ESRI
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Working Paper No. 241

May 2008

European Climate Policy and Aviation Emissions

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Abstract: We use a model of international and domestic tourist numbers and flows to investigate the effect of various climate policy instruments implemented in Europe on arrivals and emissions for the countries concerned. We find that these schemes do not fulfil their desired effects. The introduction of aviation into the European Trading system results in a fall in the number of tourists travelling into the EU in favour of other destinations. It also causes a significant welfare loss with only a small reduction in emissions. The flight taxes in the Netherlands and the United Kingdom result in different substitution effects across destinations (depending on the zones being taxed) but both policies do have the same consequence of inducing welfare losses and also reducing visitor numbers to the countries. We find that when these policies are combined their effects are additive. Welfare impacts are robust to variations in the underlying assumptions and changes in the scope of the taxes examined have the expected effects.

Key Words: Climate policy, carbon dioxide emissions, international tourism

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1. Introduction

The aviation industry has come under increasing scrutiny over the last few years from both environmentalists and policy-makers. The main issue is the responsibility the industry has in relation to global greenhouse gas emissions. Although the aviation industry and its emissions have been growing at a high rate, its contribution to greenhouse gas emissions remains small, approximately 3% of global emissions. Yet, because of the traditional view associating flying with holidays and hence a luxury product, this growth is seen as not only environmentally unsustainable but also irresponsible.

As a consequence, a number of different measures have been proposed and/or implemented around the world in a bid to curb air travel. The stated objective of these policies is to control emissions of greenhouse gases from aviation. However, they inevitably also have an impact on the number of people flying. In this paper we look at air travel for tourism purposes only. Business travel, which would not respond to financial incentives in the same manner as personal travel, is excluded.

The measures discussed in this paper are ones that have been implemented in different EU countries (the United Kingdom and the Netherlands) or that are set to be put into practice in the future (EU). The Netherlands and the UK tax passengers depending on their destination. Different levels of tax will clearly result in varying levels of change. We show that the way destinations are grouped into tax bands has different consequences on substitution between destinations. There have also been suggestions made to tax the planes as a whole and not the individual passengers. This would account for the problems associated with planes flying at less than full capacity, which emit almost the same emissions as full planes.

Other proposals involve including aviation in permit markets and the introduction of a carbon tax. Probably the most innovative proposal is the "Green Miles" scheme suggested by the British Conservative Party. This suggestion involved 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.[1] Surprisingly the most direct way of taxing emissions, a kerosene tax, has only been implemented on a domestic level in a few countries. Existing bilateral air services agreements, which preclude the introduction of fuel taxes, would need to be renegotiated if a kerosene tax were to be implemented on an international level.

So the range of measures tried and examined by governments is large. A few have already been implemented and it is likely that in the future travellers will be simultaneously subjected to national and supranational (e.g. EU) measures. In earlier papers, we studied the UK Air Passenger Duty (Mayor and Tol, 2007) and the EU Emissions Trading Systems (FitzGerald and Tol, 2007). We here add the Netherlands Flight Tax, and estimate the interactions between the three policies. We also add, for the first time, estimates of the impact of these policies on consumer and producer surplus.

Section 2 presents the model design and calibration. In section 3 we discuss the results of the analyses. The effects on arrivals, emissions and welfare of the EU, UK and Dutch policies are examined in turn. The consequences of combining these policies are also underlined. Section 4 then presents a sensitivity analysis, which examines whether the welfare impacts observed are robust to changes in the model assumptions and also how the results vary if the UK and Dutch taxes change scope. Finally, section 5 provides a discussion and conclusions.

2. The model

We use the Hamburg Tourism Model (HTM), version 1.4. Versions 1.0-1.2 were used to study the impact of climate change on international tourism (Hamilton *et al.*, 2005a,b;

[1] The proposal does not detail what these tax levels would be (Conservatives, 2007).

Bigano *et al.*, 2007a; Hamilton and Tol, 2007), while version 1.3 was designed to analyze climate policy (FitzGerald and Tol, 2007; Mayor and Tol, 2007; Tol, 2007), but also applied to the EU-US Open Skies Agreement (Mayor and Tol, 2008). Version 1.4 has a number of new features (such as the climate preferences estimated by Bigano *et al*., 2007b), but the relevant one for this paper is that, for the first time, HTM estimates the impact of climate policy on welfare.

HTM predicts the numbers of domestic and international tourists from 207 countries, and traces the international tourists to their destinations. Total tourism demand is driven by per capita income and population size. The demand for international tourism also depends on the size of the country and its climate. International destination choice is driven by per capita income and climate at the destination, and by travel time and cost.

