Working Paper No. 240

May 2008

www.esri.ie

Aviation and the Environment in the Context of the EU-US Open Skies Agreement

Karen Mayor[a] and Richard S.J. Tol[a,b,c,d]

Abstract: We examine the impacts of the EU-US Open Skies agreement on the environment, in particular looking at the effect of the agreement on emissions from the aviation sector. We use the Hamburg Tourism Model, a model of domestic and international tourist numbers and flows, to estimate these impacts. The Open Aviation Area will result in increased competition between carriers and consequently falls in the cost of transatlantic flights. This will not only have implications for the size and structure of the industry but also for climate policy. The objectives of this paper are (1) to assess what effects the expected increases in passenger numbers will have on CO_2 emissions and (2) to test whether this increase in travel will result in a corresponding rise in emissions. Model simulations show that passenger numbers arriving from the US to the EU will increase by between 1% and 14% depending on the magnitude of the price reductions. We find that because of substitution between destinations, the percentage increase in global emissions is much smaller (max. 1%) than the increase in cross-Atlantic traffic. In the current context of greenhouse gas control policies, any increase in emissions will make climate policy objectives more difficult to achieve and will attract more attention to aviation's contribution to climate change.

Key Words: International tourism; open skies agreement; carbon dioxide emissions; climate policy; externalities

Corresponding Authors: Karen.Mayor@esri.ie; Richard.Tol@esri.ie

---

[a] *Economic and Social Research Institute, Whitaker Square, Sir John Rogerson's Quay, Dublin 2, Ireland*
[b] *Institute for Environmental Studies, Vrije Universiteit, Amsterdam, The Netherlands*
[b] *Department of Spatial Economics, Vrije Universiteit, Amsterdam, The Netherlands*
[d] *Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA, USA*

Aviation and the Environment in the Context of the EU-US Open Skies Agreement

1. Introduction: Open Skies

On the 22nd March 2007, the European Commission announced that an Open Aviation Area agreement (OAA) had been reached between the US and the EU. The agreement came into effect on the 30th March 2008 and EU carriers are now allowed to fly to any airport in the US from any European city and vice versa. This partly liberalised market[1] has replaced the traditional markets dominated by national carriers and is expected to lead to increased competition not only between airlines but also between major hubs. As a result, passengers should expect to see a fall in the cost of flying.

The transatlantic market has been the subject of attention from both policy-makers and industry due to its size and its financial importance. Indeed, the EU and the US are two of the largest transport markets in the world, not only in terms of tourist arrivals but also in relation to business and freight transport. Figure 1 shows the average passenger traffic between the EU and the US between 1995 and 2005. The dip in traffic after 2001 is visible but the market has remained strong and in the range of 45 million passengers a year. Any agreements leading to further liberalisation of such an important market will inevitably result in even further traffic. The Brattle Group (2002) estimated that the Open Skies agreement will lead to an additional 70 000 jobs across the EU and the US and between €6.4 and €12 billion dollars in consumer surplus over a five year period.

The Open Skies agreement and the additional passenger flows it will bring about, will undoubtedly help maintain and develop this aviation market. Although a number of studies have investigated the economic and financial implications of the Open Skies agreement, few have looked at the potential environmental effects. The objective of this paper is to investigate the environmental impacts of the Open Skies agreement.

The following section looks at previous literature on the subject of the environmental impacts of the aviation industry and policies to control emissions. Section 3 describes the motivation behind the paper. Section 4 presents the model design and calibration. In

[1] Restrictions on airline ownership and on domestic flights remain.

section 5 we discuss the results of the analysis and the impacts on carbon dioxide emissions from the US and the EU. This is followed by a sensitivity analysis, which includes different elasticity scenarios and the effect of substitution between domestic and international holidays. Finally, section 7 provides a discussion and conclusions.

2. Aviation and the environment: externalities

The environmental impacts of aviation have been of public interest since air transport became a popular form of travel. As with any type of transport mode, a number of externalities are associated with aviation. These range from localised impacts to global impacts. This section aims to present a number of these externalities, their effects, and how they have been dealt with in the past.

Schipper et al. (2001) distinguish between three types of externalities from aviation. These are "external effects depending directly on output in airline markets", "indirect external effects, upstream and downstream" and "external effects associated with presence of infrastructure". For information, the indirect externalities relate to pollution resulting from the production and disposal of aircrafts and materials used to construct and service aircrafts. The infrastructure externalities relate to the environmental impacts on wildlife and ecosystems associated with the construction of new airports and terminals. The Open Skies agreement may result in the construction of additional infrastructure to deal with extra capacity, but these issues are beyond the scope of this paper.

The most "visible" aviation externality is noise pollution and it is one of the external effects depending directly on output in airline markets. The noise associated with aircrafts affects people living close to the airport as well as homes on major flight paths. Hedonic analyses and contingent valuation studies have been conducted to assess the welfare costs of aircraft noise (Schipper, 2004). Complaints arising from noise pollution around airports led to research into noise reduction strategies and the implementation of regulation (Janić, 1999). This has resulted in considerable improvements in noise reduction from a technological perspective, but noise remains a challenge. In relation to the Open Skies agreement, noise pollution might increase due to increased congestion and frequency of flights at main airports. The opportunity given to airlines of flying from foreign airports, could result in smaller (and typically less congested) airports seeing an increase in frequency. Whether this does happen will depend on the level of substitution between travel destinations that occurs. To our knowledge no research has been done on this as of yet.

