

# Aligning the Aviation Industry with Global Climate Goals: The Role of Pricing Mechanisms

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## Introduction

Aviation is still off track in its efforts to meet its global climate objectives. As a hard-to-abate sector, it remains among the world's most carbon-intensive industries. Moreover, its historically intense growth is projected to continue, with global air traffic predicted to more than double its 2019 levels by 2050 (Air Transport Action Group [ATAG] 2021; IATA 2024). Although carbon efficiency in aviation has improved notably, these gains are insufficient to offset the overall increase in CO<sub>2</sub> emissions, which continue to grow in tandem with air traffic volumes. Just as disconcerting, recent studies have shown that CO<sub>2</sub> emissions are not the primary driver of aviation's climate impact. Indeed, non-CO<sub>2</sub> effects, including contrails and nitrogen oxides (NO<sub>x</sub>), have been shown to contribute two to three times more to global warming than CO<sub>2</sub> emissions alone (Lee et al. 2021).

In response, the aviation sector has implemented various climate policies of varying scope and ambition. Among these, pricing instruments have attracted the most attention and remain the most widely adopted policies globally. These instruments include the European Union Emissions Trading System (EU ETS), in which industries are required to purchase tradable permits to emit carbon. Another example is the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), which aims to cap international aviation CO<sub>2</sub> emissions at 2019 levels. There are also various national-level taxes and charges.

Economists have long advocated pricing instruments for reducing emissions. They are cost-effective (Baumol and Oates 1971), stimulate innovation and low-carbon investment

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(Popp 2002), and are efficient in addressing uncertain abatement costs (Weitzman 1974). Moreover, they are a means of raising revenue. Yet public support for such measures is often weak, due in part to perceptions that they are regressive—that is, concerns that they will disproportionately harm those with less income (Carattini, Carvalho, and Fankhauser 2018; Maestre-Andrés, Drews, and van den Bergh 2019; Douenne and Fabre 2022). Public support increases when revenues are recycled toward lower-income households (Metcalf 2009; Carattini, Carvalho, and Fankhauser 2018). How this is achieved, however, is not always credible or clearly communicated in terms of how revenues are to be used or the effectiveness of the pricing instrument itself.

Aviation constitutes a particularly compelling case because demand is highly skewed toward wealthier individuals and nations (O’Garra and Fouquet 2022). Among the world’s highest emitters, aviation-related emissions often represent a significant share of their carbon footprint (Chancel and Piketty 2015). Frequent flyers—who make up no more than 1 percent of the global population—are responsible for more than half the sector’s aviation emissions (Gössling and Humpe 2020). Perhaps because most people are not frequent flyers, flight taxes have larger support than general fossil fuel taxes (Dechezleprêtre et al. 2025). This means that pricing strategies in the industry offer a rare opportunity to be both equitable and environmentally effective.

On the other hand, major tension in the current policy landscape exists between the sector’s pricing instruments—valued for their flexibility and efficiency—and regulatory mandates, such as sustainable aviation fuel (SAF) blending requirements, which are set to gain in importance in coming decades.<sup>1</sup> Although mandates of this kind offer greater certainty because they enforce specific technological shifts, they limit the range of options for mitigating emissions, and they risk imposing higher losses on overall welfare (Proost 2024). Pricing instruments, by contrast, are technology-neutral and allow market actors to identify the least cost abatement strategies. However, regulatory mandates have greater political traction because they shield airlines and fuel suppliers from directly paying carbon taxes or purchasing permits for emissions. This makes them more appealing to stakeholders despite their inefficiency (Proost 2024) and despite uncertainties regarding whether they can be scaled up (Gössling and Humpe 2023). Given aviation growth projections and the need for efficient climate action, this article focuses its attention on pricing instruments as the cornerstone of cost-effective, equitable mitigation in the sector.

In addition, the obvious international nature of aviation makes it especially vulnerable to carbon leakage. When climate policies—especially pricing instruments—are not implemented globally, there is a significant risk that emission reductions within regulated areas are offset by increases elsewhere. In aviation, leakage can occur by rerouting flights, relocating aircraft, and shifting hub operations, as we highlight below in a review of existing empirical evidence on these dynamics.

<sup>1</sup>The ReFuelEU Aviation initiative means suppliers will have to incorporate 2 percent SAFs by 2025, 6 percent by 2030, and 70 percent by 2050. Moreover, as of 2030, 1.2 percent of fuels must also be synthetic, rising to 35 percent in 2050. Norway has imposed a 0.5 percent biofuel obligation since 2020. Similar programs are to be implemented in several countries, including the United States, Brazil, India, and Japan. Likewise, a few countries, notably France and the Netherlands, have introduced capacity restrictions at the airport or route level. Although their impact on direct emissions may be limited, these measures signal a shift toward more assertive climate policies in aviation.

The rest of the article proceeds as follows. The next section presents stylized facts on aviation emissions using airline-route-level data from RDC Aviation. The section “Aviation Mitigation Pathways” outlines key mitigation pathways, and “Environmental Policies in the Aviation Sector” reviews empirical evidence on pricing policies, focusing on studies that report causal interpretations of their results. The subsequent section explores carbon leakage, and the final section concludes with a policy discussion.

## Data: Global Emissions

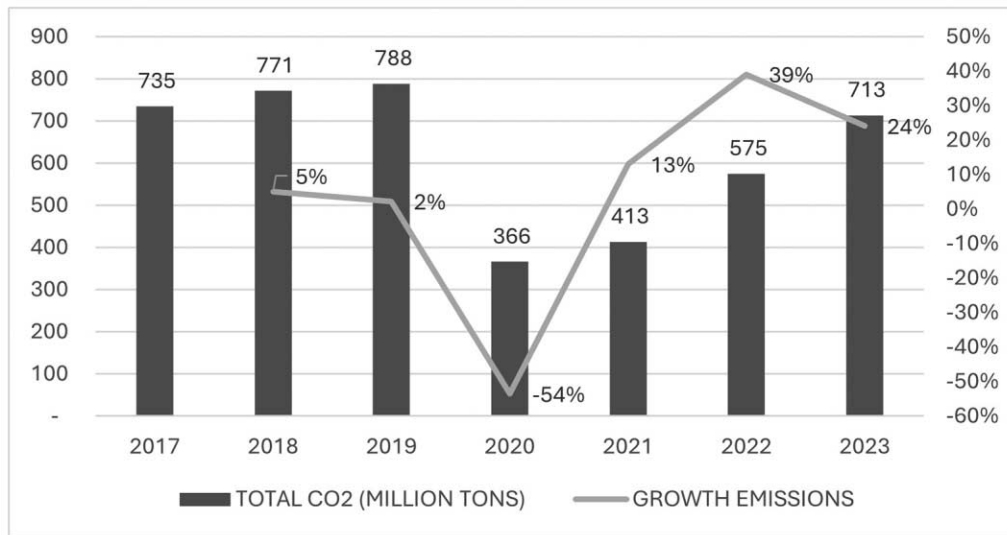
In 2023, airlines worldwide operated some 35 million flights that generated more than 700 million tonnes of CO<sub>2</sub>; the maximum was reached in the year before the pandemic, with almost 39 million flights that generated 788 million tonnes of CO<sub>2</sub>.<sup>2</sup> Figure 1 shows an overall growth trend, despite the severe disruption attributable to the pandemic. Notably, 2023 emissions had already rebounded to 90 percent of their 2019 levels, underscoring the speed of the recovery, even though the pandemic was the most significant crisis in commercial aviation since World War II.

