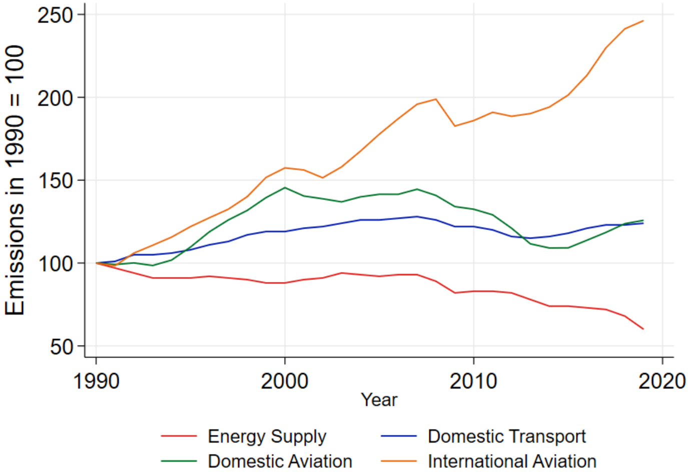
Carbon Cost Pass-Through in European Aviation

Evidence from low-cost airlines

Adrián Santonja, Jordi Teixidó & Aleksandar Zaklan

Aviation CO_2 emissions are rising quickly



Source: European Environmental Agency

Motivation

- Transport decarbonization is lagging behind other sectors

→ sector is increasingly drawing the attention of policymakers

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- Air transport stands out as particularly challenging due to
  1. sector's growth path
  2. its international nature
  3. the release of non-CO_2 emissions at high altitudes
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- European flights included under EU ETS, but unclear to what extent consumers receive the carbon price signal due to a potential lack of pass-through
- Carbon cost pass-through would imply windfall profits for European airlines from free allocation of EUAAs

Literature

The intersection of three fields of empirical research:

1. EU ETS and the aviation sector (Fageda and Teixidó 2022; Jong 2022; Kang et al. 2022)
2. Fuel cost and tax pass-through in aviation (Bernardo et al. 2022; Bradley and Feldman 2020; Cannon and Watanabe 2020; Gayle and Lin 2021; Wolter et al. 2021)
3. Carbon cost pass-through
   - under the EU ETS (Cludius et al. 2020; Duso and Szücs 2017; Fabra and Reguant 2014; Hintermann 2016)
   - in transportation (Erutku 2019; Knittel et al. 2015; Stitzing 2017)

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→ No study on the carbon cost pass-through in aviation

This paper

? Research Question

- What is the degree of carbon cost pass-through in European aviation under the EU ETS?
- Does carbon cost pass-through differ by market structure?

Data

- Granular route by airline level data on schedules and fares
- Restriction to 2017-2019 and focus on two low-cost airlines (Ryanair & easyJet)

Results

- Full carbon cost pass-through on average
- No conclusive pattern on differences across market structures

The EU ETS and aviation

- Aviation included in 2012 as the first non-stationary sector
  - *Stop-the-clock* decision restricted coverage to within EEA flights
  - Range of exceptions at the route and operator level
- 80% of the baseline allowance volume is allocated for free
  - Sector growth over time → aviation as a net buyer of allowances
  - Around half of total emissions of the sector are covered through purchased allowances

Three main data sources

1. Data on flight schedules (RDC)
2. Data on fares (RDC)
3. Input prices (Bloomberg)
   - EU ETS allowance price
   - New York Harbor kerosene spot price

Flight schedules

Total flights and seats for routes landing/departing in Europe by

- origin and destination airport
- month-of-sample
- airline (categorized into network, low-cost and other)
- aircraft type

→ includes estimate of CO_2 emissions (or equivalent fuel consumption)

Final dataset aggregated to the month-route-airline level

→ Number of seats from London-Heathrow to Barcelona-El Prat in October 2017 with Ryanair

Flight ticket prices

Average economy class fare for routes landing/departing in Europe by

- origin and destination airport
- month-of-sample
- airline (Fare coverage)
- time-of-sale (three months ahead, one month ahead, one week ahead, weighted average)