The next major environmental issue associated with aviation relates to exhaust emissions and their impacts on health. The emission of pollutants such as carbon dioxide emissions, nitrogen oxides, carbon monoxide or volatile organic compounds can affect human health. Schipper (2004) discusses how this type of externality can be measured in monetary terms. The impacts of emissions on health are in general local effects. Due to improvements in technology, this type of pollution is no longer of central interest to the public, which is now concentrating on the global effects of these pollutants.

The contribution of the airline industry to global greenhouse gas emissions has been a topical issue in the context of recent climate change discussions. Indeed, as tourism is a fast growing sector, emissions from airlines are growing at a very high rate. However, they remain small in the context of global emissions. Total international aviation is responsible for just 3% of global emissions.[2] Unlike other sectors of the European economy, the aviation sector was until recently excluded from emission reduction policies. The European Commission has now proposed to include aviation in the European Trading System for carbon dioxide emission permits.

The primary objective of this paper is to look at the implications of the Open Skies agreement for carbon dioxide emissions. In the current context of climate change and greenhouse gas control policies, increases in emissions will make climate policy objectives more difficult to achieve. In order to quantify the change in emissions, the effect on travel must first be investigated. This will be done in two phases. First the direct impact on travel of the Open Skies agreement will be investigated. Second, how much of the increased travel between the United States and the European Union is due to an increase in the number of trips made between the two regions, and how much is due to displacement from other destinations will be examined.

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

3. Motivation

This paper builds on the model used in Tol (2007), FitzGerald and Tol (2007) and Mayor and Tol (2007) but instead of looking at the effect of carbon pricing or air passenger duty, it looks at the environmental impact of price falls due to increased competition. Mayor and Tol (2008) focus on traveller numbers. Even though the number of transatlantic trips taken may increase because of the price reductions, this does not necessarily mean that emissions will increase accordingly. Tourists can only make a limited number of trips a year (because of limited time off and budget) and an increase in travel between the US and the EU may result in a fall in trips to other EU countries by EU tourists in favour of long-haul, now cheaper but more polluting trips to the US. However, this may also make the US a more attractive (cheaper) long-haul destination and take tourists away from other more distant or exotic trips, resulting in a fall in emissions.

Only *international* aviation *demand* by *tourists* is examined. Business travel and domestic air travel are hence excluded. Note that business travellers are less likely to respond to price changes than tourists and consequently the impact of "Open Skies" on emissions from business air travel is unlikely to be significant. Only shifts in emissions induced by a fall in the price of air travel between the US and the EU are considered. It should also be noted that the present analysis does not look at the impact of an EU-US OAA on intra-EU flights but only on transatlantic journeys.

In this paper, we look at the size of the changes in emissions due to the OAA. To date, access to the transatlantic market was restricted by bilateral Open Skies agreements between individual European countries and the US. The agreement aims to completely liberalise this market and replace individual agreements with a uniform procedure for the EU. As of March 2008, EU carriers are no longer restricted to fly to the States exclusively from their own countries. The main result is expected to be increased competition between airlines, which will eventually lead to lower fares for passengers. The possibility of mergers and deeper alliances will also present the prospect of cost savings within airlines, which can also translate into lower fares. In this context, the Open Skies agreement will without a doubt result in increases in transatlantic trips and consequently have an impact on emissions from aviation. This paper aims to measure the size of this impact.

4. The model

The results presented in this paper are derived from simulations 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.*, 2007) while the current version is designed to analyse climate policy.

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. A reduction in the cost of travel is expected to lead to increased travel to the destinations affected by the cost fall. 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, only results for 2010 are shown.

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 +0.14ln*y*, where *y* is the average per capita income in the country of origin. This translates into an elasticity of –0.45 for UK travellers and –0.41 for US travellers which compare well to the estimates of Crouch (1995) and Wohlgemuth (1997) but are low compared to those used by the Brattle Group (2002) and Booz Allen Hamilton (2007).

We use these lower elasticities for four reasons. Firstly, our price elasticity falls with rising per capita income, and is therefore lower than in previous, older 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. The OOA is assumed not to affect the flight duration. Thirdly, we consider trade-offs between *countries*. The higher estimates for the price elasticity of travel demand used in previous studies are found for alternative city destinations, which are closer substitutes than alternative country destinations, and for price competition on the same route. Fourthly, what matters to the tourist is the total cost of the holiday. As airfares have fallen, the share of travel in total holiday costs has decreased, and travellers have become less sensitive to the price of tickets (Njegovan, 2006).

The model was used to "predict" tourist numbers for 1980, 1985, and 1990, and shown to have a predictive power of over 70%. While the model accounts for changes in the quantity of travel, it does not take into account changes in the *quality* of air travel. The OOA will predominantly affect the cost of transatlantic flights. We recognise however that other aspects of travel such as quality of air travel may also be affected. Moreover, as mentioned above the model only looks at air travel for tourism purposes and does not account for business travel. The secondary impacts of the OOA such as airline alliances or increased trade due to lower transport costs are also not examined here (cf. Button and Taylor, 2000). Airline mergers and alliances would have an impact on the price of flights within the EU, which would inevitably affect intra-EU travel patterns. The final limitation of the model in the context of this particular analysis is that it treats the US as a single destination. Although this does not affect the rational behind destination choice by EU tourists, increased travel from the EU to, for instance, west coast destinations instead of east coast destinations would have an effect on emissions.

The model assumes 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. 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. 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. 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.[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.