Table 1 provides further details of the evolution of both supply and emissions in the period 2017–2023. If we omit the disruption caused by the pandemic, emissions can be attributed primarily to the number of flights. Globally, emissions per flight stand at around 20 tonnes; the 2023 rate was largely the same as that reported for 2017. In addition, the average length of flights has remained quite stable at around 1,100 miles. Thus, one obvious channel for tackling emissions is a reduction in the number of flights, although in what follows, we explore other channels that might help mitigate emissions. Note that the rest of the figures and tables in this section are based on data for 2023.

There are, in fact, currently very few examples of policies that seek to affect aviation emissions. Only the EU has made significant progress in this area, with the inclusion of aviation in the EU ETS. Indeed, the only international schemes currently operational are the EU ETS and the CORSIA. Figure 2 provides details regarding the share of total emissions by scheme. The EU ETS covers just 8 percent of global aviation emissions, whereas CORSIA covers almost one-third, but there is greater uncertainty as to the mitigation effects of CORSIA compared with those of the EU ETS (see below for further details). All in all, most flights in the world are not affected by any environmental policy that seeks to control their associated emissions.

Figure 3 shows the share of emissions attributable to the top emitters and their respective shares of the global population. The United States and the European Economic Area (EEA, including the EU, the United Kingdom, Norway, Switzerland, and Iceland) account for 46 percent of global aviation emissions but represent just 12 percent of the population, whereas high-income countries (i.e., United States, EEA, Japan, United Arab Emirates, Australia, and Canada) account for 57 percent of emissions but represent just 15 percent of the population. In contrast, China and India account for 15 percent of total emissions but represent 40 percent

<sup>2</sup>RDC Aviation data provide direct estimates of worldwide CO<sub>2</sub> emissions at the airline-route level from 2017 onward.



**Figure 1** Global CO<sub>2</sub> emissions per year (million tons). Source: Authors' own, based on RDC data.

of the population. India (1.4 billion inhabitants) has similar levels of emissions to those of the United Arab Emirates (1 million inhabitants), Australia (26 million inhabitants), and Canada (39 million inhabitants). We can expect the richest individuals living in high-income countries to fly most (Gössling and Humpe 2020; Baltruszewicz et al. 2023).

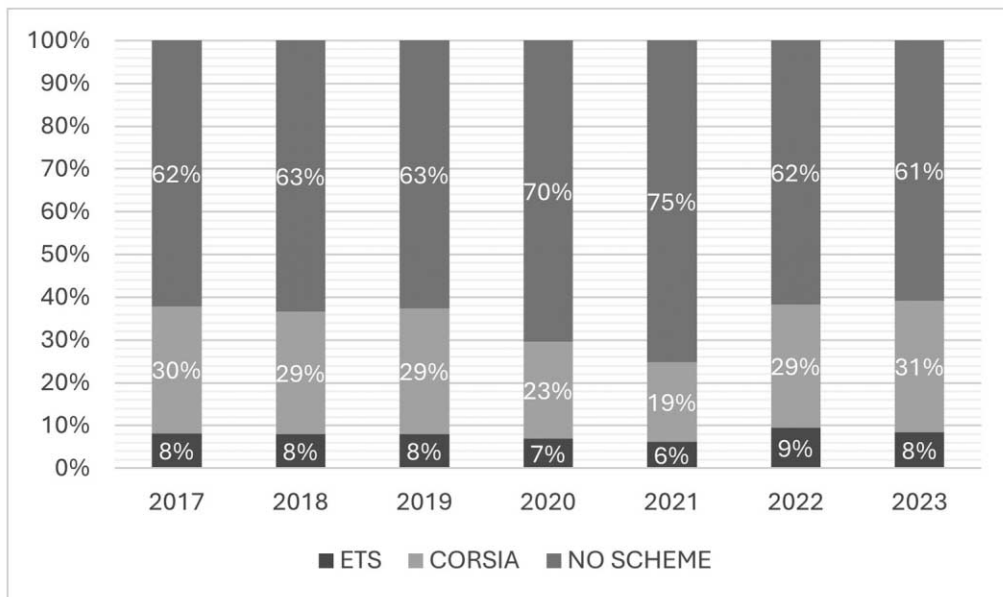
Thus, a high proportion of global emissions is generated by the richest individuals in a few high-income countries. This observation has two implications. First, the implementation of policies aimed at containing aviation growth could easily satisfy equity concerns. Second, the potential for traffic growth in highly populated middle-income countries is enormous. Thus, the goal of reducing aviation emissions worldwide will be extremely difficult to achieve, but the greatest potential may lie in high-income countries.

Another striking fact that can be inferred from figure 3 is that under the “full scope” of the EU ETS as it was originally designed (to include all flights taking off or landing in the EEA), the scheme would cover almost three times the emissions currently covered under the “reduced scope” scheme (only flights within the EEA) and 23 percent of total global emissions. Most notably, the United States, which generates the most aviation emissions in the

**Table 1** Factor decomposition of supply and emissions

| Year | Flights (million) | Distance (miles) | Total CO <sub>2</sub> (million tonnes) | CO <sub>2</sub> per flight (tonnes) |
|------|-------------------|------------------|----------------------------------------|-------------------------------------|
| 2017 | 36.6              | 1,077            | 734.6                                  | 20.1                                |
| 2018 | 38.1              | 1,093            | 771.3                                  | 20.2                                |
| 2019 | 38.8              | 1,101            | 788.4                                  | 20.3                                |
| 2020 | 21.8              | 1,004            | 365.8                                  | 16.8                                |
| 2021 | 25.0              | 1,006            | 413.4                                  | 15.6                                |
| 2022 | 31.3              | 1,053            | 575.1                                  | 18.38                               |
| 2023 | 35.3              | 1,079            | 713.5                                  | 20.2                                |

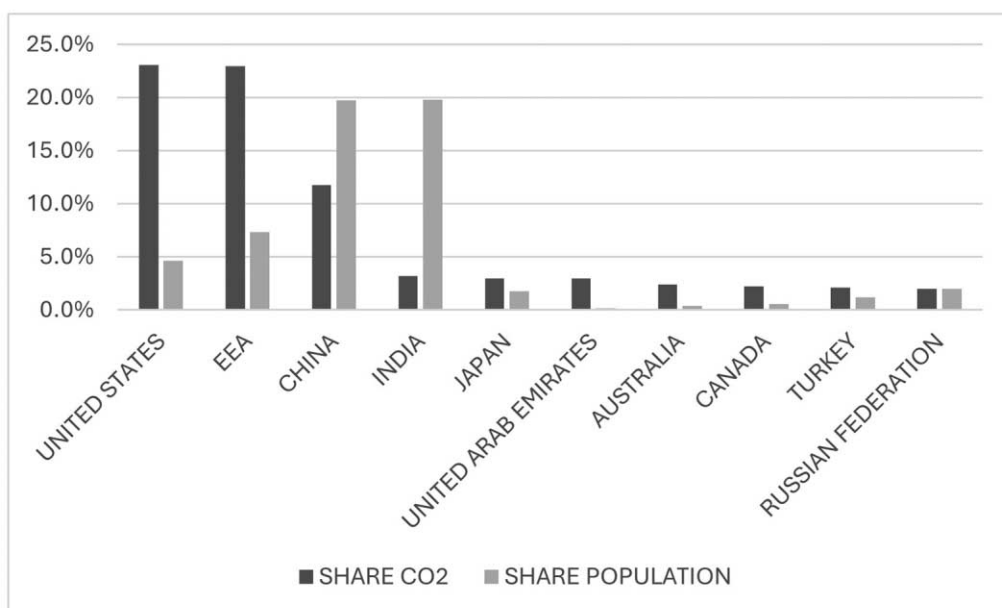
Source: Authors' own, based on RDC data.



