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Net(-work) Impact of Non-CO_2 Pricing in EU ETS: Demand and Ticket Price Dynamics in Air Transport Across Geographical Scopes

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Abstract

This study examines the airline network effects of possible non-CO_2 climate effect pricing mechanisms under the European Union Emissions Trading System (EU ETS) on air transport demand and ticket pricing. It is focusing on three regulatory scopes: full coverage of all flights including those in and out of the EEA (European Economic Area), a reduced scope limited to intra-European routes and a departure-allocation scope covering outbound flights only. Ticket price adjustments are analyzed using pre-calculated trajectory optimizations that account for varying weather conditions, particularly regarding the formation of contrails. Contrail-induced cloudiness significantly enhances non-CO_2 climate effects increasing costs to different extents depending on the geographical scope of the regulation. Based on these cost increases, demand changes are assessed through passenger preference models that incorporate intra-market dynamics, capturing the competitive and behavioral responses of passengers across different market segments. This analysis provides valuable insights into the interplay between environmental policy and market behavior. It particularly includes mitigation strategies for non-CO_2 impacts, airline pricing strategies, and passenger behavior, offering guidance for the design of effective and equitable climate mitigation measures in aviation by quantifying the demand and network effect of these measures.

Keywords: Non-CO_2 Effects; Aviation; Pricing; EU ETS; Demand; Price Elasticity; Network Effects; Airlines

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1. Introduction

While CO_2 emissions have been the primary focus of environmental regulation in aviation so far, non-CO_2 effects, including contrail-induced cloudiness (CIC) and nitrogen oxides (NO_x), also contribute significantly to aviation's climate impact. Operational mitigation strategies, such as lateral and vertical flight adjustments, can reduce the formation of contrails and thus the climate effect. However, these strategies pose operational challenges, including short-term changes in flight planning and increased costs for airlines, which have been subject to various studies addressing both CO_2 and non-CO_2 effects (e.g., Lührs et al., 2016, Niklaß et al., 2025). Additionally, higher costs and longer flight times may impact airline planning, requiring adjustments in scheduling and network planning. Specifically, these changes may lead to increased ticket prices and various network effects, such as shifting flights temporally and adapting the schedule of an airline to achieve profit maximization with a non-CO_2 climate effect pricing included (Kölker et al., 2024b).

This study explores the potential impacts of integrating non-CO_2 climate effect pricing mechanisms into the EU Emissions Trading System (EU ETS, the cap-and-trade system to limit CO2 emissions via tradable allowances) on air transport demand and ticket pricing. Ticket price changes resulting from non-CO_2 pricing are calculated based on pre-optimized flight trajectories using CO_2e (CO_2 equivalents). Without CO_2e pricing mechanisms, flight re-routing has to balance the trade-off between two conflicting objectives: minimizing operating costs one the one hand and mitigating the climate impact on the other hand (black dots in Figure 1). Introducing CO_2e accounting eliminates this trade-off, transforming decisions into a purely cost-driven approach that incentivize reducing climate impact (red and blue dots in Figure 1). Contrail-forming conditions (see Figure 1b) offer significant CO_2e reduction potential through trajectory adjustments, lowering overall costs despite higher fuel consumption. This highlights the influence of non-CO_2 pricing on individual flights, with variations based on route, weather and departure time and therefore, its implications on broader network-level.