More specifically, the basic data for the model are for the year 1995, the most recent year with reasonably complete data coverage. Data were primarily taken from the WTO (2003) and EuroMonitor (2002); see Bigano *et al*. (2007b). Behavioural relationships, estimated for 1995, were used to interpolate missing observations. Data are available on total numbers of tourists, international departures and international arrivals. The model was used to generate the 207x207 matrix of bilateral tourism flows. The model was calibrated such that the row and column totals of this matrix match the observations; the matrix itself is not observed.

The model runs in 5 year time periods from 1950 to 2100, but we here only show results for 2010. Tourist numbers are calculated as perturbations of 1995. Total demand for tourism grows with per capita income, using an elasticity of 0.52. The total number of holidays is capped at 6 per year. The share of international trips in total holiday demand grows with per capita income, using an elasticity of 0.56 plus 4.6 10^{-5} times per capita income. These elasticities were obtained by minimizing the squared relative distance between the model predictions of global tourism demand and the observations of WTO (2006) for 1995-2005. Climate also factors into the trade-off between domestic and foreign holidays. Tourists from countries with an average annual temperature of 18.6ºC are least inclined to travel abroad. As the temperature gets warmer or colder, the desire to spend a holiday in a different climate grows.

The share of international trips in total holiday travel is capped from above by the size of the country, using an inverse logistic function with country area to the power of 0.61. Tourists from large countries are less likely to travel abroad because the home country offers a more diverse range of holiday options. This cap is valid only for countries with an annual per capita income above $1,000. Very poor countries offer few holiday destination options, and the wealthy few who can afford holidays tend to travel abroad. The share of international holidays is capped from below by the size of the country, using an elasticity of -0.28, and per capita income, using an elasticity of -0.01. Again, holiday makers from very small and very poor countries take their vacations abroad. These parameters determine the frontier, and were set by minimizing the distance between the frontier and 1995 observations.

International tourists are allocated to their destination countries by four factors.[2] Per capita income is important, with an elasticity of 0.8, as poverty deters tourists. Climate is important too. The ideal annual average temperature is 16.2 ºC; colder and warmer destinations attract fewer tourists. Travel time and travel cost are not observed, and therefore assumed to be linear in the distance between airports, using data for Heathrow, Europe's busiest airport. The airfare elasticity of destination choice equals –1.50 +0.14ln*y*, where *y* is the average per capita income in the country of origin. For UK travellers, the elasticity equals -0.45, which compares well to the estimates of Oum *et al.* (1990), Crouch (1995), Witt and Witt (1995) and Wohlgemuth (1997). The time elasticity of travel is assumed to be -0.45 too, but is independent of per capita income. Travel costs are assumed to fall by 10% per five years, while the value of travel time is assumed to grow by 15%. These parameters follow from calibrating the model results to the regional observations of WTO (2006). The assumed parameters imply that travel becomes cheaper over time and people travel farther as a result. Furthermore, as people grow richer, the

[2] There is also a calibration factor for 1995; essentially, all variables that are important to tourists but not explicitly listed (e.g., safety) are assumed to be constant at their 1995 values.

cost of travel matters less in their decision-making. However, as people take more and shorter holidays, travel time becomes more important.

WTO (2003) reports the average expenditure per day per international tourist, as well as the average length of stay. Total expenditure per tourist readily follows. As expenditure does not have an identifiable relationship with any characteristic of the host country, we keep expenditure per tourist constant, and thus make expenditure per host country proportional to the number of international arrivals. We assume, somewhat arbitrarily, that the profit rate in the tourism industry is 10%, and thus set the change in the producer surplus equal to 0.1 times the change in total expenditure. We approximate the change in consumer surplus by the change in airfare. For the majority of tourists who do not change their behaviour in response to a change in airfare, this is exact. For tourists who do change their destination, the difference in welfare between the two destinations must be smaller than the difference in the flight tax, so that we overestimate the welfare impact. Note that we study the effect of taxation, that is, a loss of consumer surplus. Our estimate of the changes in consumer surplus are therefore an upper bound to the actual loss.

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). Emissions fall by 7.5% per five years, following the trend in fuel efficiency in Faber *et al*. (2007). No holidays at less than 500 km distance (one way) are assumed to be by air, and all holidays beyond 5000 km are assumed to be by air; in between the fraction increases linearly with distance. For island nations, the respective distances are 0 and 500 km. Total modelled emissions in 2000 are 129 million metric tonnes of carbon, which is some 2% of total 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] See http://themes.eea.europa.eu/Environmental_issues/climate/indicators.