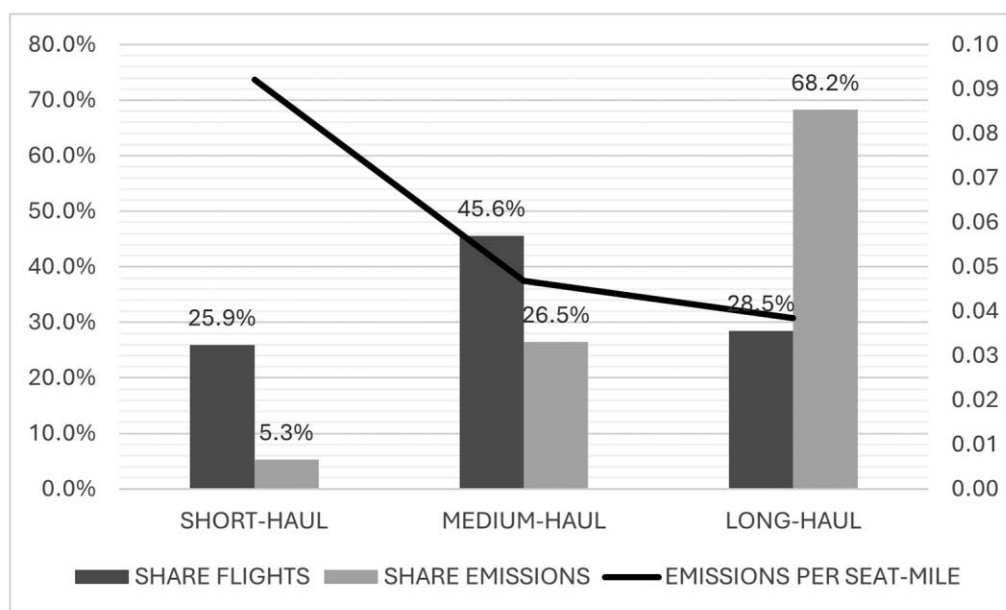
**Figure 2** Share of total CO<sub>2</sub> emissions from aviation by scheme. Source: Authors' own, based on RDC data.

world, does not have any specific policy in place to contain the growth of its air traffic and emissions.

Figure 4 provides information on the global share of CO<sub>2</sub> emissions by route distance, where flights are categorized as short-haul (fewer than 350 miles), medium-haul (350–1,000 miles),



**Figure 3** Share of aviation CO<sub>2</sub> emissions and population—top emitters. Source: Authors' own, based on RDC data.



**Figure 4** Global share CO<sub>2</sub> emissions and flights by distance. Short-haul flights operate over fewer than 350 miles, medium-haul flights between 350 and 1,000 miles, and long-haul flights more than 1,000 miles. Left axis, percentage share; right axis, emissions per seat-mile. Source: Authors' own, based on RDC data.

and long-haul (more than 1,000 miles). We find a marked influence of distance on total emissions. Thus, although short-haul flights represent 25 percent of total flights and just 5 percent of emissions, long-haul flights account for almost 70 percent of emissions yet fewer than 30 percent of flights. Medium-haul flights are somewhat more balanced, accounting for 45 percent of flights and 26 percent of emissions. However, note that the intensity of emissions (measured as emissions per seat-mile) negatively correlates with distance. Longer flights consume less fuel per distance traveled, because fuel consumption is markedly higher when taking off or landing at an airport. Long-haul flights also use larger planes, which are also more efficient in terms of emissions per seat-mile.

Three specific conclusions can be drawn from the foregoing. First, short-haul flights represent a considerably higher proportion of flights than they do emissions; however, on such routes, it is possible to take a train or bus as a substitute mode of travel, so connectivity between the two points does not depend solely on aviation. At the same time, long-haul flights represent a disproportionate weight in total emissions. For a long-haul trip, however, substitution of mode is not always possible in terms of travel time or costs. In this sense, long-haul flights make a greater contribution than short-haul flights to consumer welfare. From this perspective, reducing short-haul flights would not necessarily harm employment or welfare if travelers shift to cleaner modes such as trains and buses.

Second, long-haul flights perform better in terms of the intensity of their emissions. Thus, environmental policy priorities need to be defined in terms of either total emissions or emissions per seat-mile. What ultimately matters for our planet are global emissions. However, a

focus on intensity of emissions means that the output generated can be taken into consideration, with the consequent implications this has in terms of efficiency and economic growth.<sup>3</sup>

Third, policies affecting short-haul and, to some extent, medium-haul flights can be implemented by national governments (or by the European Union as a special case). In contrast, any measures that affect long-haul flights necessarily require the coordination of governments from different countries.

Finally, table 2 compares the main aircraft used globally. Just two types of aircraft—the Airbus A320 and Boeing B737-800—dominate medium-haul routes. Together, they account for almost half of total worldwide flights, or more than 13 million flights each year.

New aircraft use conventional fuel, but they are much more efficient than older models. Although flying less is the most obvious way to cut emissions, the table illustrates what might be achieved by fleet renewal. The newest versions of the A320 and B737-800 are, respectively, the A320neo and the B737 MAX, two models that highlight the most significant technological changes in the sector to date in the twenty-first century. These newer models reduce emissions by 18 to 22 percent. However, the wholesale adoption of the newest aircraft would have only a limited impact on global CO<sub>2</sub> emissions. Assuming that a 20 percent reduction in emissions per flight implies a saving of around 3 tonnes of carbon per flight, if the 13.5 million flights currently using an old model were to be replaced by A320neo/B737 Max, we would see a reduction of 40.5 million tonnes—that is, only around 5.7 percent of global aviation emissions.

## Non-CO<sub>2</sub> Emissions

Although CO<sub>2</sub> is typically seen as the main driver of climate impacts, aviation's non-CO<sub>2</sub> emissions—water vapor, soot, and nitrogen and sulfur oxides—also contribute significantly, mainly through the formation of persistent contrails. Research indicates that these effects may be roughly twice as large as those of CO<sub>2</sub> alone (Lee et al. 2021), although not as long-lived. For instance, contrails have a 20 percent higher climate impact than CO<sub>2</sub> over 20 years; however, because they do not accumulate in the atmosphere, their impact drops to about one-third over a 100-year horizon (Teoh et al. 2024).

Recent empirical studies emphasize the highly uneven distribution of non-CO<sub>2</sub> emissions within the aviation sector. Teoh et al. (2024), analyzing data from 40 million flights in 2019, find that just 2 percent of these flights account for 80 percent of their overall climate effects. Although non-CO<sub>2</sub> emissions are more spatially differentiated than CO<sub>2</sub> emissions, research has identified specific atmospheric conditions under which they are most pronounced. This growing understanding opens the door to targeted policy measures aimed at mitigating the sector's broader climate impact.

Several policy instruments have been proposed to tackle non-CO<sub>2</sub> emissions in aviation. One option is optimizing flight paths to avoid contrail-sensitive regions and conditions, as explored by Simorgh et al. (2024). Although operationally feasible, the challenge lies in determining whether such optimizations should be mandatory or merely recommendations. An alternative

<sup>3</sup>In the transportation sector, the relevant output is the number of passengers/seats per mile rather than the number of passengers/seats (i.e., a flight from New York to London has a higher count than a flight from New York to Washington, DC).