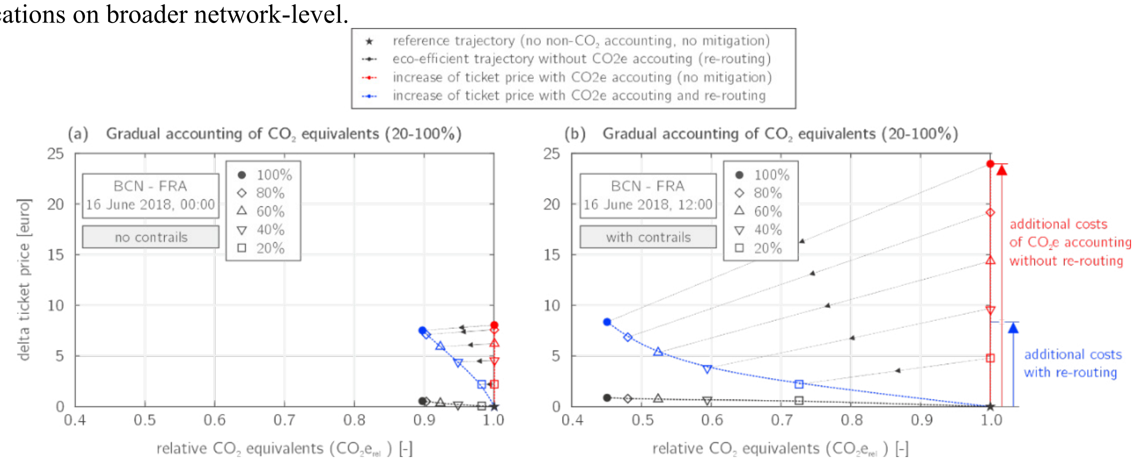

Fig. 1. Impact of CO_2e accounting on ticket prices for varying accounting options (e.g. emitters must hold permits for 20-100 % of the calculated CO_2e emissions) along a mission from BCN (Barcelona) to FRA (Frankfurt) on June 16, 2018 at 00:00 UTC (left, no contrails) and 12:00 UTC (right, with contrails) (adapted from Niklaß et al., 2025)

To evaluate the impact of pricing changes evoked by CO_2e accounting on demand and the airlines' network, passenger preference models are employed. These models capture passenger responsiveness to ticket price variations across different market segments, incorporating factors such as route length, market competition, and substitution effects. The framework includes flexible structures that account not only for the direct influence of attributes but also for more complex relationships between available options to the passengers. We use elasticity models describing the overall elasticity and cross-elasticity between options on the market to describe the spilled and recaptured demand that occur with changing ticket prices. Since structural changes affect all possible choices within the same market rather than a single itinerary, we employ this advanced model to capture more complex dynamics and to relax the assumption of independence of irrelevant alternatives. This approach integrates multi-factorial cross elasticity into the model, describing how demand responds when the prices of competing options change to varying degrees. It also enables the identification of routes where ticket price increases lead to significant declines in passenger volume, particularly in price-sensitive short-haul markets with lower price levels. This enables an adequate assessment of the impact of non-CO_2 climate effect pricing mechanisms on airline costs, as well as their subsequent effects on demand and the airline network. In this study, we analyze a single origin–destination (OD) market to demonstrate the potential of an integrated impact assessment while highlighting the complexity of quantifying both demand effects and airline-network impacts of non-CO_2 pricing.

2. Literature Review

Several studies have examined how climate-related costs reshape air-travel demand and network strategies. Scheelhaase et al. (2010) deduced CO_2 costs within the EU ETS by modelling aviation's inclusion in the EU ETS. They calculated only modest shifts in competitive positions between European and non-European network carriers having less large-scale network overhauls. Ehlers et al. (2024) extended this comparison to projected cost increases under the 'Fit for 55' package.

Beyond climate cost calculation for airlines, in many studies initial demand effects have been derived by employing route-level elasticities. Albers et al. (2009) simulated EU ETS costs at €20 per t CO_2 and estimated per-route cost increases of €9–€27, using these elasticities to quantify marginal demand shifts.

CO_2-pricing mechanisms do not only alter costs and prices but also drive airline-network adjustments by altering cost structures and demand including passenger flows. Pagoni and Psaraki-Kalouptsidi (2016) applied a game-theoretic framework to determine market shares under CO_2 charges, finding fare increases of 1.2–11.8 % and demand reductions of 2.4–21 %, depending on the carbon price. Malina et al. (2012) employed a market-equilibrium model to project EU ETS impacts on U.S. carriers, observing only marginal network adjustments and small competitive distortions. For quantifying the effects of the 'Fit for 55' – package on airline demand, Kölker et al. (2023) used elasticities and cross-elasticities to calculate demand shifts.