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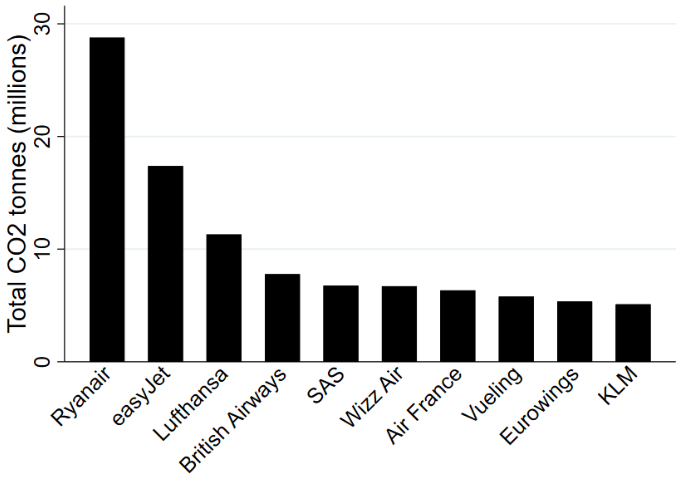
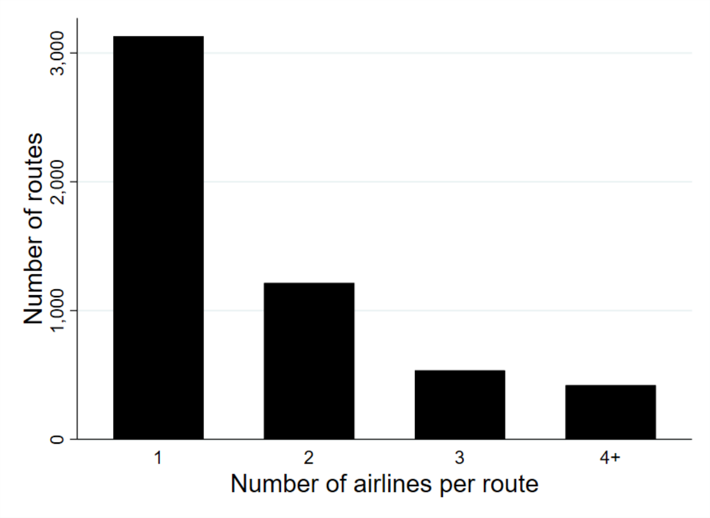
→ Restrict sample to most two prominent airlines catering to point-to-point travellers