**Table 2** Statistics on main aircraft (global data)

| Aircraft   | N of flights | Size<br>(n of seats) | Mean distance<br>(miles) | Share global<br>flights (%) | Emissions per<br>seat-mile |
|------------|--------------|----------------------|--------------------------|-----------------------------|----------------------------|
| A320       | 6,976,594    | 171                  | 923                      | 19.79                       | 0.041                      |
| A320neo    | 1,306,975    | 177                  | 1,043                    | 3.71                        | 0.032                      |
| B737-800   | 6,573,909    | 172                  | 969                      | 18.64                       | 0.040                      |
| B737 MAX 8 | 1,161,052    | 176                  | 1,198                    | 3.29                        | 0.033                      |

Source: Authors' own, based on RDC data.

approach involves imposing tolls on flights passing through high-impact atmospheric zones, which could achieve more than 90 percent of the climate mitigation potential of optimized flight trajectories (Niklaß et al. 2021). Another proposal is to introduce a multiplier to the EU ETS permit price for CO<sub>2</sub> emissions, where airlines would pay two to three times the permit price per ton of CO<sub>2</sub> if postflight verification confirmed contrail formation. Advances in forecasting software (Frias et al. 2024) now allow airlines to predict contrail regions some 6 to 36 hours in advance, enabling them to adjust flight paths accordingly; this does come at the cost of slightly increased CO<sub>2</sub> emissions, which remain covered under the EU ETS. In addition, air traffic control could play a role by monitoring flight routes, computing effective global warming potential, and integrating non-CO<sub>2</sub> effects into pricing mechanisms. Building on these advances, the 2023 revision of the EU ETS establishes requirements for the monitoring, reporting, and verification of non-CO<sub>2</sub> emissions (operational since January 2025).

## Aviation Mitigation Pathways: How Can Emissions Be Reduced?

There are three major mitigation pathways in the aviation sector: (a) the reduction of flights, which yields a proportional reduction in emissions; (b) improving CO<sub>2</sub> efficiency, which is achieved not solely by aircraft substitution but also by exploiting current retrofitting options and operational changes; and (c) using SAFs. Below, we consider each mitigation pathway and highlight any relevant technical insights.

### Flight Reductions

Reducing air traffic poses a dilemma in terms of economic growth. Air traffic has been shown to have a positive impact on employment in service-related industries (Brueckner 2003), on employment growth (Green 2007), on economic output per capita (Florida, Mellander, and Holgersson 2015), and on income (Blonigen and Cristea 2015). Moreover, the increase in a city's connectivity leads to growth in urban population and total employment, driven in part by the entry of new firms into the local market (Cristea 2023).<sup>4</sup> Similarly, a reduction in long-haul flights seems to be associated with a reduction in economic activity. Using satellite-measured night lights for a sample of 819 cities with major airports in 200 different countries, Campante and Yanagizawa-Drott (2018) showed that air links have a positive impact on local

<sup>4</sup>The increase in connectivity is measured in terms of a weighted count of all destinations reached by non-stop flight service to the national aviation network.

economic activity by increasing business links, and the movement of people fosters the movement of capital, with flows primarily from high-income to middle-income countries. However, Dechezleprêtre et al. (2025) use a large-scale survey to analyze international attitudes toward climate policies and determined that approximately half of the respondents declare themselves willing to limit flights.

### **Adoption: Retrofitting and Operational Changes**

The second mitigation pathway involves increasing the efficiency of aircraft fleets. This can be achieved by renewing the fleet, adopting retrofit options (Müller, Kieckhäfer, and Spengler 2018), flying larger aircraft (Brueckner and Abreu 2017), or changing the seat configuration (Park and O’Kelly 2014). Newer planes are generally more fuel-efficient (Brueckner and Zhang 2010; Csereklyei and Stern 2020; de Jong 2022). Indeed, the current generation of aircraft is 15 to 20 percent more efficient than the previous generation and 80 percent more efficient than aircraft 50 years ago (IATA 2023). However, financial constraints can prevent airlines from selecting this option. For example, de Jong (2022) shows that, for European and North American airline fleets, the median age for retiring an aircraft is 22.5 years.

Alternatively, emission intensity can be reduced by retrofitting new technologies into existing aircraft. These include cabin weight reductions, electric taxiing systems, and blended winglets (curved tips mounted on the wingtips that improve a plane’s aerodynamics by reducing drag and, consequently, fuel consumption of certain aircraft; Müller, Kieckhäfer, and Spengler 2018). Both Airbus and Boeing offer winglets as a retrofit option. For Boeing, the resulting fuel savings range from 2.5 to 4.4 percent (Freitag and Schulze 2009) and for Airbus up to 4 percent (Airbus 2025). Cabin weight reductions can be achieved by using lightweight trolleys, reducing the weight of seats, and replacing traditional entertainment systems and paper manuals with tablets. According to Schäfer et al. (2016), aggressive cabin weight reduction on narrow-body aircraft could lead to a 2.1 percent decrease in emissions over the life cycle of an airplane. Similarly, seat configuration decisions can improve fuel efficiency; as seat capacity increases, fuel use per seat-mile decreases (Park and O’Kelly 2014; Csereklyei and Stern 2020). Indeed, larger planes are usually more fuel-efficient, and their operation reduces fuel usage and carbon emissions (Brueckner and Abreu 2017; Csereklyei and Stern 2020). Finally, electric taxiing systems allow aircraft to taxi with the propulsion of an electric motor, thus avoiding having to start up the engines, as is current practice, and reducing reliance on traditional pushback tractors. There are two classes of this technology: onboard electric taxiing systems, such as the wheel tug installed in the nose landing gear, and an electric green taxiing system installed in the main landing gear (Ajayi 2023). Although onboard systems have the potential for achieving zero-emissions taxiing and considerable time reductions, they increase aircraft weight, making them unsuitable for long-haul aircraft, because the benefits of the fuel saved during taxiing would be offset by higher consumption during the airborne phase (Lukic et al. 2019). Moreover, they require the reconfiguration of the aircraft architecture, which presents substantial challenges in terms of certification and legislation (Lukic et al. 2019).

### **Sustainable Aviation Fuels**

The third mitigation pathway is through the adoption of greener technologies and fuels. These include currently employed SAFs and the development of future hydrogen-propelled aircraft

projects. SAFs are drop-in fuels whose use does not require any modifications to current engines. They are produced from nonfossil sources such as plant matter. SAFs are blended with jet kerosene in ratios for certified pathways that allow up to 50 percent mixing (Cabrera and de Sousa 2022). Though their combustion produces almost the same amount of CO<sub>2</sub> emissions as kerosene jet fuel, their CO<sub>2</sub> savings potential comes from the feedstocks used as their raw materials and the associated production and conversion processes (Braun, Grimme, and Oesingmann 2024). International Civil Aviation Organization (ICAO 2017) estimates that a 100 percent substitution of kerosene jet fuel with SAFs would result in a 63 percent reduction in baseline CO<sub>2</sub> emissions from international flights by 2050.<sup>5</sup> However, in 2023, SAFs accounted for just 3 percent of all renewable fuels produced and less than 1 percent of the fuel needed for the aviation industry. The reasons for these low levels of use lie in questions of availability and cost. Indeed, SAF production costs and market prices are substantially higher than those of traditional fuels, and the infrastructure and supply chains for efficient large-scale production of SAFs have yet to be fully developed (Braun, Grimme, and Oesingmann 2024).

Hydrogen aviation fuel could eliminate most greenhouse gas emissions (Degirmenci et al. 2023). However, hydrogen-propelled aircraft are not yet in operation; the first major technical challenges are fueling and safe and efficient storage of hydrogen (Boretti 2021). According to Yusaf et al. (2024), efficiency has improved, but the lack of refueling stations and large production costs are clear obstacles to the commercialization of hydrogen fuel.

In short, we can expect an increasing number of flights to be operated by more efficient aircraft using SAF. In this regard, Lohawala, Toman, and Joiner (2026) provide a comprehensive discussion of demand- and supply-side policies aimed at expanding its use. However, in the short term, the sector will remain very energy-intensive and will likely continue to be dominated by aircraft using traditional fuels. Hence, flying less is the most effective way to reduce current emissions, although this entails significant economic, social, and political challenges.