Besides CO_2-related effects on demand and airline networks, additional climate impacts—such as those from contrail formation and NO_x emissions—have also been examined in recent studies. Kölker et al. (2024b) analyzed contrail-avoidance rescheduling for North Atlantic flights, demonstrating up to a 20 % reduction in contrail forcing at under a 3 % increase in block hours—indicating that network flows can flexibly integrate climate-driven rescheduling.

3. Methodology

3.1. Network and Fleet Scenario

To assess the impact of non-CO_2 pricing in the EU ETS on airline networks, a network scenario is defined using demand and schedule data (Sabre, 2025). One origin–destination (OD) market is selected, comprising eight possible itineraries and one direct connection. For each route and airline, possible fleet assignments, resulting trajectories, and CO_2e costs are calculated in order to compare their effects on demand and on airline-network indices.

3.2. Modelling of flight trajectories, emissions and non-CO_2 climate effects

The climate impact of the considered flight trajectories is assessed in a three-step modelling chain implemented at German Aerospace Center (DLR). The method consists of trajectory simulation with the Trajectory Calculation Module (iTCM; Linke et al. 2017, Zengerling et al. 2023), emission calculation with the Global Air Traffic Emission Distribution Laboratory (GRIDLAB, Linke et al. 2017, Weder et al. 2025) and climate impact assessment with climate chemistry response model AirClim (Grewe and Stenke 2008, Dahlmann et al. 2016). Firstly, iTCM is applied to generate realistic four-dimensional flight trajectories applying performance data provided by EUROCONTROL Base of aircraft data version 4 (BADA4, Nuic et al. 2010) in a total-energy-model approach. Secondly, resulting flight performance parameters such as speeds, forces and fuel consumption along the trajectories are fed into GRIDLAB to estimate emission flows. While emissions from CO_2 and H_2O are assumed to be proportionate to fuel burn, NO_x emissions are determined applying Boeing Fuel Flow Method 2 (BFFM2, DuBois and Paynter 2006). The emission quantities are stored in a three-dimensional numerical grid representing the basis for the following climate impact assessment. Finally, the resulting emission grids per flight mission are fed into AirClim determining the resulting changes in radiative forcing in dependence of emission quantity as well as lateral and vertical emission location based on pre-calculated values from normalized emissions. The aircraft emissions are treated as pulse emissions under SSP245 background climate conditions and conventional jet fuel (see Dahlmann et al. 2016). Climate mitigation potentials of possible re-routings are estimated based on data from Castino et al. (2024; Tables 3 and 4). The conversion of non-CO_2 effects into CO_2 equivalents and the subsequent monetization are conducted following the methodology outlined by Niklaß et al. (2025).

3.3. Classification of Airline Network Effects

Network effects can be assessed at increasing levels of complexity and dynamics. Assuming a static airline network and considering only route-level effects captures the direct (own-price) elasticity of demand, which measures the sensitivity of demand to ticket-price changes for all connections on the same route, while prices on other routes are unchanged (*Route Dependent Elasticity*). Typical modelled values are around -0.6 to -1.1. In this study an elasticity of –0.89 (Oesingmann and Kölker, 2025) has been applied. However, this route-dependent approach ignores competitive interactions. Demand also depends on competitors' ticket prices on the same market and on market-specific characteristics such as average fare level and fare dispersion (*Market-Dependent Demand Effects*) (see Kölker et al. (2024a) for an introduction to demand shifts and the interdependencies of elasticity and cross-elasticity). To capture network effects appropriately, the airline network must be treated as dynamic (*Airline Network Effects*). In this case, carriers adapt their supply—in terms of routes, departure times, or capacity—in response to fare and demand changes. In the long term, all carriers adjust, leading to a new system-wide equilibrium of airline networks (*System Equilibrium of Airline Networks*). Although this full equilibrium is outside the scope of the present study - which focuses on smaller adaptations by a single OD market - it represents an important aspect for future research. The three approaches – namely *Route Dependent Elasticity, Market-Dependent Demand Effects and Airline Network Effects* - described above are applied here to assess how non-CO_2 pricing, which varies by route according to flight trajectories and emissions, induces ticket-price increases, demand shifts and airline network effects.