5. Scenarios and Results

5.1 Scenarios

The model is 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 the effect of hypothetical price falls as changes from the current situation. The scenarios used were price falls of 5%, 20% and 50% on the cost of flights to EU27 countries. The results for other price changes can be deduced from the results presented here. The effects of these airfare price reductions on emissions from the US, EU countries and the rest of the world are examined. The first group of European countries (henceforth referred to as EU5) comprises the five countries that did not have pre-existing Open Skies agreements with the US, i.e. the UK, Ireland, Greece, Spain and Hungary. Hence, it would be expected that routes from these countries would face a higher level of liberalisation and consequently a bigger change than those from countries with pre-existing treaties. We also look at the effect on emissions from the EU 27 countries and then include the three EEA countries (Iceland, Switzerland and Norway). In order to put the changes in emissions in context we first examine the effect of price reductions on passenger numbers.

5.2 Results

It is expected that the Open Skies agreement will result in increased competition between airlines and hubs in the United States and in Europe. In order to quantify the effect of the agreement on emissions from Europe and the US, we must first look at the effect it will have on passenger numbers. Figure 2 shows the change in arrivals from the US into the EU5, the EU27-5 and the EU+EEA-EU27 due to price falls of 5%, 20% and 50% on the cost of flights to EU27 countries. The increase in passenger arrivals into the EU5 is slightly higher than for the EU27 whereas EEA countries experience a fall in arrivals. When the price of flights to the EU27 falls by 20%, the number of arrivals into Switzerland, Norway and Iceland falls by 3.7% while other EU countries experience an increase in arrivals of the order of 4.5%. As flights to the EU27 become cheaper, US tourists will substitute away from other European countries and towards the cheaper destinations. This substitution will be slightly higher for the EU5 countries, as they did not have pre-existing Open Skies agreements with the US. This slight advantage could be attributed to the "novelty factor" of these countries to US tourists. What is important to note here is that as flights to Europe become cheaper, US tourists naturally travel there more often. This will undoubtedly have implications for emissions from all countries concerned.

Figure 3 shows this effect. The change in emissions from the EU5, EU27-EU5 and US resulting from 5%, 20% and 50% reductions in the cost of flights to the EU27 are shown. Emissions from all EU countries increase by between 0.2% and 3.4% and increase as the price reductions become more important. The effect on emissions from the US is less important with the rise in emissions ranging from 0.1% to 1.4%.

The effect of the price reductions and the increase in passenger travel on global emissions is not large. Figure 4 shows the change in emissions from the world for different price reduction scenarios. The increase in emissions ranges between 0.04% and 0.70% depending on the price reductions. The reason for the low effect on world emissions is that the increase in travel to some European countries is offset by a fall in passenger arrivals for other countries. This can be seen in Figure 2 where US tourists substitute away from the now relatively more expensive destinations towards those made cheaper by the OOA. The effect is the same for European travellers, who may go to the States more often. However, due to a restriction in time off work and funds for possible on-site costs, these long distance holidays to the States will to a certain extent be replacing other trips and not adding to them.

6. Sensitivity Analysis

In the analysis above, it was assumed that a change in transatlantic fares resulted in a substitution between foreign holiday destinations, but not between domestic and international holidays. To test the sensitivity of 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 of this test. When substitution between domestic and international destinations is taken into account, emissions increase more than in the base case. For instance, a 20% decrease in the cost of flights to EU27 countries leads to an increase in world emissions of 0.2% in the base case. The increase is 0.9% when substitution is taken into account. This is due to tourists substituting away from (short-haul) domestic flights to (long-haul) international flights.

The assumed price elasticity is very important but also very uncertain. The surveys of Oum *et al.* (1990) and Gillen *et al.* (2004) reveal a wide range of estimates. The price elasticity used here is a result of calibration rather than estimation. The model was recalibrated so that the price elasticity equals twice and four times the time elasticity. The price elasticity for the USA is -0.41 in the base case, but falls to -0.54 (twice) or -0.64 (four times).[4]

The impacts of elasticity changes on emissions from the US and the EU27 are visible in Figure 5. This shows the effect on emissions from the US and the EU27 after a 20% price fall in flights to the EU27 using different elasticity and domestic/international substitution conditions. First, it is noticeable that the higher the elasticity the higher the increase in emissions, for both sources. As tourists become more sensitive to price, the more travelling they will do as the effect of the price reduction is increased.

Second, the impact of the domestic/substitution condition is a lot more important than that of the elasticities. In the original scenario, it was assumed that a change in the cost of flights would result in substitution between different holiday destinations but not between domestic and international destinations. In this case this assumption is relaxed. The switch from domestic to international flights results in a significant increase in emissions from both the US (4.4%) and the EU (2%).

Finally, Figure 5 also shows that emissions from EU27 countries are more sensitive to changes in the price elasticity whereas emissions from the US are more sensitive to changes in the domestic/international substitution assumption. This is reinforced by Figure 6, which shows the base elasticity versus the substitution condition for emissions from the EU27, the US and the rest of the world for the three levels of price reductions. The left hand side of the graph shows effects of price reductions on emissions from the EU27, the rest of the world and the US under the base elasticity scenario. The effect on emissions from the EU27 is the strongest, followed by the US. There is a minimal effect

[4] Note that the studies surveyed 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.

on the rest of the world. Looking at the right hand side of the graph, we see that the effects have reversed. Now, the increases in emissions from the US are stronger than those from the EU. This is in the case where substitution between international and domestic flights is allowed by the model. As the price of flights to the EU27 get smaller, US tourists will substitute away from other destinations in favour of Europe. As the price reductions get very high (50% fall in price) they will move an even higher proportion of their trips to Europe, including what would have been domestic trips. Due to the size of the country a lot of trips in the US are domestic and this would result in a very big shift.