3. Results

We investigate the impact of three different climate policies for aviation that have been or are going to be implemented in the near future. The first is an EU wide scheme using emission permits. Then we look at two countries which have individually introduced measures to deal with emissions from the aviation sector. The Netherlands is about to introduce a flight tax levied on all departing passengers and the United Kingdom has recently doubled its flight tax. Although the taxes in the Netherlands and the United Kingdom are boarding taxes, rather than emissions taxes, they have been presented as climate policy instruments. The following section will look at the effects of these policies in turn and then examine the impacts on emissions and arrivals when all three are applied at once.

3.1. The European Union

In December 2006 the European Commission adopted a proposal for legislation to include aviation in the EU Emissions Trading Scheme.[4] It is planned that by 2012, carbon dioxide emissions for all flights arriving in and departing from the European Union will be part of the European Trading System for emission permits. The Commission states that "including civil aviation in the EU ETS is a cost effective way for the sector to control its emissions" (European Commission, 2006). We here consider the effect on arrivals, emissions and welfare of a permit price of €23/tCO_2, the 2010 futures price in early 2008.

Table 1 shows the effect of including aviation in the ETS on international arrivals in 2010. There are three effects. Firstly, non-EU visitors are less inclined to visit the EU, and travel elsewhere instead. This amounts to approximately 4.3 mln travellers. This is equal to a reduction of 1.1% in the EU, and an increase of 0.8% elsewhere. Secondly, EU tourists are less inclined to travel far, and therefore tend to holiday in the EU more often. This holds for 0.2 mln tourists. This amounts to an increase in the EU of 0.1%, and a decrease of 0.3% elsewhere. Overall, therefore, the tourist industry shrinks in the EU and grows elsewhere. Thirdly, there is a redistribution of tourists within the EU. Island

[4] See http://ec.europa.eu/environment/climat/aviation_en.htm

nations that depend on aviation see a decrease of 0.1 mln tourists from the EU (-0.7%) so that the rest of the EU sees an increase of 0.3 mln tourists from the EU (0.2%). Overall, the number of tourists in the EU shrinks by 0.8%, but this represents a fall of 1.2% for the island member states, and 0.7% for the mainland.

Table 2 shows the changes in consumer surplus (approximated by the change in actual airfare paid), producer surplus (approximated by ten percent of the change in expenditures), and total welfare (the sum of producer and consumer surplus) for each of the policies. In the EU, consumer surplus falls by €1.1 bln and producer surplus by €0.6 bln for a total welfare loss of €1.7 bln. Outside the EU, consumer surplus falls by €6.8 bln as non-EU tourists are restricted in their choice or face higher prices. Producer surplus increases by €0.8 bln, for a total welfare loss of €6.0 bln. The world as a whole loses €7.7 bln.

Table 3 shows the corresponding emission reduction. Emissions by EU travellers fall by 68 thousand tonnes of carbon, and emissions by non-EU travellers fall by 343 ktC. Considering the previously mentioned welfare losses, this makes for a rather expensive policy. Table 4 shows the average cost of emission reduction. If only costs and emissions in the EU are considered, the average cost is 77,000 €/tC. If all costs and emissions are taken into account, the average cost falls to 23,000 €/tC. This compares to a permit price of 84 €/tC.

In summary, the inclusion of aviation in the EU ETS using a permit price of €23/tCO_2, has a number of negative consequences for the tourist industry within the EU as well as for consumer welfare both within and outside the EU. Due to the size of the permit price, the emission reductions are minimal and carried out at a very high cost. The following sections look at the policy instruments used by the Netherlands and the United Kingdom.

3.2. The Netherlands

As of the 1st of July 2008, the Netherlands will implement a new flight tax. This tax will be levied on all passengers on board flights departing from the Netherlands (apart from those in transit). The tax is €11 per passenger for flights less than 2500 km distance, and €45 for all other flights (Netherlands Ministry of Finance, 2007). Consequently the flight tax on departures from the Netherlands is a boarding tax conditional on the length of the trip. Figure 1 shows the effect on the airfare. There are two impacts. Firstly, long distance travel becomes more expensive and is thus deterred. Secondly, within each tax band, the relative price increase is largest for short haul flights. As relative prices matter more than absolute prices, this induces people to fly further. Table 5 shows this pattern. Overall, the number of long-distance holidays (over 2500 km) falls by 22,000. However, the number of very long-distance holidays (over 12500 km) increases, albeit only by 81. Note that Cyprus and Turkey which are just over 2500 km from Amsterdam see the steepest decline in Dutch visitors.

The number of short-distance holidays (under 2500 km) increases by 22,000. However, this number does not reflect the sharp redistribution that occurs across destinations. Visits to island nations that can best be reached by plane fall by 36,000, while the European mainland sees an increase in Dutch visitors of 58,000.