3.4. Market Share Model

To calculate the market-dependent demand effects, we use the model proposed by Kölker et al. (2023). Specifically, the model applies route- and market-level elasticities and cross-elasticities based on route and market characteristics. For every route offered by an airline, the increase in ticket price and the resulting spilled demand to other airlines and routes competing in the same market are calculated. However, for all routes, demand can be recaptured if those routes are also confronted with increased prices. The final market share is given by the sum of all spilled and recaptured passengers. This approach considers the context of every alternative offered to the passenger under the framework of *Market-Dependent Demand Effects*.

3.5. Model for Airline Network Effects

To model airline network effects, we computed four structural indices for the complete airline network of major North American and European carriers. The average path length (mean number of segments per passenger itinerary), the Herfindahl–Hirschman Index (HHI, measuring market concentration among competitors), closeness centrality (mean topological distance of each airport to all others) and the clustering coefficient (local robustness of airport linkages) were all calculated. A detailed description of these metrics and their interrelationships is provided in Kölker et al. (2025). Because ticket prices are largely set by airlines' revenue-management algorithms and may not accurately reflect structural shifts, we instead use demand-based indices to capture market dynamics. Accordingly, we regress monthly passenger demand against each network index using airport-level data from 2022 to 2024 for all major North American and European carriers. All four indices exhibit statistically significant correlations with passenger volumes, demonstrating the extent to which the network structure drives the observed demand variations.

4. Use Case and Data

To assess network impacts of non-CO_2 pricing in EU ETS, we analyzed the origin-destination demand for one market and potential passenger routes including a direct connection, various transfer connections via major hubs and conceivable alternatives that are subject to different CO_2 pricing schemes (EU ETS, UK ETS, CORSIA). (Although Turkey is not currently a mandatory participant in CORSIA, Turkish Airlines participates voluntarily. Therefore, a proportionate CO_2 emissions compensation was applied to flights routed via Istanbul).

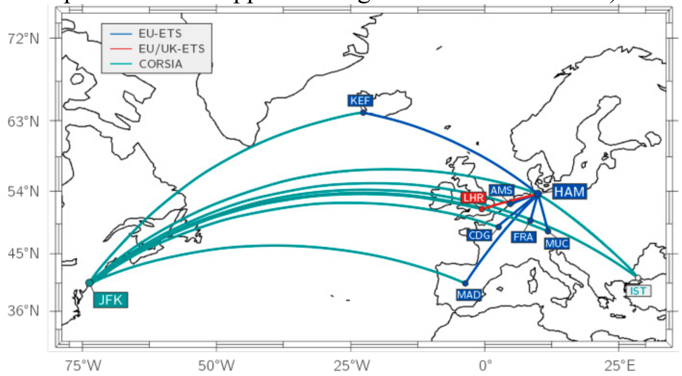

Fig. 2. Network scenario of our study showing: different routing options between HAM and JFK with varying intermediate stops, subject to different CO_2 pricing schemes (EU ETS, UK ETS, CORSIA)

For the OD market from Hamburg to New York, nine potential passenger routes were defined. The data was generated following real-world information but adapted due to availability and reliability. The routes are visualized in Figure 2 and characterized in Table 1. As the paper mainly focuses on network effects, different aircraft types are chosen for trajectory and climate calculations, as these different fleets represent different network structures and hence different network performances and effects. For comparison, two additional fleet scenarios were performed, where all short-haul and all long-haul flights are operated by the same aircraft independently of the airline. In this static-fleet scenario, network effects are driven solely by demand and geographic factors rather than by fleet performance. Since the observed shifts in demand and network structure are not significant, they are not discussed further here. Additionally, ticket prices were based on real 2023 data. However, since not all routes are operated frequently, these prices may not reflect a true market equilibrium. Therefore - and for confidentiality reasons - the average of one year was taken and for routes that haven't been operated frequently, the average over comparable routes from all German airports was assigned within this hypothetical scenario. Because our analysis focuses on relative differences between routes and networks, these adjustments are considered acceptable.