The effect on emissions of the Open Skies agreement is sensitive to the assumptions in the model. First, the price elasticity assumption will influence how sensitive tourists are to the price reductions and consequently how many more trips they will be likely to make. This is particularly relevant for Europe where most holiday destinations require going abroad. For the US, the case is different. Considering the scale of the domestic tourist market (and the range of holiday types available within the country) the change emissions from the US due to the OOA will be more sensitive to the domestic/international assumption. Once, substitution between domestic and international trips is allowed, emissions from the US increase further (14% increase for a 50% reduction in price).

7. Discussion and Conclusion

We use a model of international flows of tourists to determine the effects of the US-EU Open Skies agreement on carbon dioxide emissions and traveler numbers. We find that the fall in fares will result in increased passenger flows. The number of passenger arrivals is however much lower than previous studies have suggested. These studies used price elasticities that are too high for transatlantic flights. Carbon dioxide emissions will also increase because of the Open Skies agreement. However, the increase in global emissions is smaller than the increase in transatlantic travel. This is because the increase in travel between the EU and the USA will be counterbalanced by a reduction in travel to other destinations.

We did not consider climate policy. Aviation will be included in the European Trading System of carbon dioxide emission permits. According to the current proposals, all flights in and out of the European Union would need permits for the entire route. At the expected permit price of less than €25/tCO_2,[5] a transatlantic roundtrip would increase in price less than €50.[6] Therefore, the price *increase* from climate policy is on the lower end of the price *decrease* that can be expected due to the Open Skies Agreement. Even if the two policies offset one another over the Atlantic, climate policy would still affect travel between Europe and the rest of the world. US travel to the rest of the world may also be affected, as passengers avoid stopovers in the EU. The effects of emissions trading on tourism flows are discussed by FitzGerald and Tol (2007). The same authors note that changes in taxiing, take-off and landing behaviour, reduced runway congestion, and a shortening of routes may substantially cut emissions at modest costs and in the short run. However, these aspects are unaffected by the current EU proposals for pricing emissions.

It should also be noted that the airlines themselves, regardless of climate policy, have an incentive to reduce emissions. Indeed, increasing energy prices[7] are a huge financial incentive for airlines to invest in new, more fuel-efficient technology. Not only are airlines looking to invest in aircrafts that require less fuel but they are also increasing aircraft capacity and in consequence reducing emissions per passenger. A lot of the reduction in emissions from aviation could end up being the result of investments made by the industry itself in better technology rather than due to a fall in travel.

Acknowledgements

The authors benefited from helpful comments from seminar participants at the "The Impact of EU-US Open Skies" AIRNETH Workshop and the AIRNETH annual conference in The Hague. Financial support by AIRNETH and the Environmental Protection Agency is gratefully acknowledged.

---

[5] http://www.eex.com/en/

[6] Emission data from http://www.climatecare.org/calculators/flight/

[7] See Figure 7.

References

Bigano, A., Hamilton, J.M., Tol, R.S.J, 2007. The Impact of Climate Change on Domestic and International Tourism: A Simulation Study. Integrated Assessment Journal, 7 (1), 25-49.

Booz Allen Hamilton, 2007. The Economic Impacts of an Open Aviation Area between the EU and the US – Executive Summary, at <http://ec.europa.eu/transport/air_portal/international/pillars/global_partners/doc/us/eu_us_study_executive_summary.pdf>.

Brattle Group, 2002. The Economic Impact of an EU-US Open Aviation Area, at <http://www.brattle.com/_documents/Publicatinos/ArticleReport2198.pdf>.

Button, K., Taylor, S., 2000. International Air Transportation and Economic Development. Journal of Air Transport Management 6, 209-222.

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

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

Fitz Gerald, J., Tol, R.S.J., 2007. Aviation in the European Trading System of Carbon Dioxide Emission Permits. CESIfo Forum, 1/2007, 51-54.

Gillen, D.W., Morrison W.G., Stewart C., 2004. Air Travel Demand Elasticities: Concepts, Issues, Measurement, at <http://www.fin.gc.ca/consultresp/Airtravel/airtravStdy_e.html>.

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

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

Janić, M., 1999. Aviation and Externalities: the accomplishments and problems. Transportation Research Part D, 4, 159-180.

Mayor, K., Tol, R.S.J., 2007. The Impact of the UK Aviation Tax on Carbon Dioxide Emissions and Visitor Numbers. Transport Policy, 14 (6), 407-513.

Mayor, K., Tol, R.S.J., 2008. The Impact of the EU-US Open Skies Agreement on International Travel and Carbon Dioxide Emissions. Journal of Air Transport Management, 14, 1-7.

Nakicenovic, N., Swart, R.J., 2001. IPCC Special Report on Emissions Scenarios. Cambridge University Press, Cambridge.

Njegovan, N., 2006. Elasticities of Demand for Leisure Air Travel: A System Modelling Approach. Journal of Air Transport Management 12, 33-39.

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

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

Schipper, Y. 2004. Environmental costs in European aviation. Transport Policy, Volume 11, Issue 2, April 2004, Pages 141-154.