The Netherlands also becomes less attractive for foreign tourists. Visitor numbers fall by 337,000. These tourists travel elsewhere, to avoid Dutch airports and this reduction in arrivals is consistently higher than the corresponding decline in Dutch tourism for all destinations except the European island nations.

Table 2 shows the associated welfare losses. Global consumer surplus falls by €0.4 bln, of which more than a quarter comes from reductions in the Netherlands alone. Producer surplus in the Netherlands falls by €0.1 bln. Although producer surplus increases elsewhere in the EU (with the exception of the UK and Ireland), global producer surplus falls by €0.03 bln. This is because the Netherlands is one of the dearest tourist destinations in the world.

Table 3 shows the change in emissions. Emissions by Dutch tourists fall by 5,000 tC. Global emissions fall by 14,000 tC considerably less than the result with the EU ETS scheme. Table 4 shows the average costs of emission reduction, which are even higher than for the tradable permits of the EU policy. This is no surprise, as the EU policy targets emissions directly, whereas the Dutch policy approaches emission reduction in a roundabout way.

The scheme by the Netherlands to unilaterally tax passengers departing from its airports depending on their flight distance, results in a fall in arrivals into the Netherlands and in long-distance holidays becoming relatively cheaper for Dutch tourists. Popular destinations for Dutch tourists and foreign residents in the Netherlands, such as Cyprus and Greece (both of which are just outside the "short-distance" tax band) are negatively impacted. Finally emissions are hardly affected as travel patterns re-adjust to avoid Dutch airports. What should also be noted is that the tax is on passengers only. As a consequence, flights that leave the Netherlands below full capacity are paying less tax and yet contributing as much to emissions. Next, we look at a similar policy in the United Kingdom.

3.3. The United Kingdom

The United Kingdom doubled its air passenger duty (APD) in February 2007, to £11 per person for flights to the European Union and £44 for all other flights (The Guardian, 2007).[5] Like the Netherlands, the United Kingdom levies a boarding tax, the level of which is comparable, €14 and €57 versus €11 and €44 for the Netherlands. However, the tax is not determined by travel distance, but rather by EU membership. This means that travel to some destinations which are closer to the UK geographically (for example Switzerland) are being taxed more than other more distant European Union members (e.g. Greece).

Figure 1 shows the effect of the tax. Although the pattern is at first sight similar to that of the Netherlands, there are in fact short-haul destinations in the high tax regime and medium-haul destinations in the low tax regime. For the Netherlands, the interplay of absolute and relative prices makes it impossible to say, based on first principles, whether

[5] The UK distinguishes economy classes and other classes; the quoted numbers are the average tax rate.

emissions would go up or down; however, the numerical model foresees an emission reduction. The UK has the same ambiguity. However, destinations between 1600 and 3200 km are treated very differently, and the boarding tax actually makes a few closer but non-EU destinations cheaper to fly to than farther, EU destinations.

Table 6 shows the results for visitor numbers. An additional 85,000 British tourists stay within the EU due to the boarding tax. However, short-range holidays fall by 82,000, while medium-range holidays increase by 168,000. UK holidays outside the EU fall by 85,000, but holidays at less than 4000 km distance fall by 177,000 while farther destinations see an increase of 91,000. As a result, UK emissions rise by 26,000 tC (Table 3).

The perspective of potential visitors to the UK is different, and their number falls by 964,000. These tourists travel elsewhere, and their numbers more than offset the drop in UK visits in the near-EU – but not in the near non-EU. Table 3 shows that emissions from the rest of the EU increase too, as people travel farther than the UK. However, emissions from the rest of the world decrease as tourists stay closer to home rather than travel to the UK. However, this effect is smaller than the increase in UK emissions.

Table 2 shows the welfare implications of this tax regime. The consumer surplus of UK tourists falls by €0.7 bln, and other tourists lose another €1.7 bln. UK producer surplus falls by €0.7 bln. Although other EU producers are better off, this does not offset the UK losses and producer surplus for the EU and the world falls. The welfare changes are dominated by the producer surplus effects and the same reductions occur.

Although the UK scheme resembles the Netherlands in the instrument used (passenger tax) it is applied in a different fashion and hence produces different results. The tax makes travel for UK tourists to far EU destinations relatively cheaper than closer EU countries. In parallel, destinations outside the EU that are close to the UK become relatively more expensive than countries further away. This results in a shift in passengers between destinations and an increase in overall emissions from the UK.

Foreign tourists avoid traveling to the UK and as a result emissions from the rest of the world fall slightly. The negative effect from the UK on consumer and producer surplus is too strong to be compensated by increases in other countries and overall welfare falls.