## Environmental Policies in the Aviation Sector

A range of policies address aviation's environmental impact, but this review focuses on pricing instruments—cap-and-trade systems, offsetting mechanisms, and taxes or airport charges—widely viewed as cost-effective tools for internalizing externalities. Most evidence comes from Europe, where regulation has advanced furthest; in contrast, US studies mainly examine airline responses to fuel price changes rather than explicit environmental policies.<sup>6</sup>

We focus on econometric studies that provide causal estimates of the results of policies after they are implemented. These have primarily examined the EU ETS, taxes, and airport charges. The causal effects of SAF subsidies and related market-based instruments remain

<sup>5</sup>Rupcic et al. (2023) show that the most promising kerosene substitutes for reducing climate change impacts seem to be second-generation biofuels (those produced from agricultural waste rather than from crops or land that could provide food) and electrofuels using carbon-capture technologies. Hybrid-electric and electric aircraft performed better than conventional aircraft when the alternative fuel and electricity greenhouse gas emissions were low.

<sup>6</sup>Various studies estimate the rate at which increased fuel costs are passed through to consumers (Wadud 2015; Scotti and Volta 2018; Chuang 2020; Gayle and Lin 2021). Others analyze the drop in fuel usage when fuel costs increase (Brueckner and Abreu 2017, 2020; Fukui and Miyoshi 2017; Brueckner, Kahn, and Nickelsburg 2024).

largely unexplored, given their limited deployment and relatively recent implementation. For instance, since 2019, California's Low Carbon Fuel Standard (LCFS) has allowed SAF suppliers to claim carbon credits to offset their low-carbon fuel requirements; however, SAF accounted for only 0.3 percent of all LCFS credits in 2021. Similarly, no causal evidence is yet available for CORSIA, which will only become mandatory in 2027, although we discuss it here for the sake of completeness. Finally, most existing studies analyze policies in isolation, overlooking potential interactions that are likely to become increasingly relevant.

Theoretical and structural models offer useful insights, particularly on policy effects under the imperfect competition that characterizes many aviation markets.<sup>7</sup> However, they fall outside our scope. Empirical evidence so far points to adjustments in flight frequency, fares, and aircraft type, but little is known about other responses, such as seat reconfiguration, cabin weight reduction, or electric taxiing.

### EU ETS: The European Cap-and-Trade System

The EU ETS, launched in 2005, is the largest ETS in the world and the European Union's main environmental policy. The ETS caps the level of total CO<sub>2</sub> emissions; within the scheme, companies can buy and sell emission permits (also known as allowances) on a carbon market, although they also receive some for free. The EU ETS is gradually becoming more stringent as the cap is reduced and a lower share of free allowances is made available.

Initially, the EU ETS covered only the manufacturing and electricity sectors. In 2008, it was extended to include aviation, so that all flights landing at or taking off from any airport in the EEA were required to monitor, report, and verify their emissions.<sup>8</sup> Airlines were to be required to use their allowances against those emissions starting on January 1, 2012. The decision, however, generated considerable resistance from international carriers. As a result, in November 2012, the European Commission issued a proposal to stop the clock on the aviation ETS and to reduce the scope of the directive to include only intra-EEA flights, retroactively to January 2012.

Table 3 summarizes those studies that have examined the impact of the EU ETS on the aviation sector. A carbon price leads to an increase in operating costs for airlines. Under conditions of imperfect competition, airlines react by reducing supply and increasing prices to maximize profits. Consumers' response to higher prices (the elasticity of demand), combined with higher fares and lower frequencies, should lead to less demand. Furthermore, airlines subject to the EU ETS may have greater incentives to reduce aircraft emission intensities and, hence, to use newer, more efficient planes. Ultimately, the responses of airlines and passengers alike should result in a reduction in emissions, at least relative to the counterfactual scenario without carbon pricing.

Few studies provide *ex post* econometric evidence of the impact of the EU ETS on the aviation sector. Analyses undertaken at the airline-route level employing standard techniques

<sup>7</sup>Imperfect competition exists in the aviation industry because the number of airlines is limited by extensive regulations, high capital requirements to enter the industry, and other factors. Imperfect competition can lead to higher consumer prices relative to theoretically perfect competition. For example, Cardoso (2023) and Rausch and Straubinger (2026) argue that the welfare-maximizing carbon tax on aviation should be lower than the marginal environmental damage, because the sector is characterized by imperfect competition and already exhibits excessively high prices.

<sup>8</sup>Directive 2008/101/EC of the European Parliament and of the Council of 19 November 2008 amending Directive 2003/87/EC.

**Table 3** Empirical studies of the impact of the EU ETS on aviation

| Study                                          | Unit                      | Dataset                                                    | Scheme                      | Outcome                                               | Methodology                                          | Results                                                                                                                |
|------------------------------------------------|---------------------------|------------------------------------------------------------|-----------------------------|-------------------------------------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------|
| Fageda and Teixidó (2022)                      | Airport pair              | Europe (2010–2016)                                         | EU ETS                      | CO <sub>2</sub> emissions                             | DiD with entropy balance                             | Entire market: –5%<br>Short-haul flights: –10%<br>Low-cost airlines: –11%                                              |
| Kang et al. (2022)                             | Airport pair              | Europe (2007–2017)                                         | EU ETS                      | Seats, aircraft size                                  | Synthetic control                                    | Seats: –20% at its peak<br>(stronger effects for short-haul flights and low-cost airlines)<br>Aircraft size: No effect |
| De Jong (2022)                                 | Airline's aircraft fleets | Network airlines from Europe and North America (2004–2019) | EU ETS                      | Retirement age                                        | DiD and hazard-based duration model                  | Short-haul aircraft: –2.8 years decrease (–14%)<br>Long-haul aircraft: 2 years (11%)                                   |
| Oesingmann (2022)                              | Country pair              | EEA (2002–2018)                                            | EU ETS, flight ticket taxes | Passengers                                            | Poisson pseudo-maximum likelihood with fixed effects | EU ETS: No significant effect                                                                                          |
| Fageda and Teixidó (2025)                      | Airport pair              | Europe (2010–2021)                                         | EU ETS                      | Emission intensity, fuel-efficient aircraft, winglets | DiD                                                  | Emissions intensity: –2.4%<br>Fuel-efficient aircraft: 5%<br>Winglets: 8%                                              |
| Zhang and Wang (2024)                          | Country pair              | EU and non-EU countries (2000–2019)                        | EU ETS                      | CO <sub>2</sub> emissions                             | DiD with entropy balance                             | Domestic market: –40%<br>International market: No significant effect                                                   |
| Fageda and Oesingmann (2025a)                  | Airport pair (one stop)   | EEA + UK to Asia and North America (2010–2023)             | EU ETS                      | Passengers                                            | DiD with high-dimensional fixed effects              | Hub competition: –2%/–5%<br>No hub competition: –5%/–6%                                                                |
| Fageda and Oesingmann (2025b)                  | Airport pair              | Europe, North Africa and Middle East (2010–2022)           | EU ETS                      | Emissions, passengers, seats, flights                 | DiD with entropy balance                             | Emissions: –7%<br>Passengers: No significant effect<br>Seats: –8%<br>Flights: –15%                                     |
| Albert, Gómez-Fernández and Boto-García (2025) | Country pair              | European Union (2005–2019)                                 | EU ETS                      | Passengers, flights                                   | Vector autoregression (VAR)                          | Passengers: –1%/–1.2%<br>Flights: –1%/–1.5%                                                                            |

of impact evaluation (essentially, differences-in-differences [DiD] and synthetic control methods) find the expected reactions—that is, a reduction in supply and a hike in fares. Fageda and Teixidó (2022) report that the EU ETS reduced total CO<sub>2</sub> emissions by an average of 5 percent compared with the counterfactual, driven primarily by a reduction in flight frequencies. Kang et al. (2022) report a peak reduction of 20 percent in total seat capacity but found no effect on aircraft size, meaning fewer flights were being operated. In both studies, the estimated effect was stronger on short-haul flights and on routes operated by low-cost airlines. This latter finding is in line with Zhang and Wang (2024), who found a strong impact of the EU ETS on domestic markets.