Table 1. Overview Network and Fleet Scenario for roundtrip OD-market Hamburg (HAM) to New York (JFK); with routes via London (LHR), Frankfurt (FRA), Amsterdam (AMS), Munich (MUC), Paris (CDG), Keflavik (KEF), Madrid (MAD) and Istanbul (IST).

Route	Airline	AC Type (short-haul)	AC Type (long-haul)	Ticket Price [EUR]	Geographical Scope
HAM – LHR – JFK	BA	Airbus A320-200	Boeing 777-300ER	660	Full scope
HAM – FRA – JFK	LH	Airbus A321-100	Airbus A340-300	810	Full scope
HAM – AMS – JFK	WA, KL	Embraer 190	Boeing 787-9	720	Full scope
HAM – MUC – JFK	LH	Airbus A320-200	Airbus A340-600	690	Full scope
HAM – CDG – JFK	AF	Embraer 190	Boeing 777-300ER	680	Full scope
HAM – KEF – JFK	FI	Airbus A320neo	Airbus A320-neo	705	Full scope
HAM – MAD – JFK	IB	Airbus A320-200	Airbus A350-900	620	Full scope
HAM – IST – JFK	TK	Airbus A321-100	Airbus A330-300	870	Only HAM – IST in full scope
HAM – JFK	UA		Boeing 757-200	950	Full scope

Non-CO_2 charges were applied to these routes according to their geographical scope. Pricing was assumed to be fully passed through to the ticket price, such that the non-CO_2 charge was reflected as the increase in ticket price in total. In the following study, the network effects of this increase in ticket price due to the non-CO_2 charges was assessed. To do so, we evaluated three regulatory geographical scenarios: (1) a full scope, including all flights regardless of origin or destination; (2) a reduced scope, limited to intra-European flights; and (3) a departure-based approach, attributing emissions to the country of departure. Non-CO_2 charges were estimated per flight based on CO_2 output or fuel burn. Additional fuel costs from climate-optimized rerouting were included, assuming a fuel price of €800 per ton. Emissions charges were modeled under the EU emission trading scheme (EU ETS), UK ETS, and the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Carbon prices were set at €80 per ton for EU ETS and €50 per ton for UK ETS. For international routes falling under CORSIA, we assumed that only emissions above 2019 levels are subject to offsetting. To approximate this, we applied a compensation rate of 30% to total CO_2 emissions per flight and assumed an offset price of €15 per ton of CO_2. Non-CO_2 effects were estimated for the climate metric average temperature response (ATR) over 100 years, with 50% inclusion, and the ETS carbon prices.

5. Results

The findings indicate differences in ticket-price and demand changes between the full-scope, reduced-scope, and departure-allocation scenarios, driven by their sensitivity to climate-mitigation measures. Short-haul intra-European routes with lower market concentration and average ticket prices are more sensitive to price increases, with even moderate cost increments leading to notable demand reductions. However, results depend on the sensitivity of different routes due to varying base fares and geographical characteristics.

Table 2. Resulting differences in ticket price and induced difference in demand for outward and return flights on selected routes, including the impact of different geographical scopes for non-CO_2 pricing.

Route	Geographical Scope	Δ ticket price				Δ demand (route level)	Δ demand (market level)
		Δfuel cost	ΔETS cost	ΔCORSIA cost	non-CO_2 charge		
HAM-FRA-JFK	Full Scope	+12.74 €	+30.96 €	-1.67 €	+50.48 €	-10.2 %	-9.7 %
	Reduced Scope	+0.74 €	+0.07 €	-	+0.67 €	-0.2 %	0.0 %
	Departure Allocation	+6.73 €	+15.47 €	- 0.83 €	+25.29 €	-5.1 %	-4.8 %
HAM-IST-JFK	Full Scope	+3.36 €	+8.65 €	-0.47 €	+16.14 €	-2.8 %	0.3 %
	Reduced Scope	-	-	-	-	0.0 %	0.2 %
	Departure Allocation	+1.68 €	+4.33 €	- 0.23 €	+8.05 €	-1.4 %	0.2 %
HAM-JFK	Full Scope	+10.94 €	+28.18 €	-1.52 €	+61.13 €	-9.2 %	-9.7 %
	Reduced Scope	-	-	-	-	0.0 %	0.2 %
	Departure Allocation	+5.47 €	+14.09 €	- 0.76 €	+30.78 €	-4.6 %	-4.8 %