1. Ryanair (31% of total low-cost seats)
2. easyJet (20% of total low-cost seats)

Low-cost airlines among top CO_2 emitters

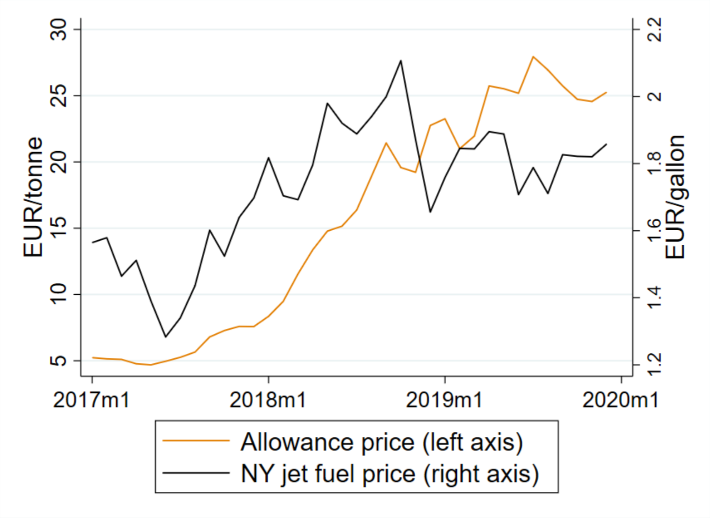


Low-cost airlines face highly concentrated markets



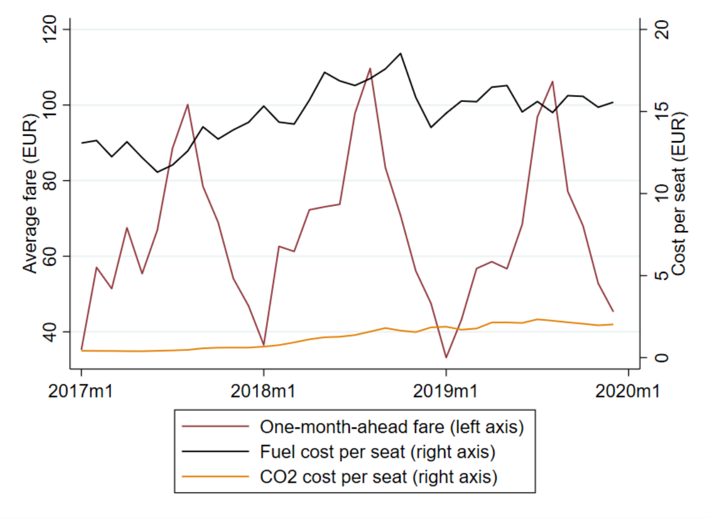
▸ HHI

CO_2 prices experienced sharp increase during sample period



Price evolution 2013-2022

CO_2 costs only small fraction of fares



▸ CO_2 cost distribution ▸ Fuel cost distribution

Theoretical background

Competition in the aviation sector (Koopmans and Lieshout 2016)

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Equilibrium pass-through rate of sector-wide price shock (Koopmans and Lieshout 2016; Weyl and Fabinger 2013)

- Monopoly: $\rho = \frac{1}{1+\frac{\epsilon_D - 1}{\epsilon_S}+\frac{1}{\epsilon_{ms}}}$
  - ➢ Constant MC + linear demand ($\epsilon_{ms} = 1$): $\rho = 0.5$
  - ➢ Constant MC + constant elasticity demand ($\epsilon_{ms} = -\epsilon_D$): $\rho > 1$
  - ➢ In general: $\uparrow |\epsilon_D|$ leads to $\downarrow \rho$

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  - ➢ In general: $\uparrow |\epsilon_D|$ leads to $\downarrow \rho$
- Symmetric imperfect competition: $\rho = \frac{1}{1+\frac{\theta}{\epsilon_\theta}+\frac{\epsilon_D - \theta}{\epsilon_S}+\frac{\theta}{\epsilon_{ms}}}$
  - ➢ Constant MC + constant conduct parameter θ + linear demand or constant elasticity demand: $\uparrow$ competition leads to $\uparrow \rho$

Identification strategy

- We follow Fabra and Reguant 2014 in instrumenting costs per seat with monthly fuel price and monthly allowance price
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  3. Full load factors as a good approximation to reality

Empirical model

$$y_{iat} = \beta_0 + \delta_1 fuel_{iat} + \delta_2 co2_{iat} + X_{iat} + \mu_{ta} + \lambda_{ia} + \epsilon_{iat}$$

- y_{iat} – average one-month-ahead fare in month-of-sample t for route i and airline a
- $fuel_{iat}$ – contemporaneous fuel cost per seat
  - instrumented with fuel price (by distance)
- $co2_{iat}$ – contemporaneous (opportunity) cost of CO_2 per seat
  - instrumented with allowance price (by distance)
- X_{iat} – vector of controls
  - yearly population and income at origin and destination
  - competition intensity (HHI, only low-cost, market share)
- μ_{ta} – year or year by airline fixed effects
- λ_{ia} – airline by route fixed effects

First Stage

	Fuel cost per seat				CO_2 cost per seat			
Jet fuel price	1.646***	1.646***	1.620***	1.620***	-0.001	-0.001	-0.003	-0.003
	(0.02)	(0.02)	(0.02)	(0.02)	(0.00)	(0.00)	(0.00)	(0.00)
Jet fuel price × Distance	0.005***	0.005***	0.005***	0.005***	0.000**	0.000**	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Allowance price	0.003**	0.003**	0.004***	0.004***	0.016***	0.016***	0.016***	0.016***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Allowance price × Distance	-0.000***	-0.000***	-0.000***	-0.000***	0.000***	0.000***	0.000***	0.000***
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Route by Airline FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No	Yes	Yes	No	No
Year by Airline FE	No	No	Yes	Yes	No	No	Yes	Yes
Pop. & Income controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Competition controls	No	Yes	No	Yes	No	Yes	No	Yes
Observations	128300	128300	128300	128300	128300	128300	128300	128300