Although the supply side seems to have contracted, the impact of the EU ETS on the demand side is less clear. Oesingmann (2022) finds no evidence of any significant effect on the total number of passengers. Fageda and Oesingmann (2025b) and Albert, Gómez-Fernández, and Boto-García (2025) analyze both demand and supply responses to the EU ETS and find a stronger reaction of the supply side. These results point to an improvement in the efficiency of airlines, which have responded by increasing flight-load factors (i.e., the share of available seats that are filled). The fact that demand does not seem to respond to the EU ETS is consistent with the predictions of Brueckner and Zhang's (2010) theoretical model, whereby increasing fuel costs attributable to the emissions market encourages airlines to reduce flight frequency and increase the load factor of individual flights.

Thus, the EU carbon market has contributed to reducing emissions—even during its early years of low carbon prices—by reducing the number of flights supplied. However, because this reduction in flight frequencies seems to have been offset by increased load factors, the negative effects on economic growth may have been partially mitigated. This would also be the case if carbon pricing influenced investment in low-carbon technologies. Fageda and Teixidó (2025), for example, investigate the adoption of such technologies in the aviation sector, focusing mainly on early aircraft substitution and the installation of winglets. The authors find that the EU ETS has accelerated the replacement of older aircraft with more efficient models and spurred a notable increase in the installation of winglets. They also find that the EU ETS improved emissions intensity (measured in kilograms of CO<sub>2</sub> per seat-kilometer) by 2 to 6 percent as prices rose in the period 2018–2021.

Overall, evidence suggests that policies increasing fuel costs—such as the EU ETS—primarily trigger supply-side adjustments by airlines. Conversely, measures that reduce fuel costs—such as subsidies for SAF—could generate a rebound effect by encouraging additional flying, thereby offsetting some of their expected environmental gains (Evans and Schäfer 2013).

### **CORSIA: The International Carbon Offsetting Scheme**

CORSIA was established by the International Civil Aviation Organization (ICAO). As noted above, CORSIA aims to cap international aviation CO<sub>2</sub> emissions at 2019 levels by requiring participating countries to commit to offsetting any emissions above this baseline by purchasing certified CORSIA credits, each representing 1 tonne of CO<sub>2</sub>.<sup>9</sup> The scheme began with a voluntary

<sup>9</sup>As of 2026, 130 nations participate in CORSIA, including the United States and EEA countries but not China or India; these two countries are expected to join starting with the 2027 mandatory phase (ICAO 2025).

pilot phase (2021–2023) and phase I (2024–2026), covering only countries that chose to participate; it will become mandatory for all ICAO members starting in 2027. Because emissions during the COVID-19 period stayed below 2019 levels, no offsetting was required in the pilot phase, and phase I demands offsets only above 85 percent of 2019 emissions. Given its limited scope so far, CORSIA’s effectiveness has not yet been evaluated, though prior studies suggest notable shortcomings compared with the EU ETS.

First, CORSIA compensates for emissions growth rather than reducing absolute emissions, covering at most 25 percent of global aviation emissions between 2021 and 2035 (ICCT 2017). Second, its environmental integrity is also uncertain because of the problem of additionality. “Additionality” means that the carbon reduction would not have happened without the policy. This implies that the policy does not reliably induce emissions reductions beyond business as usual. In this regard, additionality is often doubtful. Outside the aviation context, a European Commission study of offsetting credits found that about 85 percent of 5,655 certified projects were nonadditional (Cames et al. 2016). Similarly, Calel et al. (2025) estimate that 52 percent of wind projects in India lacked additionality. Although comparable evidence for CORSIA is unavailable, recent assessments raise similar concerns about its eligible programs and point to further risks of double counting with other national commitments to reduce carbon emissions (ICF Consulting, Air Transportation Analytics, NewClimate Institute, HFW, and Sven Starckx 2020; Schneider and Wissner 2022).

The economic incentive created by CORSIA is, moreover, relatively weak. Under the EU ETS, allowance prices directly affect an airline’s marginal costs of operation, effectively increasing fuel prices. By contrast, CORSIA’s costs are averaged across sector-wide emissions growth relative to a baseline. Only from phase II onward (2027) will emissions also gradually take into consideration an airline’s individual growth. For instance, in 2029, an airline would need to offset emissions corresponding to 5 percent of its emissions under CORSIA if the sector grew by 5 percent. From 2030 onward, 80 percent of the obligation will be based on sector growth and 20 percent on airline-specific growth. This diluted attribution weakens the marginal incentive to reduce emissions.

Finally, CORSIA applies only to international flights. In 2023, domestic flights represented 42 percent of aviation emissions. These structural weaknesses—limited ambition, weak enforcement, concerns over the quality of credits that are used to offset emissions, and minimal marginal incentives—have led many to question the scheme’s effectiveness. Indeed, numerous studies conclude that CORSIA is significantly less stringent than the EU ETS (Scheelhaase et al. 2018; Larsson et al. 2019; Gössling and Lyle 2021; Mayer and Ding 2023).

The development of CORSIA has been closely linked to policy decisions emanating from the European Union. Initially, the EU ETS was designed to cover all flights to and from the EEA. The decision to limit its scope to flights within EEA airports (reduced scope) was justified by the ongoing development and implementation of CORSIA. Although applying the EU ETS to all flights arriving in or departing from an EEA country (full scope) has been shown to be compliant with international travel regulations, the European Union opted to apply CORSIA to extra-European flights until the start of 2027. At that time, the commission intends to make a legislative proposal based on an assessment of CORSIA’s ambition and its coherence with the Paris Agreement.

## Taxes and Airport Charges

Several European countries have implemented flight ticket taxes. The taxable event is a departing passenger flying with a commercial airline, the latter being responsible for collecting the tax and paying it to the government. In line with the expected effects of the EU ETS, this tax implies an additional cost for airlines, which may lead to less supply (and lower emissions), higher prices, and less demand. In contrast, no effects are expected in terms of the type of aircraft being operated, because the measure does not tax emissions.

The first ticket-tax policies were introduced in the 1990s in Italy, France, and the United Kingdom, although their primary goal was to generate revenues for the state's general budget or for specific funds. Malta, Ireland, and the Netherlands later introduced ambitious ticket-tax schemes, but these were withdrawn because of opposition from airlines and the tourism industry. The main aim of the schemes implemented since 2011 in Austria, Germany, the Netherlands, Norway, Sweden, and Portugal is to reduce the environmental costs of air traffic. However, only in the case of Portugal are the revenues generated specifically assigned to projects that reduce emissions. The tax rate per passenger (connecting passengers are typically excluded) varies considerably, although it usually ranges between 5 and 15 euros; although this is not especially high, it can represent a significant overall cost for an airline.

In the case of airport charges, the two main chargeable items are the passenger or the flight, with a few countries in Europe also opting to apply NO<sub>x</sub> emission charges. The latter have been imposed in the main airports of Switzerland (1997), Sweden (1998), Norway for domestic flights (2007), Germany (2008), Copenhagen (2010), London's two main airports (2004), Barcelona (2014), and Amsterdam (2022). They are usually set to be neutral, in the sense that they should not increase an airport's overall revenues (Scheelhaase 2010).