According to 2008 Budget reports, the APD is set to be substituted by a single tax per plane in 2009. The British government's aim is to send "better environmental signals" (HM Revenue and Customs, 2008). Switching the tax from a per passenger basis to a per flight basis is a bid to compensate for the emissions resulting from partially empty planes. However, airlines hardly need further encouragement to increase the occupancy rates of their planes. It is unclear how the plane tax would be transferred to the passengers and thus affect behaviour. Presumably, passengers would pay a fixed share of the plane tax when booking, and the airline's shareholders would absorb the uncovered taxes. The second aim of the reform is to make the tax better correlated with distance traveled – but the proposed plane tax is still unrelated to emissions. Two suggestions have been put forward in this regard (HM Revenue and Customs, 2008): basing the tax on great circle distance or creating a banded system of concentric zones around London. A distance tax would not differentiate between more and less energy-efficient aircraft. The government also aims to increase the forecasted total tax revenue from taxes on aviation by 10% in 2011-2012. It has yet to be decided what form this tax will take and we therefore excluded it from this analysis.

3.4. The three policies combined

Tables 2 and 3 show the impact on welfare and emissions of the three policies combined. The model is approximately linear, that is, the effect of the combined policies is about equal to the sum of the policies. The error introduced by separately analysing the policies is very small for the consumer surplus results. It is generally less than 4% for welfare and emission changes.

Global producer surplus show the largest approximation error. The change in global producer surplus is small, but it is the sum of large positives and negatives. The sum of the three policies overestimates the impact on global producer surplus by an amount that is relatively large but absolutely small.

At first glance, the fact that the three policies supplement each other is a good sign as it indicates that if countries take action separately and not as part of a uniform international measure, the measures won't necessarily counteract each other. Unfortunately, in these examples the measures taken to curb emissions all have a negative impact on tourism and just a very small impact on emissions. Consequently, the combination of the policies results in an even higher loss of welfare for each of the countries concerned.

3.5. Discussion

Tables 2 and 3 show the effect of the EU plan on the UK and the Netherlands. Table 2 shows the effects on welfare. If a permit price of €23/tCO_2, is applied to EU flights, consumer surplus, producer surplus and total welfare for the EU fall. The effect on the UK and the Netherlands is the same. In the UK, consumer surplus falls by €0.2 bln and producer surplus by €0.1 bln for a total welfare loss of €0.3 bln. The corresponding figures for the Netherlands are €47 mln, €15 mln and €63 mln. The qualitative pattern is the same, but the scale of the welfare effect is obviously different. The importance of the UK market in the EU is particularly noticeable. The welfare loss in the UK accounts for one-fifth of the total welfare loss in the EU for producer surplus and total welfare. This is due to the size of the UK tourism market, and its heavy dependence on aviation.

The welfare impacts for the UK and the Netherlands are significantly smaller in absolute terms under the EU scheme than under their own individual schemes. This is because the other EU member states are the main source of tourists to the UK and the Netherlands, and their main competitors too.

Table 3 shows the corresponding effects on emissions. Under the EU scheme emissions by EU travellers fall by 68 thousand tonnes of carbon. There is also a reduction in emissions from the UK and the Netherlands. However, the emission reduction in the UK accounts for just 3% of the total drop in emission, a proportion that is substantially smaller than the welfare effects (19% to the UK). This is because the UK is an island nation, that depends heavily on aviation. British tourists have little choice but to accept higher fares, while the British tourist industry will see a relatively large drop in visitor numbers. Hence, welfare losses are relatively high, but emission reductions are relatively small.[6] The very small reduction in emissions from the UK is likely to be due to it being an island nation. For the Netherlands, welfare losses and emission reductions are similar in relation to the EU total.

4. Sensitivity analysis

This section presents the sensitivity analyses for the different policies. Previous papers have tested the sensitivity of the model to different parameter assumptions, elasticities, different price or tax changes as well as the assumptions relating to substitution between domestic and international travel. More details about these results can be found in Tol (2007), Mayor and Tol (2007) and Mayor and Tol (2008). Overall, the results are as one would expect. If the flight tax or carbon tax is higher, it has a bigger effect. If price elasticities are larger, the effects are bigger too. A sensitivity analysis of the APD in the UK shows unexpected results, but the reason is the design of the tax. Figure 1 shows that it is a peculiar environmental tax, so strange results should be expected. The previous sensitivity analyses also show that the qualitative pattern of our result is robust to credible variations in parameter choice. We will therefore not repeat these exercises here.

Unlike our previous papers, we here estimate welfare impacts. Table 2 shows that the impact of climate policy on consumer surplus is always negative. This is no surprise, as tourists either pay higher fares or take their holiday in a different place than they would have liked. Table 2 also shows that the impact of climate policy on producer surplus is negative in the regulated countries, but may be positive in unregulated countries. Again, there are no surprises here. Finally, Table 2 shows that total welfare losses are almost always negative. There are two exceptions. First, Other EU countries gain from the Netherlands flight tax. This is because the producer surplus is larger than the consumer surplus, if we assume that the producer surplus equals 10% of tourist expenditure. Other

[6] Recall that we attribute emissions to the country of origin of the tourist.

