THE ENVIRONMENTAL IMPACTS OF INCREASED INTERNATIONAL AIR TRANSPORT – PAST TRENDS AND FUTURE PERSPECTIVES

Eric Pels
VU University
Department of Spatial Economics
De Boelelaan 1105 1081HV
Amsterdam

Introduction

- Environmental impact of air travel gets a lot of attention in the media as well as in the policy debates.
- Climate change, environmental and economic damage.
- Air travel causes external effects, which need to be accounted for in the price of air travel.

Objective

- Review the literature on the environmental impact of aviation.
- Discuss trends in emission patterns.
- See how the external cost of aviation is determined in various studies.

Outline

- Developments in the aviation sector since the Second World War
- Literature on the environmental impact of aviation
- Conclusion

Developments in aviation markets.

- Air traffic causes emissions.
- Understanding drivers of air traffic helps to understand trends in emissions.
  - Economic developments.
  - Policy developments.
  - Technical developments.

Economic developments.

	North America		Europe		China		Southwest Asia	
	1987-2006	2007-2026	1987-2006	2007-2026	1987-2006	2007-2026	1987-2006	2007-2026
GDP growth rate	3.2%	2.8%	2%	2.1%	9.9%	6.6%	5.6%	5.7%
RPK growth rate	4.1%	4.0%	5.7%	4.2%	11.0%	8.0%	6.2%	6.9%
GDP-to-RPK multiplier	1.3	1.4	2.9	2.0	1.1	1.2	1.1	1.2

Table 1 GDP and Revenue Passenger Kilometres annual growth rates
Source: Boeing Aircraft Company (2007).

Economic developments.

- IATA: aviation contributed US$ 3.557 billion to global economy in 2007 (7.5% of world GDP)
  - Measurement?
- Airlines, suppliers, economic activity made possible by aviation.
- Button and Taylor (2000): areas surrounding U.S. hubs internally generated relatively more employment than non-hubs.

Airline network development.

- Aviation markets deregulated in 1978 (U.S.), 1980s-1990s (E.U.).

- Deregulation led to lower fares.
  - Decline in fares from 1976 to 1985: savings of $11 billion U.S. to passengers in 1986 (Kahn, 1988)
  - Increase in demand.

Airline network development.

- Deregulation led to adoption of hub-spoke networks.
  - Exploit density economies.
  - Formation of fortress hubs.
    - Competition in spoke markets limited: anti-competitive effect on ‘thin’ markets.
    - Strong competition on hub-hub markets and indirect markets.
  - Formation of alliances.
- Concentration.

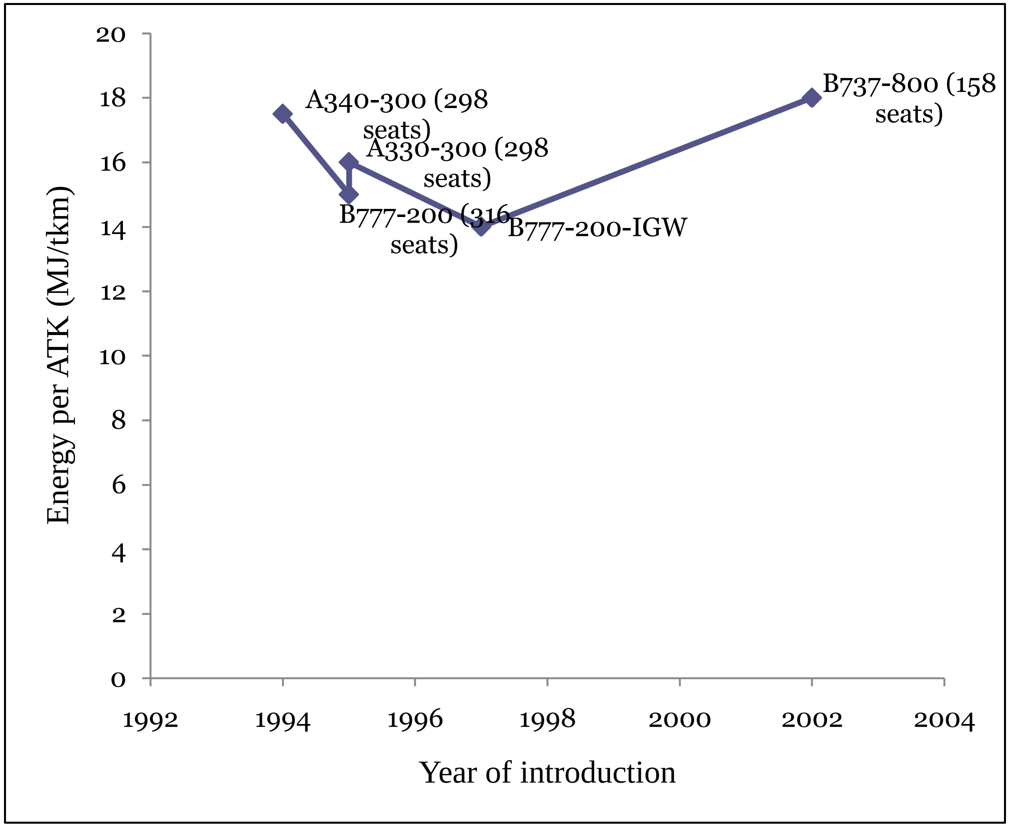
Technological developments.