Table 4 summarizes those studies that have examined the impact of taxes and airport charges on the aviation sector. All extant research into the impact of flight ticket-tax schemes provides evidence of a significant effect. Falk and Hagsten (2019) examined the short-run impact of such schemes in Germany and Austria using aggregate data at the airport level. They conducted a DiD analysis and found that the tax reduced the number of passengers by 9 percent in the year of introduction and 5 percent in the subsequent year. Bernardo, Fageda, and Teixidó (2024) applied a staggered DiD using data at the airline-route level and covering all schemes implemented after 2011 (Austria, Germany, Norway, and Sweden). They found that flight ticket taxes have a significant overall effect on supply (and therefore on overall emissions), reducing the number of flights per airline-route by an average of 12 percent compared with the counterfactual and resulting in a 14 percent reduction in carbon emissions. They also reported that the tax burden is greater for passengers paying low fares. This means the schemes have a stronger effect on avoidable flights, which have less added value and a smaller internalization of total flying costs. Collet, Quirion, and Taconet (2023) also apply a staggered dynamic DiD using data at the route level and covering all schemes after 2001. They found that a 1 euro increase in the tax has led to a 1 percent drop in traffic. When estimated at the country level, air-tax effects are heterogeneous but are found to reduce air traffic significantly for Germany, France, the Netherlands, and the United Kingdom.

The empirical literature dedicated to airport charges is scarce. Doi (2022) developed a structural model with an application to the Japanese domestic market to analyze the effect of airport

**Table 4** Empirical studies on the impact of taxes and airport charges in the aviation sector

| Study                                | Unit         | Dataset                                  | Scheme                                      | Outcome                               | Methodology                                | Results                                                                                                                                                |
|--------------------------------------|--------------|------------------------------------------|---------------------------------------------|---------------------------------------|--------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------|
| Markham et al. (2018)                | Country      | Australia domestic market (1984–2017)    | Carbon tax                                  | Revenue passenger kilometers          | Time series                                | No significant effect                                                                                                                                  |
| Falk and Hagsten (2019)              | Airport      | Europe (2008–2016)                       | Flight ticket tax                           | Passengers                            | Dynamic DiD                                | –9% in the year of introduction and 5% in the year after. Significant effects only for low-cost airlines                                               |
| Borbely (2019)                       | Airport      | Germany and border countries (2003–2015) | Flight ticket tax                           | Passengers                            | Synthetic control                          | Traffic losses at German airports to the benefit of border airports                                                                                    |
| Doi (2022)                           | Airport pair | Japanese domestic market (2000–2005)     | Airport charges                             | Fares, frequencies                    | Structural model                           | Per passenger charges raise airfares (97% pass-through) and reduce frequency. Per flight charges decrease flight frequency but little effect on fares. |
| Oesingmann (2022)                    | Country pair | EEA (2002–2018)                          | EU ETS, flight ticket taxes                 | Passengers                            | PPML with fixed effects                    | Flight ticket taxes: –3%/–12%                                                                                                                          |
| Fageda and Flores-Fillol (2025)      | Airport pair | Europe (2013–2022)                       | Emission versus nonemission airport charges | Flights, fares, share newer aircrafts | Panel data with fixed effects              | Emission charges (modestly) spur fleet renewal                                                                                                         |
| Collet, Quirion, and Taconet (2023)  | Airport pair | EEA + UK (2001–2019)                     | Flight ticket taxes                         | Passengers                            | Staggered DiD with heterogeneous treatment | 1 euro increase in the tax led to –1% decrease in traffic                                                                                              |
| Bernardo, Fageda, and Teixidó (2024) | Airport pair | EEA + UK (2007–2019)                     | Flight ticket taxes                         | Flights, fares                        | Staggered DiD                              | Entire market: –4%<br>Low-cost carriers: –12%<br>Cost pass-through: 20–56%                                                                             |

charges on fares and frequencies. He found that per passenger charges significantly increase airfares and reduce flight frequencies, whereas per flight charges decrease flight frequencies but do not have any significant impact on airfares. Evidence on how these charges affect the choice of aircraft type and resulting emissions remains lacking. Per flight charges are often levied based on aircraft weight, meaning smaller planes pay lower fees. Combined with programs such as Europe's Public Service Obligation and the US Essential Air Service, which subsidize short-haul routes and small airports (see Fageda et al. 2018), this structure may inadvertently favor the use of smaller, less fuel-efficient aircraft. This highlights a trade-off between maintaining regional connectivity and improving emissions efficiency in aviation.

Fageda and Flores-Fillol (2025) showed, by means of a theoretical and empirical analysis, that the effect of  $\text{NO}_x$ -emission charges on prices and frequencies is low compared with that of nonemission charges. By contrast, emission charges modestly spur the use of newer and cleaner aircraft. Thus, the change to a tariff structure that gives more weight to emission charges has significant potential to reduce the environmental impact of aviation. However, few airports actually apply emissions charges to date, and, in most cases, the tax rate is relatively modest.

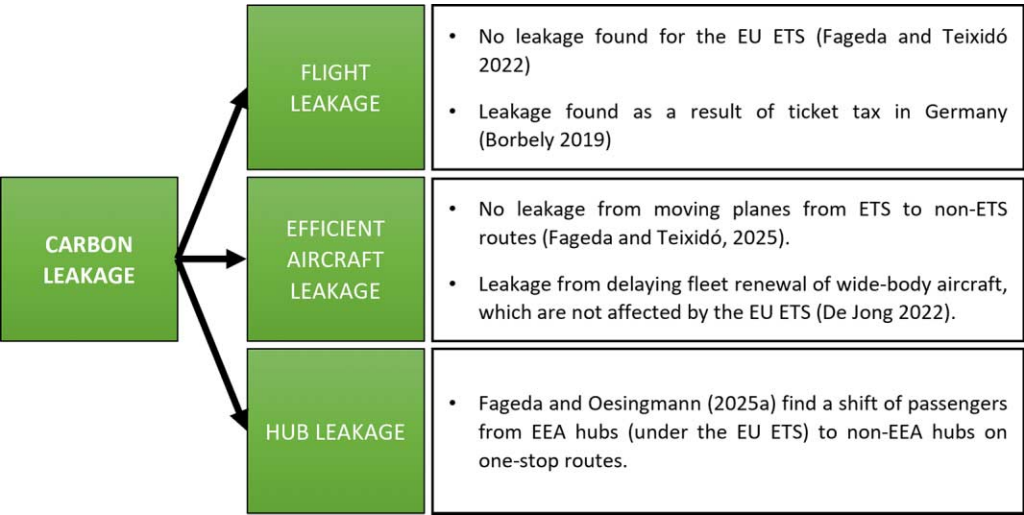
## Carbon Leakage in the Aviation Sector

The main potential problem of a country or region unilaterally adopting carbon pricing—or unilaterally adopting any climate mitigation policy, for that matter—is the effects on international competitiveness. Carbon pricing in one country (or the European Union) may result in a mere displacement of emissions to countries with less stringent climate regulations. If the cost increase brings about a loss of competitiveness of firms in the regulated country, emissions may increase in competitor countries as they increase their market shares or even drag investments away from the regulated area. The resulting carbon leakage means that the reduction of emissions in the regulated area is offset to some extent by increases in the unregulated areas.<sup>10</sup> Although the underlying principle applies across sectors, the aviation industry presents distinct characteristics: above all, its international dimension and the great mobility of its primary capital asset, airplanes. This heightens its vulnerability to carbon leakage. Figure 5 illustrates the various mechanisms through which carbon leakage may operate in aviation.