EU countries would still gain if the producer surplus would be only 3%, so the qualitative conclusion (gain) is robust to variations in the assumed profit rate. Second, other EU countries gain from the UK flight tax, but they would lose if the profit rate is set slightly below 10%, so the qualitative conclusion (loss) is fragile. For countries outside the EU, the producer is always positive but smaller (in absolute terms) than the consumer surplus. Total welfare therefore falls. This conclusion is robust, as the profit rate would need to be set at 80% or higher to reverse the result.

The Netherlands Government adjusted its planned flight tax even before it became effective. Cyprus and Turkey are two popular destinations that are just outside the original 2500 km band that differentiates between the low tariff (€12) and the high tariff (€45). Both countries are popular holiday destinations, and the Netherlands also has a large number of resident ethnic Turks. A flight from Amsterdam to Istanbul was originally in the high tariff, but a flight from Eindhoven to Istanbul was in the low tariff – even though Eindhoven is not far from Amsterdam, and a return trip Amsterdam-Eindhoven is less than €33 by train or car. The airport of Cologne/Maastricht is just across the Dutch border, and exempt from the tax. So, in response to airlines and tour operators loudly announcing that they would shift operations to Eindhoven or Cologne, the Netherlands Government has exempted Cyprus and Turkey from the high tariff. This is in fact the same as extending the lower tariff band to 3000 km. Table 7 shows the implications. The effective tax has dropped, so consumer and producer surplus in the Netherlands rise – for a total welfare gain of €4 mln. Emissions increase by 50 tC. Consumer and producer surplus in Cyprus and Turkey rise as well, by another €2 mln. The rest of the world loses welfare (by €1 mln), as visitor numbers from Cyprus, the Netherlands and Turkey fall. However, global welfare increases by €5 mln. Emissions from Cyprus and Turkey fall, as they holiday in the Netherlands rather than further afield. This more than offsets the increase in Dutch emissions, so that global emissions fall slightly by 70 tC. These effects are small – as one would expect from a marginal adjustment to a low tariff between smallish countries.

The main drawback of the UK boarding tax is that it is based on EU membership rather than distance or emissions. This is the main cause of the unpredictable and paradoxical results. We therefore assumed that the UK follows the Dutch example and levies the low tariff for flights shorter than 2500 km, and the high tariff for longer flights. This is in fact a slightly lower tax, so both the consumer surplus of UK tourists and the producer surplus of the UK tourism industry increase, for a total welfare gain of €150 mln. See Table 8. At the same time, emissions fall by 6,000 tC. Note that emissions are still higher than in the case without a boarding tax as it still reduces the relative price of long-haul flights. Table 8 shows that a boarding tax based on distance rather than EU membership redistributes welfare from the rest of the EU to the rest of the world. This is as one would expect from the abolishing of a favour-based tariff. The gains in the rest of the world are larger than the losses in the rest of the EU, so that global welfare increases by €0.2 bln. Emissions in the rest of the world increase slightly, but are still lower than in the case without a boarding tax in the UK.

5. Discussion and conclusion

We use a model of international flows of tourists to determine the effects of different climate policy instruments on arrivals, welfare, and emissions arising from aviation. We find that all three policies examined have different levels of impacts but all are detrimental to tourist activity in the countries they are implemented in. The inclusion of aviation in the EU ETS using a permit price of €23/tCO_2, has a number of unexpected consequences. The tourist industry shrinks in the EU and grows elsewhere as tourists substitute towards destinations not affected by the price increase. A redistribution also occurs within the EU. From a welfare perspective, consumer and producer surpluses for the EU fall. Finally, emissions are only reduced by a very small amount and at a very high cost.

The scheme by the Netherlands to tax passengers departing from its airports depending on their flight distance, results in a fall in arrivals into the Netherlands. Long-distance holidays become relatively cheaper resulting in a destination substitution. Popular destinations that are usually traveled to by plane, such as Cyprus and Greece (both of which are just outside the “short-distance” tax band) are negatively impacted. Finally emissions are hardly affected as travel patterns re-adjust to avoid Dutch airports.

The scheme in the United Kingdom is similar, yet the difference in the way the zones are delimited results in some different substitution patterns. In terms of tourist numbers, the scheme results in a fall in the number of visitors to the UK, who travel elsewhere to avoid the tax. British tourists switch to EU destinations and reduce trips to non-EU destinations. However, as some EU countries are further away than some non-EU countries, this switch results in an increase in emissions from the UK. Consumer and producer surplus both fall.