- Jet engines.
  - Much faster travel.
    - Generalised cost of travel decreases: demand increases.
  - Increased fuel consumption.
    - Generalised cost increases.
- Wide bodies.
  - More seats per aircraft; cost per seat decreases (density economies).

Technological developments.

- Jet engines.
  - Increased fuel consumption.
    - Fuel efficiency increased over time.
      - Increase in fuel efficiency of 70% between 1960 and 2000 (IATA, Penner et al., 1999).
      - Peeters *et al*. (2005): fuel efficiency increased with 55% if Boeing 707 is reference rather than De Havilland Comet 4.
      - Peeters *et al*. (2001): technological developments in last decades mostly for small and medium sized aircraft.
      - New aircraft (latest B777 and A380) allow for gains in long haul markets.

Technological developments.



Environmental effects of aviation.

- Growth and the environment.
  - Demand for aviation will continue to grow faster than GDP.
  - De Haan (2007):
    - Most pessimistic *economic* scenario: air travel in 2050 2.5 times 2004 level.
    - Most optimistic *economic* scenario: 9 times 2004 level.
    - GDP growth, maturation of aviation markets, network development.
    - Technological developments to reduce CO2 not enough to compensate for demand increases.

Environmental effects of aviation.

CO_2 emissions calculated for each case for years 2002 and 2030.
Source: Horton (2006). Tg = teragrams (tonnes*10^6)

	CO_2 emissions 2002 (Tg)	CO_2 emissions 2030 (Tg)	Ratio of CO_2 emissions to 2002
Case 1	489.29	1609.74	3.290
Case 2	489.29	1395.06	2.851
Case 3	489.29	1247.02	2.549
Case 4	489.29	1100.15	2.248
Case 5	489.29	969.96	1.982

Case 1: No technology improvements to fuel efficiency
Case 2: 2005 and 2008 best available technology: Boeing 787/Airbus 350/Airbus 380 technology levels
Case 3: Fuel efficiency improvements (1.3% per annum to 2010, 1.0% per annum to 2020, 0,5% per annum beyond)
Case 4: Fuel efficiency improvements as in 3, with additional efficiency improvements driven by a $50 per tonne CO_2 cost.
Case 5: Fuel efficiency improvements as in 3, with additional efficiency improvements driven by a $100 per tonne CO_2 cost.

Environmental effects of aviation.

- Total distance increases by 149% from 2002 to 2030
- Available seat-kilometres: 229% increase (aircraft size increases).
- In environmentally positive scenario (5) CO_2 emissions in 2030 22% lower compared to scenario 3 (no incentives for technological development).
- In environmentally favourable scenario CO_2 emissions twice as high in 2030 compared to 2002.
- Technological developments cannot compensate for increased demand

Environmental effects of aviation.