### Flight Leakage

Flight leakage would, in theory, occur when airlines reduce the number of flights in regulated areas only to increase them in unregulated zones. As a result, the reduction in emissions derived from fewer flights would merely be displaced to other routes that operate more flights. This scenario, however, does not seem to be supported by the empirical evidence. For example, Fageda and Teixidó (2022) compare EU ETS flight frequencies with those for a sample of routes that are regionally unconnected and operated by different but comparable airlines, in an effort to ensure their findings are not contaminated by negative spillovers to the main

<sup>10</sup>Most of the literature on carbon leakage has focused on the manufacturing and energy sectors, where limited or no evidence of carbon leakage is typically reported (Verde 2020).



**Figure 5** Carbon leakage paths in the aviation sector. Source: Authors' own.

control group. They find that the effect of the ETS remains, indicating that the smaller number of flights on the ETS routes is not offset by any increases implemented in the control group. As discussed earlier, this ETS reduction in supply seems to be accompanied by increases in load factors.

A different picture emerges when considering ticket taxes. To date, only one study has examined the issue of carbon leakage in an emissions market. Borbely (2019) analyzes the cross-border effects of a tax levied on departing passengers from German airports. Based on a sample of German airports and airports near the German border, the study finds relevant cross-border effects of the tax, with notable increases in passenger numbers in airports near German borders. The effect is limited to smaller regional airports, where low-cost carriers tend to operate. The net effect on Germany's annual air traffic amounted to 4 million passengers (2 percent); these passengers were effectively gained by neighboring airports outside the country. If this passenger leakage were to be translated into flight leakage rather than being absorbed by increased load factors, the tax would have led to carbon leakage, albeit moderate in scale and geographically limited.

**Efficient Aircraft Leakage**

A second potential channel of carbon leakage in aviation is technological redistribution. Carbon pricing is expected to promote cost-effective abatement, including by means of long-term investments in low-carbon technologies. However, unlike in other sectors, the technological conditions in which aviation firms operate are relatively homogeneous. Airlines subject to carbon pricing may therefore deploy their more efficient aircraft on regulated routes and reallocate older, less efficient planes to unregulated ones, offsetting emission reductions in the regulated area. Fageda and Teixidó (2025) explicitly examine this possibility and find that the EU ETS improves aircraft efficiency and retrofit investments without evidence of leakage through this channel. The sector as a whole tends to improve carbon efficiency, regardless of exposure to the ETS; because both regulated and unregulated routes show declining CO<sub>2</sub> per

seat-kilometer, significant leakage can be ruled out. Moreover, given that jet fuel is airlines' main operating cost, it would be economically irrational for them to use less efficient aircraft than those being replaced. The effect of the ETS also holds when restricting the control group to routes between non-EEA airports; this is important because airlines operating within the EEA rarely operate non-EEA routes, effectively ruling out the strategic allocation of aircraft within an individual airline. Another potential, though untested, leakage mechanism could involve the resale of aircraft by EU-based airlines to carriers in unregulated regions. Such leakage would arise only if these aircraft were used to expand flight activity rather than replace older equipment. Finally, the observed increase in retrofit investment cannot stem from reduced investment elsewhere, as airlines have no incentive to make their fleets less efficient. Overall, available evidence indicates that carbon leakage does not operate through this channel.

That said, although airlines may not deploy their aircraft strategically in response to climate policy stringency, they may trade early aircraft upgrades on regulated routes for delayed fleet renewal on unregulated routes. De Jong (2022) analyzes a specific case of carbon leakage by comparing the aircraft fleets of US and European airlines over a long period. Given that the EU ETS affects only intra-European flights, its effects should be concentrated on narrow-body aircraft, because wide-body aircraft are typically used for long-haul flights only. The author finds that, although the EU ETS incentivizes a faster renewal of narrow-body aircraft, it also leads to a slower renewal of wide-body aircraft because of airlines' budget constraints. Specifically, he finds that the EU ETS reduced the retirement age of "regulated" short-haul aircraft by 2.8 years (14 percent), whereas the retirement age of "unregulated" long-haul aircraft increased by 2 years (11 percent). This slower renewal of wide-body aircraft could mean an increase in emissions on long-haul flights.

## Hub Leakage

In the long-haul aviation market, a significant proportion of passengers use a stopover airport to reach their final destination. This introduces another potential pathway for carbon leakage, as passenger flows shift with the increased costs of the policy on extra-EEA routes involving both EEA and non-EEA hubs (e.g., when traveling from Western Europe to East Asia via either Frankfurt or Dubai). Indeed, long-haul flights often have a short-leg flight from the origin to an airport hub and a long-leg flight from the hub to the final destination. For instance, passengers flying from Barcelona to Hong Kong can be channeled via Frankfurt or via Dubai. Under the current reduced scope of the EU ETS, only the short leg, Barcelona–Frankfurt, is carbon priced, and Barcelona–Dubai is unaffected.<sup>11</sup> Thus, fewer flights and higher fares on the short leg affected by the ETS may mean that passengers prefer to fly through non-European hubs, with the consequent negative effects on the competitiveness of European network airlines.

Fageda and Oesingmann (2025a), using a DiD identification strategy, examine carbon leakage effects of this kind, using detailed demand data for one-stop routings connecting airports in Europe with Asia and North America. Relative to the counterfactual, the EU ETS reduces the number of connecting passengers by about 2 to 6 percent, although cooperation agreements

<sup>11</sup>Even under full scope, avoidance incentives remain. For instance, a passenger flying from Barcelona to Hong Kong might still prefer stopping in Dubai (outside the EU ETS) over Frankfurt (within the EU ETS), because only part of the route would be priced. Thus, behavior intended to avoid the policy would still favor non-EEA hubs.

between European and non-European airlines (particularly with US airlines) dilute this negative effect.

In a complementary analysis, Earl and Dardenne (2022) analyze the economic incentives of airlines adding stopovers to direct flights (as opposed to changing existing stopovers on a route) to East or South Asia. They focus on a scenario where all departing flights from the EEA are regulated under the EU ETS (full scope limited to departing flights). They show, via simulation, that the additional costs of circumventing EU climate policy (i.e., extra costs for fuel, crew, and aircraft), coupled with the demand loss expected from the increased travel time, would exceed the potential gains from avoiding EU ETS obligations.

## Conclusion

Decarbonizing the aviation sector remains one of the toughest challenges in climate policy today. The sector's projected growth, combined with the current lack of scalable technological alternatives, makes pricing instruments especially appealing for promoting efficient abatement pathways. Despite the limited scope of existing research, the literature highlights both the potential and the limitations of pricing instruments in aligning the aviation sector with global climate objectives.

Available evidence suggests that pricing mechanisms—such as the EU ETS and ticket taxes—can reduce emissions, primarily by slowing capacity expansion (though not necessarily load factors) and incentivizing operational and technological improvements. Carbon leakage appears to be relatively scarce, though not entirely negligible. Although these effects are generally modest, most studies have analyzed periods characterized by historically low carbon prices. As carbon prices increase and coverage expands, stronger effects may emerge—in terms of both emissions reduction and potential carbon leakage.

Importantly, the distributional concerns that are often associated with pricing instruments are less acute in the aviation sector, where global demand is particularly skewed toward high-income individuals. However, the political economy of aviation regulation—characterized by international coordination challenges and the disproportionate influence of frequent flyers and industry actors—often favors regulatory mandates and soft instruments over robust pricing strategies. The road ahead calls for a more coherent and ambitious integration of carbon pricing tools into aviation policy, supported by the more accurate measurement of non-CO<sub>2</sub> effects, a broader policy scope, and a more critical design of instruments that can address remaining leakage concerns.

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