We also tested the sensitivity of the welfare impacts. We find that the results are robust to changes in the assumptions used to calculate consumer and producer surplus. The effects of changes in the way the UK and Dutch taxes are applied were also tested. The extension of the Dutch tax to include countries within 3000 km distance, which encompass popular holiday destinations, causes an increase in welfare for Dutch tourists and those from the newly included countries. The impacts on emissions are small due to the small number of tourists affected. If the UK tax was based on distance rather than EU membership, welfare gains would be redistributed from EU countries to the rest of the world and global welfare would also increase.

The introduction of a wide-range of climate policies regarding aviation both at a country level and at an EU level could result in the policies complementing each other: the consequences of one policy could add to results from another. However, these climate policies do not necessarily result in a significant or cost-effective reduction in emissions. Moreover, they can end up being detrimental to the country implementing the policy and affect incoming tourist numbers. This paper also highlighted the welfare impacts of the policies. The Dutch tax is relatively new and its impact has yet to be observed. It will also be interesting to see what form the British government’s proposals for a new more environmentally targeted tax will take and whether it will avoid the pitfalls of the current APD.

Acknowledgements

Financial support by the Environmental Protection Agency is gratefully acknowledged.

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Table 1. The change in visitor numbers (in 000s and percent) in 2010 for an EU-wide carbon price of €23/tCO_2.

to\from	EU		non-EU		Total	
EU	212	0.1%	-4269	-1.1%	-4057	-0.8
Cyprus, Ireland, Malta, UK	-105	-0.7%	-543	-1.4%	-648	-1.2
Other EU	316	0.2%	-3726	-1.1%	-3409	-0.7
non-EU	-212	-0.3%	4269	0.8%	4057	0.7

Table 2. Welfare changes (mln €).

Policy	EU	NL	UK	Combined	Error (%)
Consumer surplus					
NL	-47	-107	-10	-163	0.3
UK	-182	-5	-652	-840	-0.1
Other EU	-896	-6	-141	-1044	0.0
EU	-1125	-118	-803	-2048	0.0
non-EU	-6756	-259	-1526	-8520	0.3
World	-7881	-377	-2330	-10567	0.2
Producer surplus					
NL	-15	-72	4	-81	3.6
UK	-145	-7	-729	-853	3.3
Other EU	-433	22	142	-276	-2.7
EU	-594	-56	-583	-1209	2.0
non-EU	779	30	182	984	0.7
World	185	-26	-401	-225	7.4
Welfare change					
NL	-63	-179	-6	-244	1.4
UK	-327	-12	-1381	-1693	1.6
Other EU	-1329	16	1	-1320	-0.6
EU	-1719	-175	-1386	-3257	0.7
non-EU	-5977	-229	-1344	-7536	0.2
World	-7696	-403	-2731	-10792	0.3

Table 3. Emission changes (000 tC).

Policy	EU	NL	UK	Combined	Error (%)
NL	-3.2	-4.6	2.0	-6.0	-2.5
UK	-1.9	2.1	26.1	25.5	2.6
Other EU	-63.2	1.1	5.0	-57.4	-0.5
EU	-68.3	-1.5	33.1	-37.8	-2.9
non-EU	-343.1	-12.5	-83.7	-435.9	0.8
World	-411.5	-14.0	-50.6	-473.8	0.5

Table 4. Average emission reduction cost (€/tC).

	EU	NL	UK	Combined
Costs in jurisdiction/emissions in jurisdiction	25162	38503	-53005	86100
Costs in jurisdiction/global emissions	4178	12810	27306	6875
Global costs/global emissions	18705	28894	53988	22780

Table 5. The change in visitor numbers in 2010 for the Netherlands boarding tax.

to\from	Netherlands	Other	Total Change
Netherlands	0	-337126	-337126
< 2500, excl. islands	58157	166286	224443
Iceland, Ireland, Malta, UK	-35810	13778	-22032
< 12500	-22427	154425	131998
> 12500	81	2633	2714

Table 6. The change in visitor numbers in 2010 for the UK boarding tax.

to\from	UK	Other
UK	0	-964196
EU, <500	-81941	153838
EU, >500	167758	418351
non-EU, <4000	-176900	116791
non-EU, >4000	91086	275212

Table 7. The difference of the impact on consumer surplus (mln €), producer surplus (mln €), total welfare (mln €), and emissions (ktC) of the Netherlands boarding tax between the original proposal and new proposal with Cyprus and Turkey in the low tariff.