- Long term predictions of traffic demand and emissions uncertain: unpredictable changes in demand and technological innovations.
- Some IPCC assumptions:
  - fuel prices will not increase significantly relative to other costs
  - infrastructure can accommodate all demand
  - there are no significant impacts from other modes, such as high speed rail.

Environmental effects of aviation.

Long term emissions from aviation, Tg

	FESG FC1 2050	FESG FE2 2050	DTI 2050	EDF IS92c 1990	EDF IS92c 2050	EDF IS92e 1990	EDF IS92e 2050
Fuel use (Tg)	253.8	757.7	633.2	179	837	179	2297
CO2	218.2	651.6		154	720	154	1975
NOx	3.9	8.7	4.45	1.96	5.77	1.96	15.84

Source: Penner *et al*. (1999).

Environmental effects of aviation.

- FESG:
  - High (Fe) and low (FC) economic scenarios; based on IPCC.
  - Technology scenarios:
    - NOx reductions result from current design philosophies (scenario 1),
    - More aggressive approach to NOx reductions result in smaller fuel efficiency gains (scenario 2).
- DTI:
  - Own forecast models for traffic predictions.
  - Extrapolates Greene (1992) for fuel efficiency.
  - Strong assumptions on reductions in NOx-emissions.
- EDF
  - IPCC scenarios for economic indicators and emissions
  - Greene (1992) for fuel efficiency; strong assumptions on NOx.

Environmental effects of aviation.

Average external costs.

	shadow price for climatic impact of per tonne CO_2-equivalent		
	€ 10	€30	€ 50
Fleet–average technology, in € ct per passenger-kilometre			
50 seats, 200 km	5.7	6.4	7.0
100 seats, 500 km	1.8	3.0	4.2
200 seats, 1500 km	0.7	1.5	2.2
400 seats, 6000 km	0.3	0.7	1.1
State–of–the–art technology, in € ct per passenger-kilometre			
50 seats, 200 km	2.8	3.3	3.9
100 seats, 500 km	1.2	2.2	3.3
200 seats, 1500 km	0.5	1.1	1.8
400 seats, 6000 km	0.2	0.5	0.9

Source: Based on Dings *et al.* (2003)

Environmental effects of aviation.

- Hub-spoke networks.
  - Concentration.
    - Noise
    - Large aircraft used for long distance: environmental economies of scale.
  - Peeters *et al.* (2001):
    - point-to-point networks have lowest environmental impact
      - even though larger aircraft may be used in hub-spoke networks
      - *no* environmental economies of scale
        - technological developments in the last decades were mostly made for small and medium sized aircraft.
        - results may change when technological progress is made with large aircraft
    - hubs have larger environmental impacts than non-hub airports
    - the number of hubs (in Europe) and the geographical distribution have a strong influence on the environmental impact of the total network.
    - Nero and Black (1998) also find that hubbing increases external cost.

Environmental effects of aviation.

- Morell and Lu (2000):
  - empirical case-study social costs of aircraft noise (via decline in property values) in Amsterdam Schiphol area.
  - Average social noise cost in 1999: €326.8 per landing.
  - Current noise charges €157.3 per landing.
- Morrison *et al*. (1999)
  - economic assessment of the benefits (higher property values for homeowners) and costs (airplane's reduced economical life) 1990 ANCA (Airport Noise and Capacity Act).
  - 5 billion (1995 dollars) benefits and 10 billion (1995 dollars) costs.

Conclusion.

- Strong growth in aviation demand
  - Expected to continue in long run.
- Deregulation:
  - Stimulates demand.
  - Network changes: (local) environmental effects.
- Expected emissions
  - Increase depends on scenario
    - Economy
    - Technology
    - Long run: many uncertainties.
- Technological developments cannot compensate for increased demand.