Standard errors in parentheses
$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

- F-Statistic above Stock & Yogo critical value for 5% maximal IV relative bias

Main results: average pass-through rate

	Average one-month-ahead fare				
	OLS	IV			
Fuel cost	0.52***	0.50***	0.53***	0.51***	0.53***
	(0.11)	(0.11)	(0.11)	(0.11)	(0.11)
CO2 cost	1.19**	1.19**	1.12*	1.40**	1.32**
	(0.46)	(0.46)	(0.46)	(0.46)	(0.46)
Route by Airline FE	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	No
Year by Airline FE	Yes	No	No	Yes	Yes
Pop. & Income controls	Yes	Yes	Yes	Yes	Yes
Competition controls	Yes	No	Yes	No	Yes
Observations	128300	128300	128300	128300	128300

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Pass-through rate by market structure

	Average one-month-ahead fare									
	Non-Monopoly					Monopoly				
	OLS	IV				OLS	IV			
Fuel cost	1.04***	0.95***	1.01***	0.94***	1.01***	0.24	0.17	0.17	0.17	0.17
	(0.18)	(0.18)	(0.18)	(0.18)	(0.18)	(0.15)	(0.14)	(0.14)	(0.14)	(0.14)
CO2 cost	0.97	1.29+	1.09	1.34+	1.13	1.31*	0.97	0.97	1.41*	1.41*
	(0.72)	(0.72)	(0.73)	(0.71)	(0.72)	(0.62)	(0.60)	(0.60)	(0.62)	(0.62)
Route by Airline FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	No	No	No	Yes	Yes	No	No
Year by Airline FE	Yes	No	No	Yes	Yes	Yes	No	No	Yes	Yes
Pop. & Income controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Competition controls	Yes	No	Yes	No	Yes	Yes	No	Yes	No	Yes
Observations	52640	52640	52640	52640	52640	75660	75660	75660	75660	75660

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Pass-through rate for placebo routes not under EU ETS

	Average one-month-ahead fare			
Fuel cost	1.06***	1.06***	1.27***	1.25***
	(0.27)	(0.27)	(0.28)	(0.28)
CO2 cost	0.02	0.01	-0.35	-0.48
	(1.15)	(1.15)	(1.31)	(1.31)
Route by Airline FE	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	No	No
Year by Airline FE	No	No	Yes	Yes
Pop. & Income controls	Yes	Yes	Yes	Yes
Competition controls	No	Yes	No	Yes
Observations	14237	14237	14237	14237

Standard errors in parentheses

$^{+}$ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Conclusion

🏁 Our findings

- We are the first to analyze carbon cost pass-through in the aviation sector
- Full pass-through on average, likely implying windfall profits from free allocation for airlines
- No conclusive pattern on differences across market structures

🔜 Outlook

- Incorporate demand data at the route-airline level
- Granular definition of competition at route level

Thank you for your attention!

Adrián Santonja

asantonjadifonzo@diw.de

@adrian_santonja

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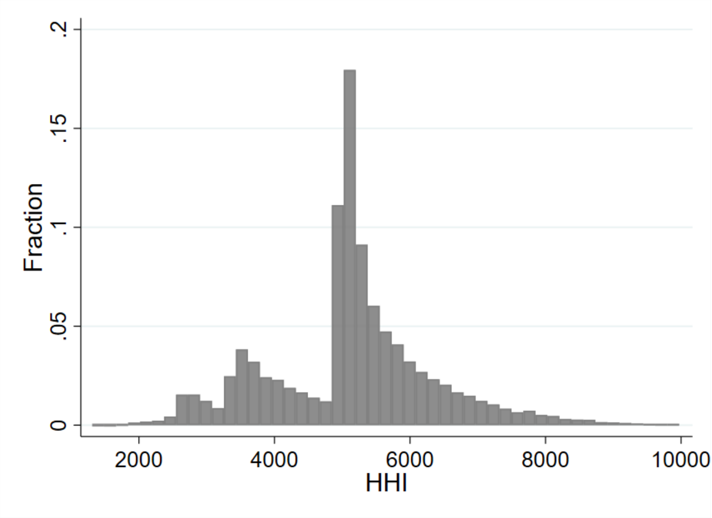
Airline fare coverage

