An Analysis of the Impact of Aircraft Lifecycles on Aviation Emissions Mitigation Policies

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Introduction

• Strategies to reduce aviation emissions often include introduction of new technology
  ❑ E.g. Open rotor engines, BWBs, ACARE targets

• Implementation affected by fleet turnover
  ❑ Greater timescale than for economic/operational policy measures

• Useful to look at historical data on fleet composition
  ❑ Investigate which factors affect emissions reduction timescales
  ❑ Estimate simple models where possible
  ❑ Consider effect on policymaking
RPK and emissions

- Historical strong growth in RPK (5.7%/year 1975-2005)
- Fuel burnt per RPK has declined (0.5-1.5%/year depending on type) → emissions growth slower

[Data: IEA]
Global Fleet

- Fleet growth 1975-2005: 3.5% per year
  - Average aircraft size has increased
  - Growth in RPK $\rightarrow$ more aircraft purchased to serve new demand than as replacements for retirements

[Data: Aviation Link Fleet Database]
Aircraft Entering the Fleet

• When are aircraft purchased?
  - Orders peak during periods of airline profit/expansion
  - ~10-year economic cycles → potential delay if technology policy applied at wrong point in cycle
  - Sensitivity tests suggest effect is small
Aircraft Entering the Fleet

[Narrowbody]

- Entering fleet
- New orders
- Cancelled orders
- Retirements

[Data: Aviation Link Fleet Database]
Aircraft Entering the Fleet

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Aircraft Entering the Fleet

• When are aircraft purchased?
  - Orders peak during periods of airline profit/expansion
  - ~10-year economic cycles → potential delay if technology policy applied at wrong point in cycle
  - Sensitivity tests suggest this effect is small

• Which aircraft are purchased?
  - Choice of aircraft available can be influenced by R&D-based policy (e.g. subsidies)
  - Airlines’ choice of aircraft from those available depends on many factors
    ▪ Potential fuel cost savings not necessarily the most important
Aircraft Entering the Fleet

- No unambiguous relationship between historical technology choice and fuel price
  - Model as simple function of available aircraft fuel burn range

![Graph showing fuel burn range over years](image-url)
Aircraft Entering the Fleet

- No unambiguous relationship between historical technology choice and fuel price
  - Model as simple function of available aircraft fuel burn range

![Graph showing sample mission fuel use, kg per RPK over years from 1970 to 2000. The graph compares average (fleet), average (new orders), and the model for widebody aircraft. Data: BADA, Aviation Link Fleet Database.]
Aircraft Entering the Fleet

- No unambiguous relationship between historical technology choice and fuel price
  - Model as simple function of available aircraft fuel burn range

![Graph showing sample mission fuel use for aircraft over years, with data from BADA, Aviation Link Fleet Database. The graph plots fuel burn range against years from 1970 to 2000, with a trend line showing a decrease in fuel use over time for 100 Seats.]
Retirements

- Aircraft lifetimes around 30 years
- Retirement behaviour remarkably consistent over time...
Retirement Curves

[Data: Aviation Link Fleet Database]
Retirements

- Aircraft lifetimes around 30 years
- Retirement behaviour remarkably consistent over time... apart from 1960-1965 manufactured narrowbodies
  - Replaced in early 1980s
  - Not due to noise regulations – very few were Stage 1
  - Likely due to combination of effects
    - US recession → difficult to sell second-hand
    - New aircraft models available with much lower fuel burn
    - High fuel price
- Reducing historical peak retirement age by 1 year → 2005 emissions 0.35% lower (for same RPK)
Changes to Operating Aircraft

[Data: Aviation Link Fleet Database]
Changes to Operating Aircraft

Several possibilities:

• Retrofits to reduce fuel use and costs
  - E.g. Winglets, re-engining, engine upgrade kits, etc.
  - Often limited applicability and/or cost-effectiveness
    - E.g. Very few historical re-enginings

• Freighter conversion, hushkitting
  - Can extend life of older aircraft – higher emissions?
  - If all historical freighters were bought new → 0.9% lower emissions in 2005
    - However, this is not a realistic scenario at current costs

• Storage
Conclusions & Policy Interventions

• Changing fuel price within limits of past variation
  - Study suggests only small effect on fleet
  - Similar to behaviour of other transport modes

• Environmental landing charges
  - Minimal effect (e.g. ICAO 2007)

• Changing available-for-purchase aircraft types
  - Does affect fleet fuel burn
  - If post-1960 decrease of best-available new aircraft fuel burn/RPK per year was 0.1% greater → emissions savings of around 1.5% now
  - Long timescales
  - A320/737 replacement most important
Conclusions & Policy Interventions

• Influencing retirements
  - Fast-growing fleet – retirements are relatively unimportant compared to demand for new aircraft
  - Historical analysis suggests good candidate replacement aircraft needed
  - Relatively short timescale

• Retrofits
  - Historically only a small effect on emissions
    - E.g. 0.1% lower global fuel burn due to all historical re-enginings
  - Limited applicability
  - Relatively short timescale
Questions?