Schipper, Y., Rietveld, P., Nijkamp, P. (2001). Environmental externalities in air transport markets. Journal of Air Transport Management, Volume 7, Issue 3, May 2001, Pages 169-179.

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.

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.

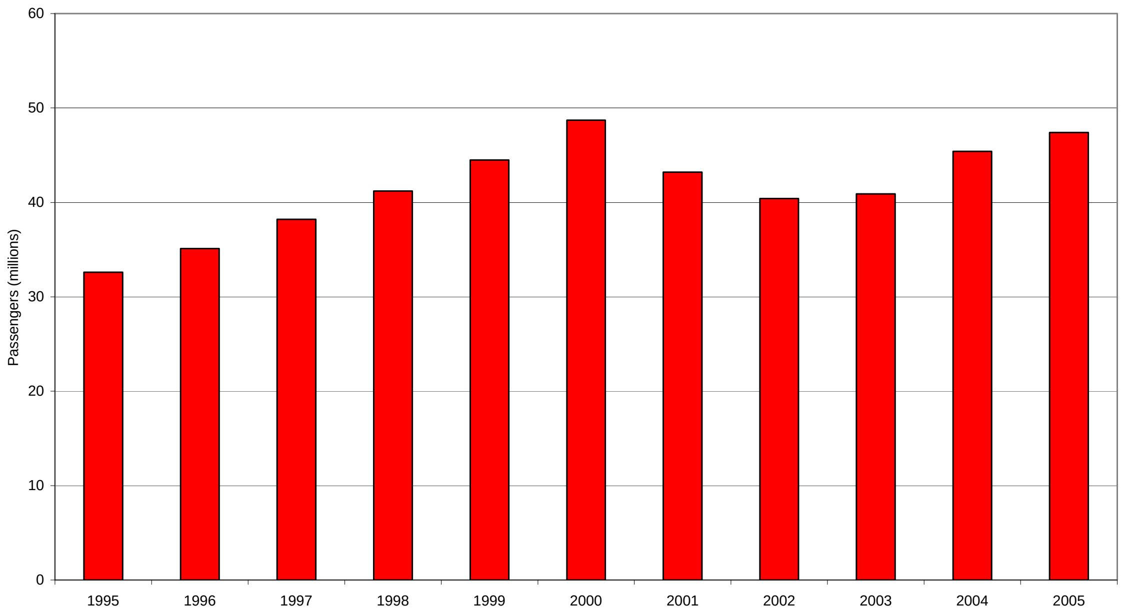

Figure 1. EU-US Passenger traffic between 1995 and 2005 (adapted from Brattle, 2002).

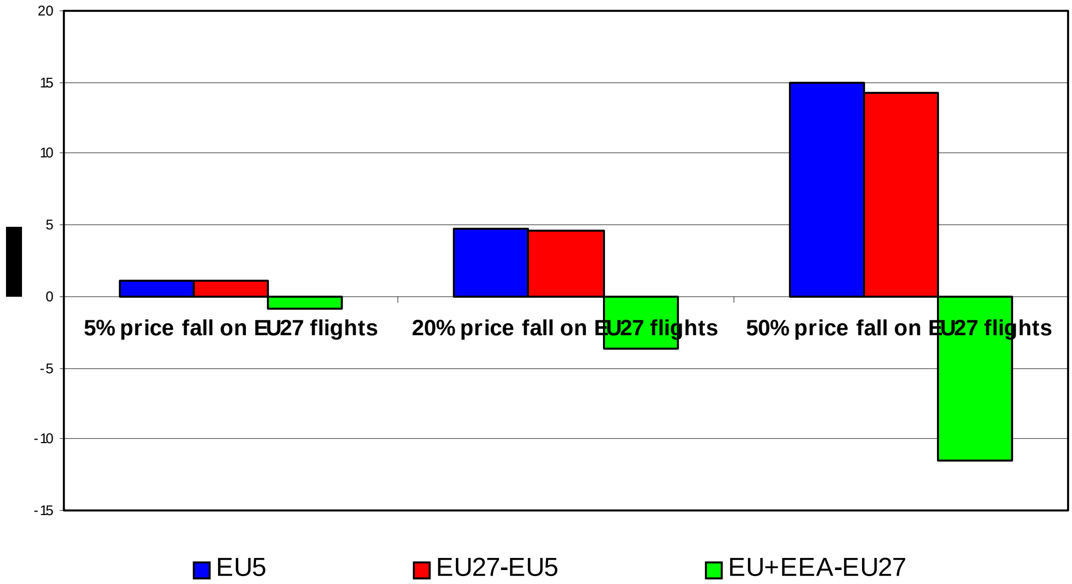

Figure 2. Effect of 5%, 20% and 50% falls in the cost of flights to the EU27 countries on arrivals in the EU5, EU27-EU5 and EU+EEA-EU27 zones from the US

