact on emissions is shown in Figure 4. 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. Figure 4 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

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<sup>4</sup> Note that the studies in Oum *et al.* (1980) 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.

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. Figure 4 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.

## **5. Discussion and Conclusion**

We use a model of international flows of tourists to estimate the effect of changes in the boarding tax in the UK. We find that the effects are small and 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 – but still small compared to the annual growth of the tourism industry. 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. Although this appears to be a form of mercantilism, in fact emissions would fall – and by about the same amount as abolishing the APD altogether. Although the green miles proposal does result in a fall in emissions compared to the present situation it also involves certain extra costs and potentials problems. Firstly, in addition to the administrative costs of levying the duty, there are the costs of administering and monitoring the “green miles” allowances.. Secondly, there may be legal implications of treating UK residents, other EU residents, and non-EU residents differently. Thirdly, compared to simply abolishing the boarding tax, 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: 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.

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. As argued by Pearce (2006), rhetoric and reality do not always match in UK climate policy.

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### **References**

Bates, J., C. Brand, P. Davison, and N. Hill (2000), *Economic Evaluation of Emissions Reductions in the Transport Sector of the EU*, AEA Technology Environment, Abingdon.

Bigano, A., J.M. Hamilton and R.S.J. Tol (2005), *The Impact of Climate Change on Domestic and International Tourism: A Simulation Study*, Research unit Sustainability and Global Change **FNU-58**, Hamburg University and Centre for Marine and Atmospheric Science, Hamburg.

Bows, A. and K. Anderson (2007), 'Policy clash: Can projected aviation growth be reconciled with the UK Government's 60% carbon-reduction target? ', *Transport Policy*, 14, 103-110.

Crouch, G.I. (1995), 'A Meta-Analysis of Tourism Demand', *Annals of Tourism Research*, **22**, (1), 103-118.

Conservatives (2007), *Greener Skies: A consultation on the environmental taxation of aviation*. Office of the Shadow Chancellor, House of Commons, London.

Department for Transport (2003), *The Future of Air Transport*, White Paper, Department for Transport, London.

Euromonitor (2002), *Global Market Information Database*, <http://www.euromonitor.com/gmid/default.asp>

FitzGerald, J. and R.S.J. Tol (forthcoming), 'Aviation in the European Trading System of Carbon Dioxide Emission Permits', *CESifo Forum*.

Hamilton, J.M., D.J. Maddison and R.S.J. Tol (2005a), 'Climate Change and International Tourism: A Simulation Study', *Global Environmental Change*, **15** (3), 253-266.

Hamilton, J.M., D.J. Maddison and R.S.J. Tol (2005b), 'The Effects of Climate Change on International Tourism', *Climate Research*, **29**, 255-268.

Michaelis, L. (1997), *Special Issues in Carbon/Energy Taxation: Carbon Charges on Aviation Fuels -- Annex 1 Export Group on the United Nations Framework Convention on Climate Change Working Paper no. 12*, Organization for Economic Cooperation and Development, Paris, **OCDE/GD(97)78**.

Nakicenovic, N. and Swart, R.J. (2001) *IPCC Special Report on Emissions Scenarios*. Cambridge: Cambridge University Press.

Olsthoorn, A.A. (2001), 'Carbon Dioxide Emissions from International Aviation: 1950-2050', *Journal of Air Transport Management*, **7**, 87-93.

Oum, T.H., W.G. Waters, II, and J.S. Yong (1990), *A Survey of Recent Estimates of the Price Elasticities of Demand for Transport*, World Bank, Washington DC, **359**.

Pearce, B. and D.W. Pearce (2000), *Setting Environmental Taxes for Aircraft: A Case Study of the UK*, CSERGE, London, **GEC 2000-26**.

Pearce, D.W. (2006), 'The Political Economy of a Carbon Tax: The United Kingdom's Climate Change Levy', *Energy Economics*, **28** (2), 149-158.

Tol, R.S.J. (2005), 'The marginal damage costs of carbon dioxide emissions: an assessment of the uncertainties', *Energy Policy*, **33**, 2064-2074.

Tol, R.S.J. (2007), 'The Impact of a Carbon Tax on International Tourism', *Transportation Research D: Transport and the Environment*, **12** (2), 129-142.

Wit, R.C.N., J.W.M. Dings, P. Mendes de Leon, L. Thwaites, P. Peeters, D. Greenwood, and R. Doganis (2002), *Economic Incentives to Mitigate Greenhouse Gas Emissions from Air Transport in Europe*, CE Delft, Delft, **02.4733.10**.