	Consumer	Producer	Welfare	Emissions
Netherlands	2.739	1.096	3.835	0.054
Cyprus	0.149	0.108	0.257	-0.002
Turkey	2.171	0.007	2.178	-0.119
Rest of the world	0.000	-1.197	-1.197	0.000

Table 8. The difference of the impact on consumer surplus (mln €), producer surplus (mln €), total welfare (mln €), and emissions (ktC) of the UK boarding tax between the original proposal and one based on distance.

	Consumer	Producer	Welfare	Emissions
UK	70.1	77.3	147.4	-5.7
Rest of the EU	-0.7	-37.4	-38.2	0.0
Rest of the World	94.6	11.2	105.7	2.6
World	164.0	51.0	215.0	-3.1

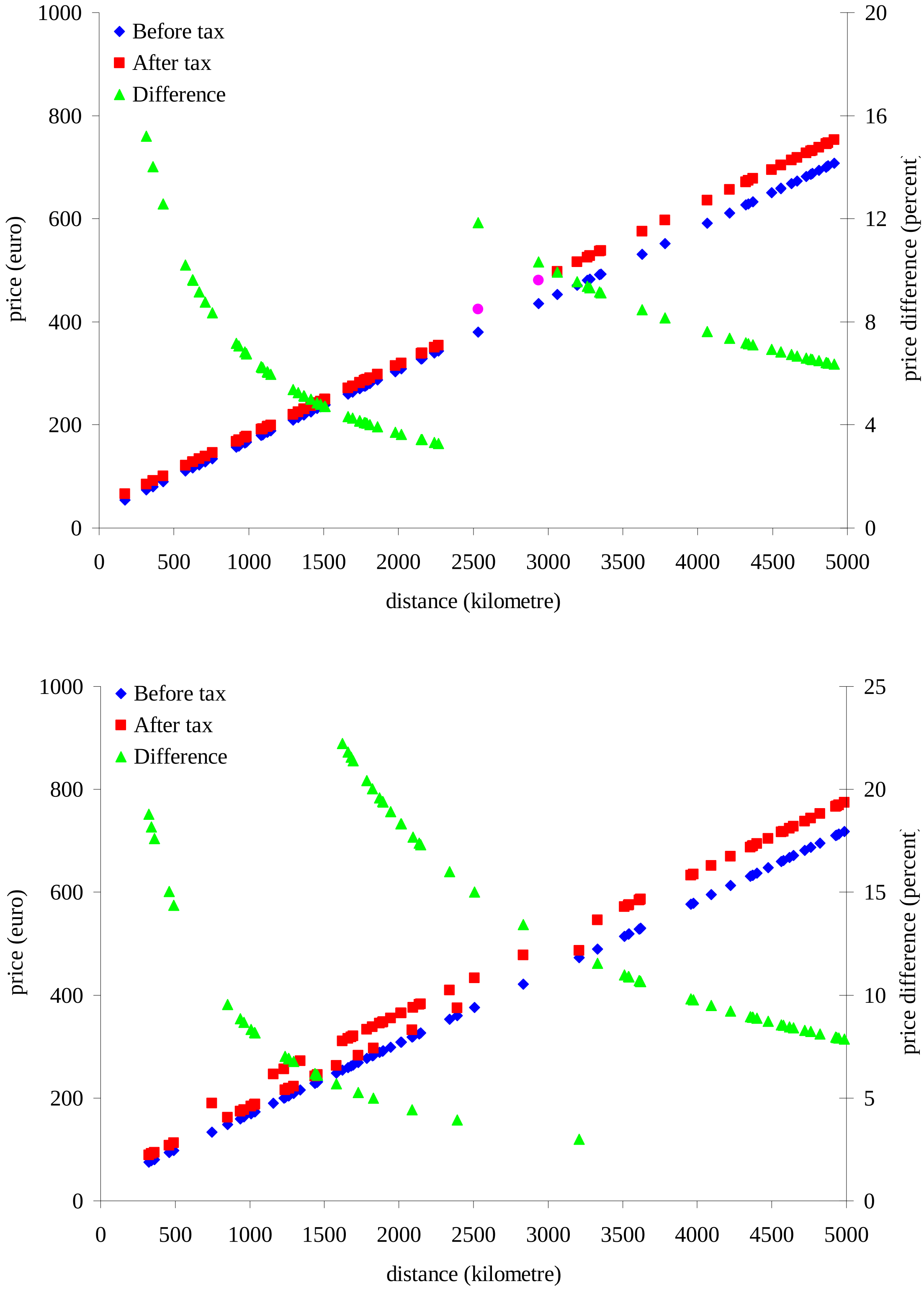

Figure 1. The effect of the boarding tax in the Netherlands (top panel – Cyprus and Turkey in pink dots) and the United Kingdom (bottom panel) on the airfare as a function of travel distance.

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