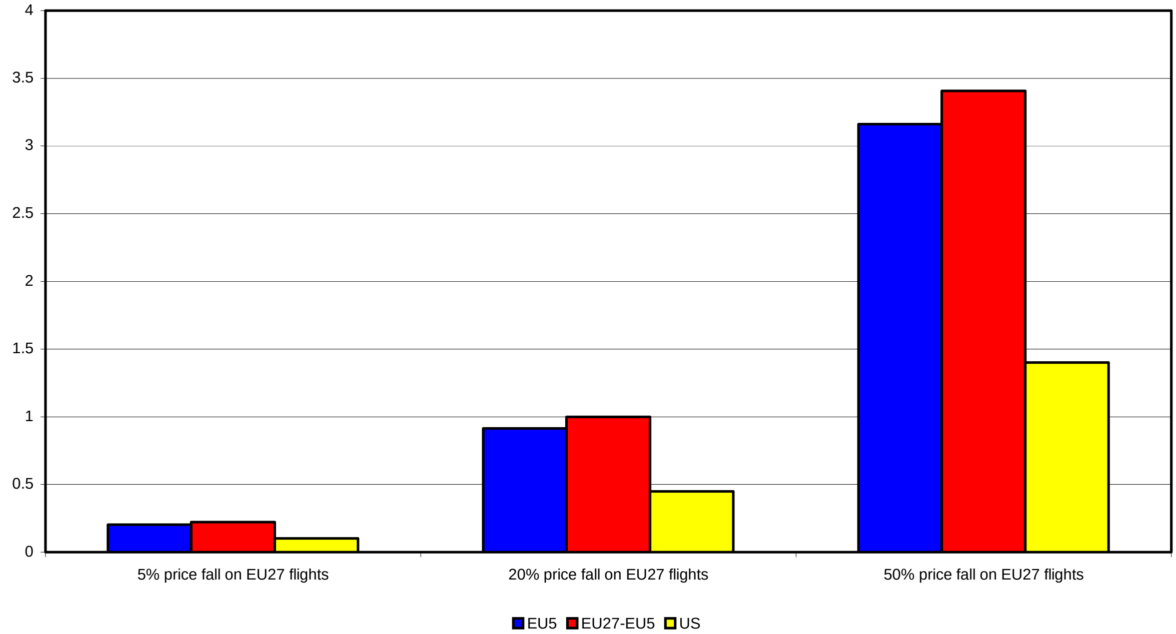

Figure 3. Effect of 5%, 20% and 50% falls in the cost of flights to the EU27 countries on emissions from the EU5, EU27-EU5 and US

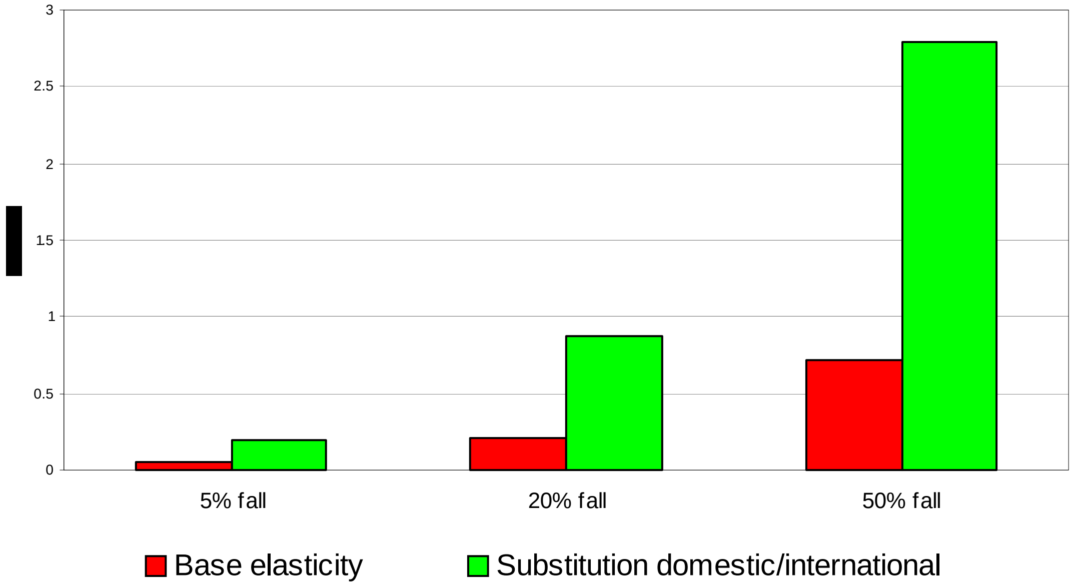

Figure 4. Percentage increase in world CO2 emissions under different price reduction scenarios for EU27 flights, for the base elasticity scenario and the scenario with substitution between domestic and international travel