Wit, R.C.N., B.H. Boon, A. van Velzen, A. Cames, O. Deuber, and D.S. Lee (2005), *Giving Wings to Emissions Trading -- Inclusion of Aviation under the European Trading System (ETS): Design and Impacts*, CE, Delft, **05.7789.20**.

Witt, S.F. and C.A. Witt (1995), 'Forecasting Tourism Demand: A Review of Empirical Research', *International Journal of Forecasting*, **11**, 447-475.

Wohlgemuth, N. (1997), 'World Transport Energy Demand Modelling -- Methodologies and Elasticities', *Energy Policy*, **25**, (14-15), 1109-1119.

WTO (2003), *Yearbook of Tourism Statistics*, World Tourism Organisation, Madrid.

Wulff, A. and J. Hourmouziadis (1997), 'Technology Review of Aeroengine Pollutant Emissions', *Aerospace Science and Technology*, **8**, 557-572.

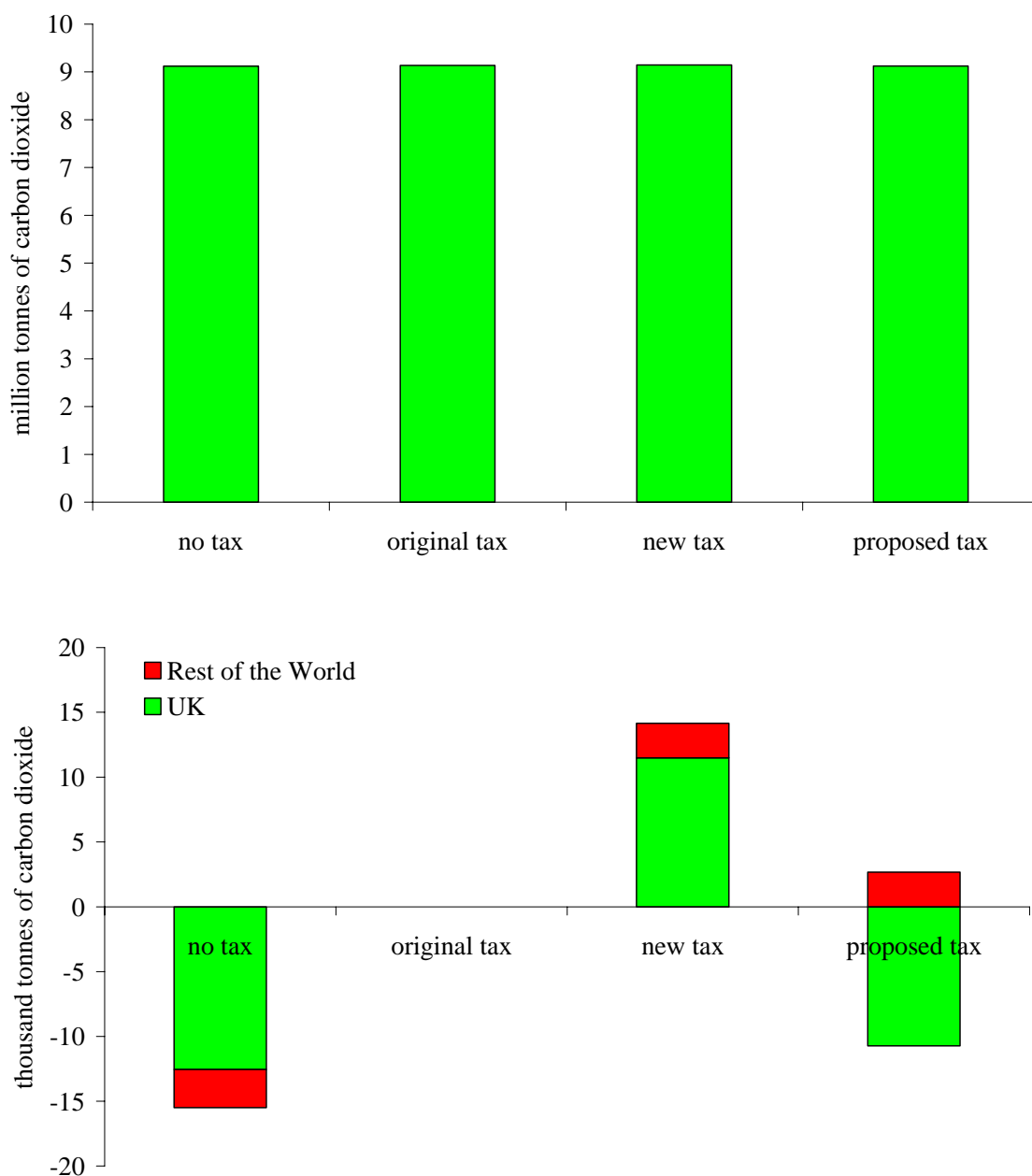


Figure 1. The impact of four alternative boarding taxes on carbon dioxide emissions. In the top panel, total aviation emissions for UK travellers are shown. In the bottom panel, the changes in emissions for UK travellers and travellers from the rest of the world are shown.

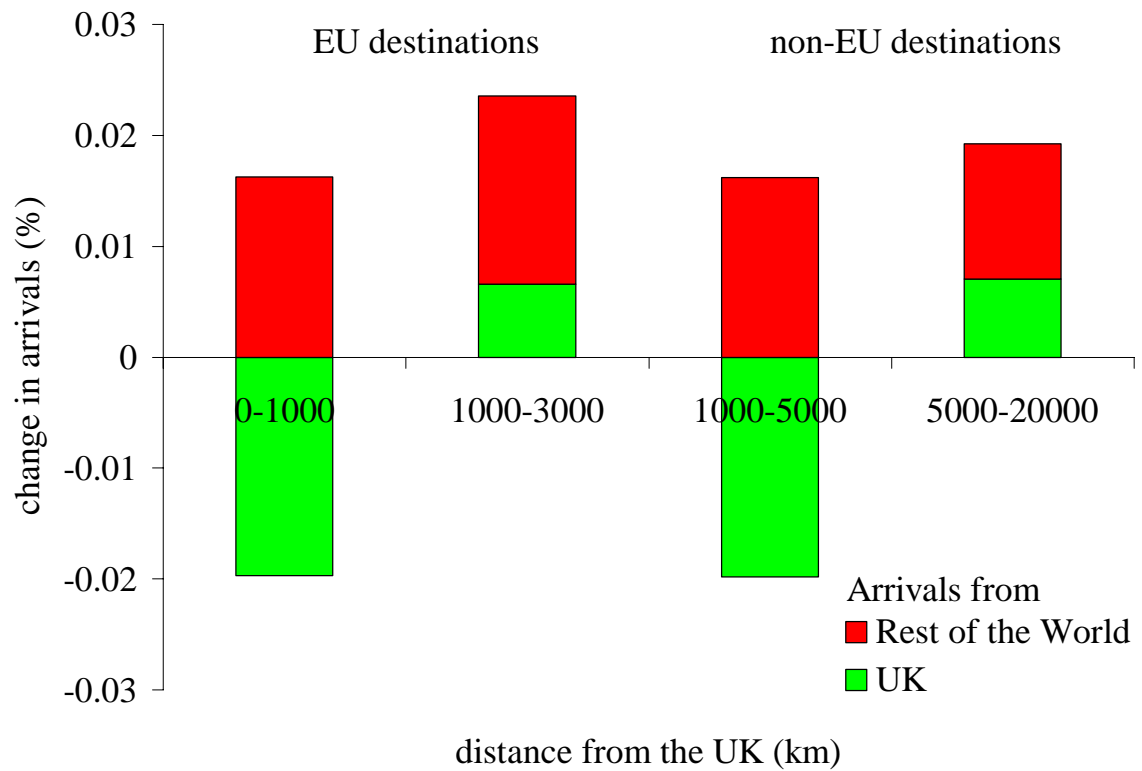


Figure 2. The change, due to the doubling of the Air Passenger Duty, in international arrivals in the EU and elsewhere, from the UK and the rest of the world, as a percentage of total arrivals with the original APD, and as a function of the distance from the UK.