Low-cost airlines	Blue Air, Eurowings, Flybe, Jet2, Laudamotion, Moarch Airlines, Norwegian Air Shuttle, Ryanair, SmartWings, Transavia, Volotea, Vueling, WOW Air, Wizz Air, easyJet
Network airlines	Aegean Airlines, Aer Lingus, Air China, Air France, Alitalia, Austrian, British Airways, Brussels Airlines, CSA, Finnair, Iberia, KLM, LOT Polisch Airlines, Lufthansa, SAS, TAP Air Portugal, TAROM, airberlin
Other airlines	Air Baltic, Air Corsica, Air Malta, Bulgarian Air, CityJet, Hainan Airlines, Hop!, Loganair, Olympic Air

Herfindahl–Hirschman Index for non-monopoly routes



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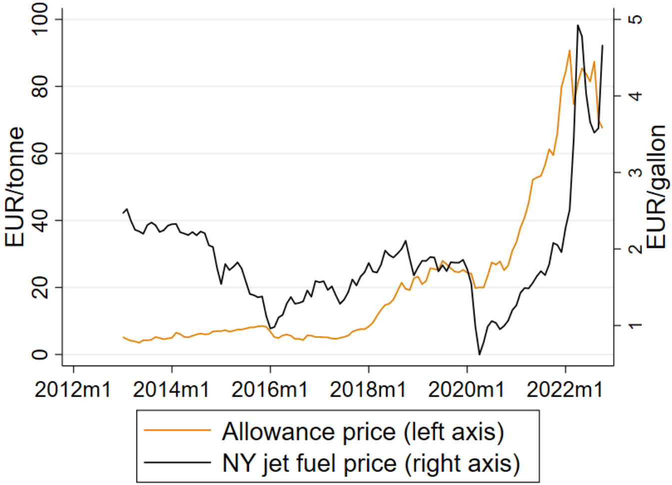
Price evolution 2013-2022



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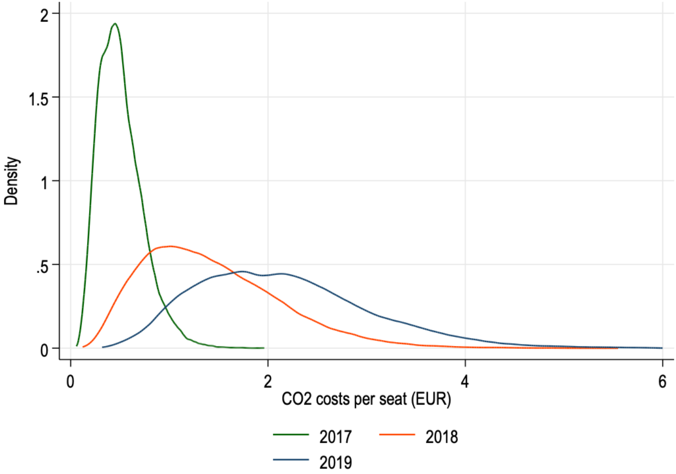
CO_2 cost distribution for low-cost airlines



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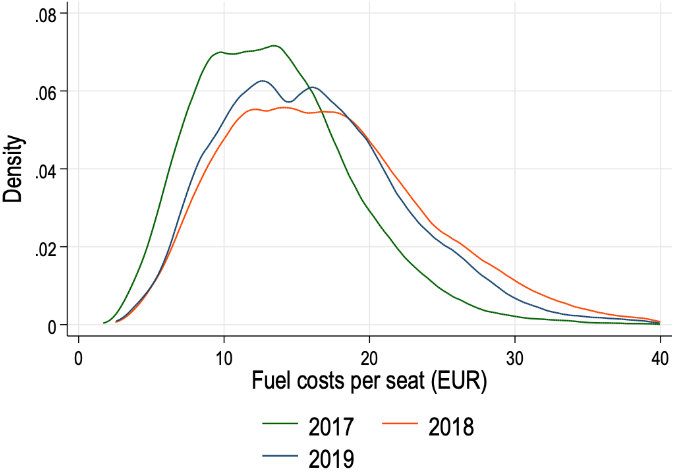
Fuel cost distribution for low-cost airlines



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