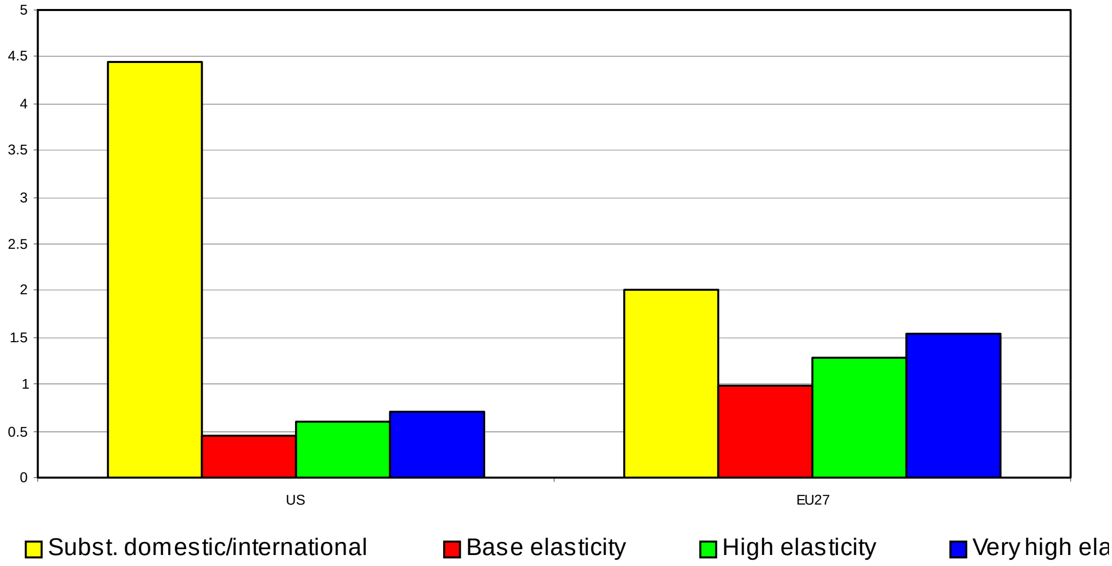

Figure 5. Effect of a 20% fall in the price of flights to the EU27 on emissions from the US and on emissions from the EU27, using different elasticity and domestic/international substitution conditions.

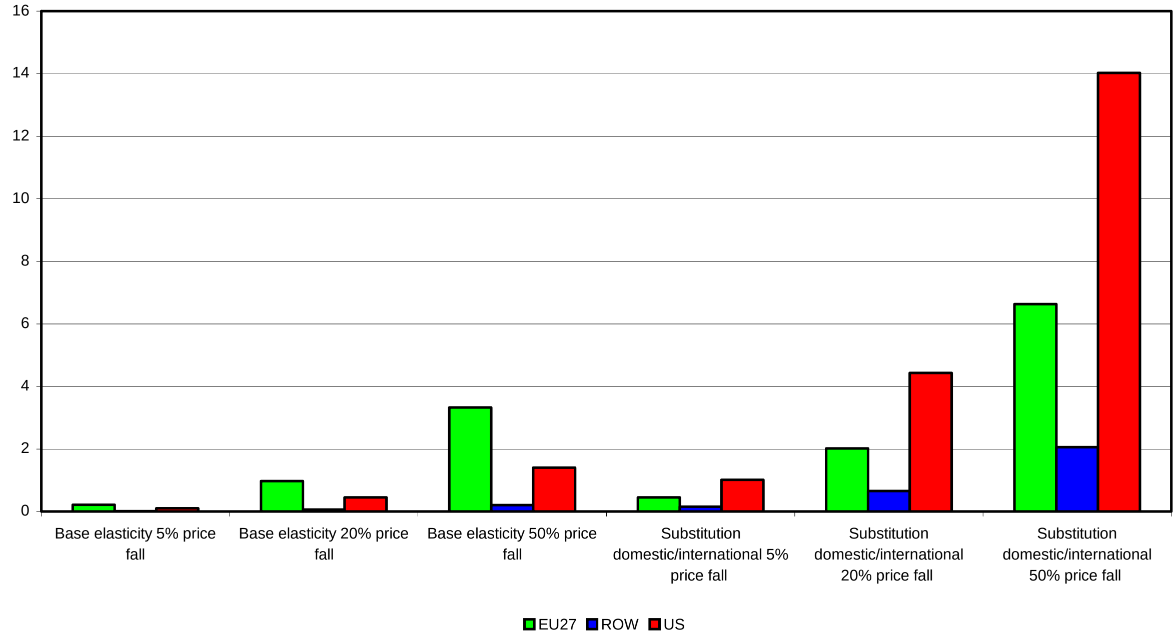

Figure 6. Change in emissions from the US and the EU27 under different price reductions for EU27 flights, for the base elasticity scenario and the scenario with substitution between domestic and international travel

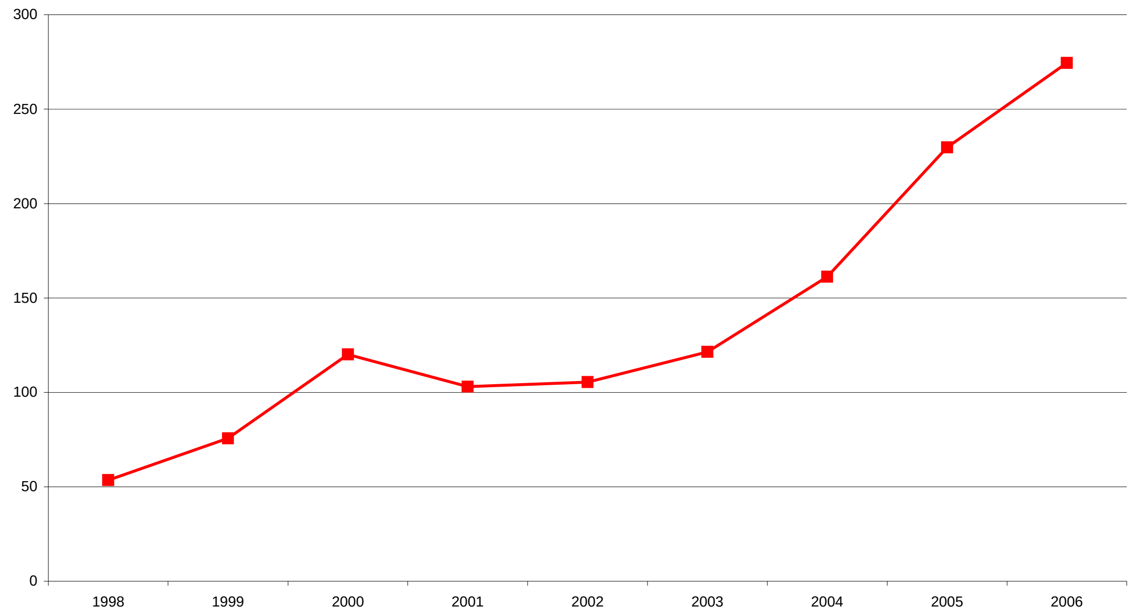

Figure 7. Index of oil prices, 1998-2006, in USD/bbl, source: International Energy Agency.