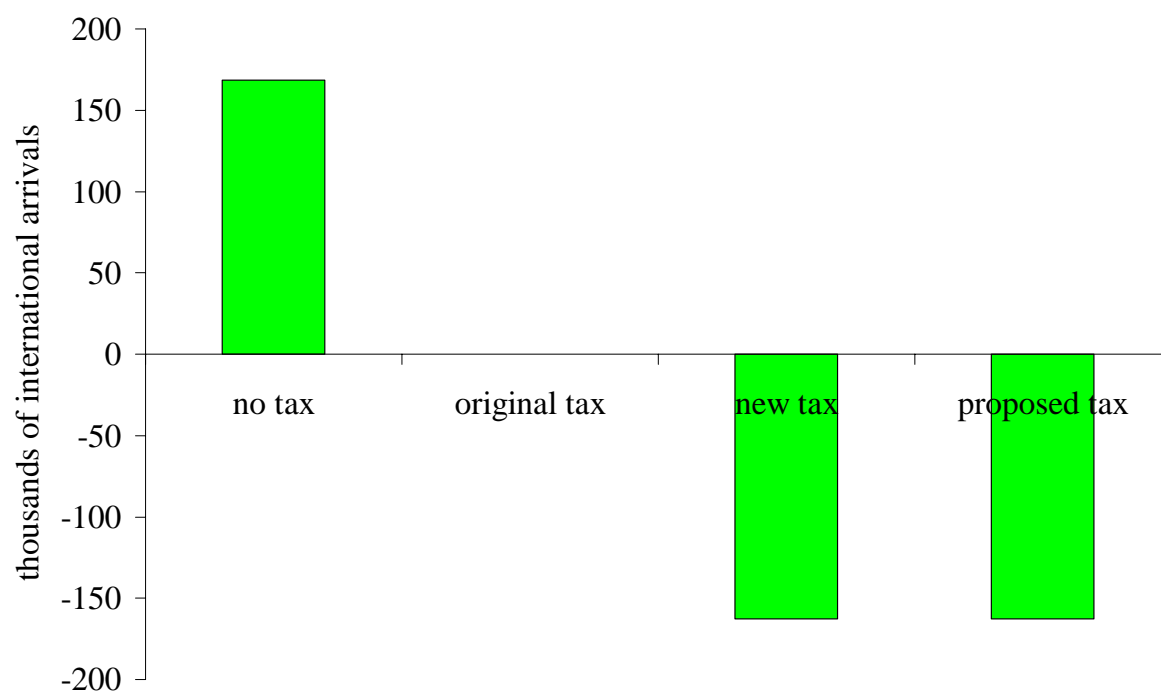


Figure 3. The change in international arrivals in the UK as a function of the tax.

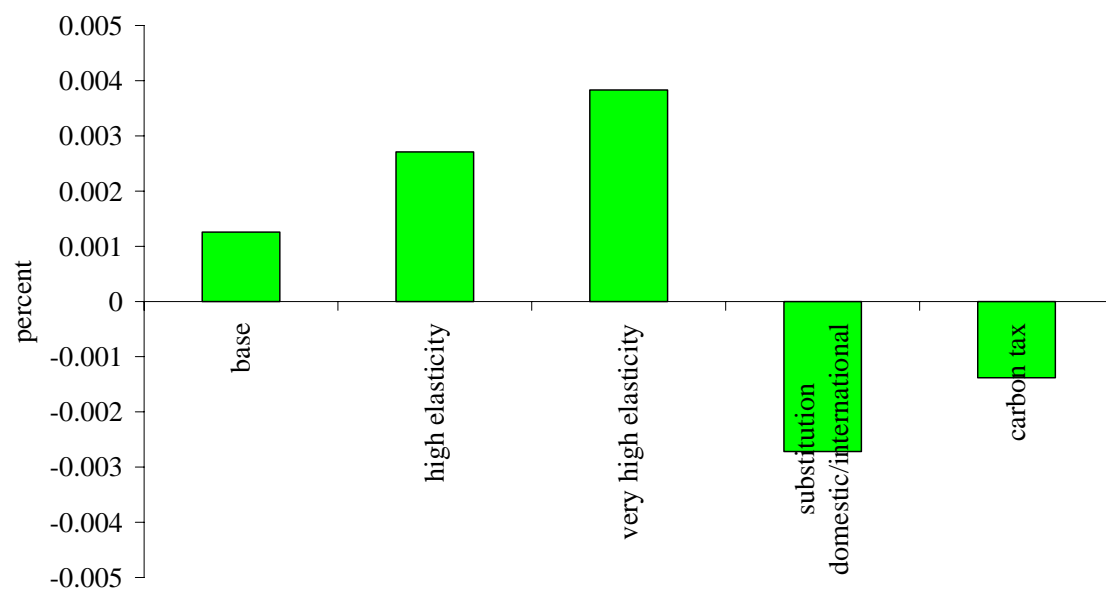


Figure 4. The change in aviation emissions attributed to UK travellers for alternative model and tax specifications.

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