Year	Number	Title/Author(s) ESRI Authors/Co-authors *Italicised*
2008	239	Yuppie Kvetch? Work-life Conflict and Social Class in Western Europe *Frances McGinnity* and *Emma Calvert*
	238	Immigrants and Welfare Programmes: Exploring the Interactions between Immigrant Characteristics, Immigrant Welfare Dependence and Welfare Policy *Alan Barrett* and Yvonne McCarthy
	237	How Local is Hospital Treatment? An Exploratory Analysis of Public/Private Variation in Location of Treatment in Irish Acute Public Hospitals *Jacqueline O'Reilly* and *Miriam M. Wiley*
	236	The Immigrant Earnings Disadvantage Across the Earnings and Skills Distributions: The Case of Immigrants from the EU's New Member States in Ireland *Alan Barrett*, *Seamus McGuinness* and *Martin O'Brien*
	235	Europeanisation of Inequality and European Reference Groups *Christopher T. Whelan* and *Bertrand Maître*
	234	Managing Capital Flows: Experiences from Central and Eastern Europe Jürgen von Hagen and *Iulia Siedschlag*
	233	ICT Diffusion, Innovation Systems, Globalisation and Regional Economic Dynamics: Theory and Empirical Evidence Charlie Karlsson, Gunther Maier, Michaela Trippl, *Iulia Siedschlag,* Robert Owen and *Gavin Murphy*
	232	Welfare and Competition Effects of Electricity Interconnection between Great Britain and Ireland *Laura Malaguzzi Valeri*
	231	Is FDI into China Crowding Out the FDI into the European Union? Laura Resmini and *Iulia Siedschlag*
	230	Estimating the Economic Cost of Disability in Ireland John Cullinan, Brenda Gannon and *Seán Lyons*
	229	Controlling the Cost of Controlling the Climate: The Irish Government's Climate Change Strategy Colm McCarthy, *Sue Scott*

	228	The Impact of Climate Change on the Balanced-Growth-Equivalent: An Application of *FUND* David Anthoff, *Richard S.J. Tol*
	227	Changing Returns to Education During a Boom? The Case of Ireland *Seamus McGuinness*, *Frances McGinnity, Philip O'Connell*
	226	'New' and 'Old' Social Risks: Life Cycle and Social Class Perspectives on Social Exclusion in Ireland *Christopher T. Whelan* and *Bertrand Maître*
	225	The Climate Preferences of Irish Tourists by Purpose of Travel *Seán Lyons, Karen Mayor* and *Richard S.J. Tol*
	224	A Hirsch Measure for the Quality of Research Supervision, and an Illustration with Trade Economists *Frances P. Ruane* and *Richard S.J. Tol*
	223	Environmental Accounts for the Republic of Ireland: 1990-2005 *Seán Lyons, Karen Mayor* and *Richard S.J. Tol*
2007	222	Assessing Vulnerability of Selected Sectors under Environmental Tax Reform: The issue of pricing power *J. Fitz Gerald*, M. Keeney and *S. Scott*
	221	Climate Policy Versus Development Aid *Richard S.J. Tol*
	220	Exports and Productivity – Comparable Evidence for 14 Countries *The International Study Group on Exports and Productivity*
	219	Energy-Using Appliances and Energy-Saving Features: Determinants of Ownership in Ireland Joe O'Doherty, *Seán Lyons* and *Richard S.J. Tol*
	218	The Public/Private Mix in Irish Acute Public Hospitals: Trends and Implications *Jacqueline O'Reilly* and *Miriam M. Wiley*
	217	Regret About the Timing of First Sexual Intercourse: The Role of Age and Context *Richard Layte*, Hannah McGee
	216	Determinants of Water Connection Type and Ownership of Water-Using Appliances in Ireland Joe O'Doherty, *Seán Lyons* and *Richard S.J. Tol*

215 Unemployment – Stage or Stigma?
Being Unemployed During an Economic Boom
Emer Smyth

214 The Value of Lost Load
Richard S.J. Tol

213 Adolescents' Educational Attainment and School Experiences in Contemporary Ireland
Merike Darmody, Selina McCoy, Emer Smyth

212 Acting Up or Opting Out? Truancy in Irish Secondary Schools
Merike Darmody, Emer Smyth and *Selina McCoy*

211 Where do MNEs Expand Production: Location Choices of the Pharmaceutical Industry in Europe after 1992
Frances P. Ruane, Xiaoheng Zhang

210 Holiday Destinations: Understanding the Travel Choices of Irish Tourists
Seán Lyons, Karen Mayor and *Richard S.J. Tol*

209 The Effectiveness of Competition Policy and the Price-Cost Margin: Evidence from Panel Data
Patrick McCloughan, *Seán Lyons* and William Batt

208 Tax Structure and Female Labour Market Participation: Evidence from Ireland
Tim Callan, A. Van Soest, *J.R. Walsh*

207 Distributional Effects of Public Education Transfers in Seven European Countries
Tim Callan, Tim Smeeding and Panos Tsakloglou