Table 2 shows the differences in ticket prices for three routes, including the resulting change in demand at the route level and when all routes on the market are considered simultaneously (market level). In general, the highest non-CO_2 costs are applied in the full-scope scenario, as all flights are charged in this scenario, whereas in the departure-allocation calculation, only outbound flights are considered. The direct route HAM-JFK has higher costs due to its different trajectory and different operated aircraft types with a smaller number of seats. However, because of higher ticket prices in general for the direct flight, the relative difference in demand is smaller compared to most connecting routes and even smaller at market level. This effect is evident for all routes (Figure 3). Nevertheless, the route via Munich shows the highest relative ticket-price increase, with an even larger demand decrease at market level. This is driven by the relatively low base fare and therefore higher relative price increase. The same applies for the route via Madrid. The reduced-scope scenario mitigates some of these impacts but limits the overall environmental benefit by excluding international flights, where non-CO_2 effects are most pronounced. It also reduces the cost burden on airlines, depending on the proportion of intra-European flights (subject to CO_2e pricing) versus international flights (which are not). This results in the highest relative price increase and therefore demand decrease for the route via Keflavik. For the routes via Istanbul and the direct route, a small positive effect in terms of demand is even visible in this scenario. In the scenario where charges are applied based on whether the departure is in the EU, the results are similar, with a small advantage at market level for the direct route and a disadvantage in terms of competitiveness for the routes via Munich and Madrid.

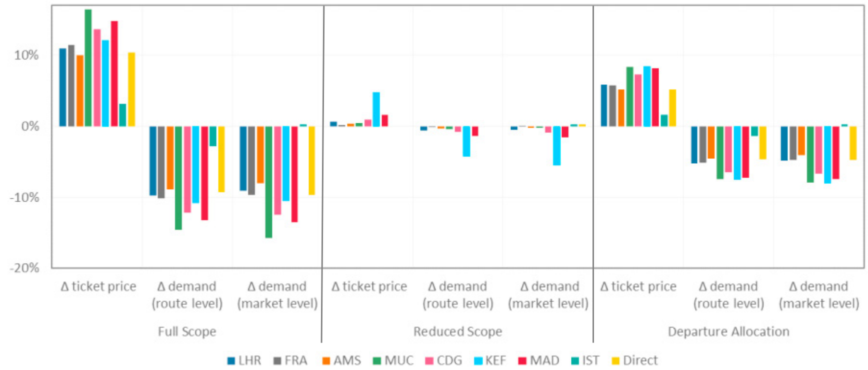

Fig. 3. Network effects as changes for ticket prices, demand on route level and demand on market level for all three different geographical scopes and all nine routes between Hamburg and New York with varying transfer options

These results indicate the high variance of changes in demand arising from non-CO_2 charges based on market structure, route characteristics, and overall network competitiveness. The same applies to long-term topological and structural changes in the network. Figure 4 shows the changes in network indices. Obviously, if demand decreases, the weighted shortest path decreases as the proportion of passengers flying direct increases compared to transfer options, as seen in the single-market results above. The average across all airports includes a huge proportion of spoke airports with a greater decrease in passenger path length. Additionally, closeness centrality increases, meaning the airports become more central in the network. This effect is more pronounced for London and New York. Nevertheless, for most airports we see a decreasing HHI. Several countervailing trends are at play: higher ticket prices and lower demand normally correlate with higher HHI; however, due to higher ticket prices for all competitors, the market becomes more balanced, which offsets the effect of higher prices. Finally, for all hubs we observe a large increase in clustering coefficient, meaning that the airport's immediate neighbors are more densely interconnected, whereas for most other airports the trend is the opposite.

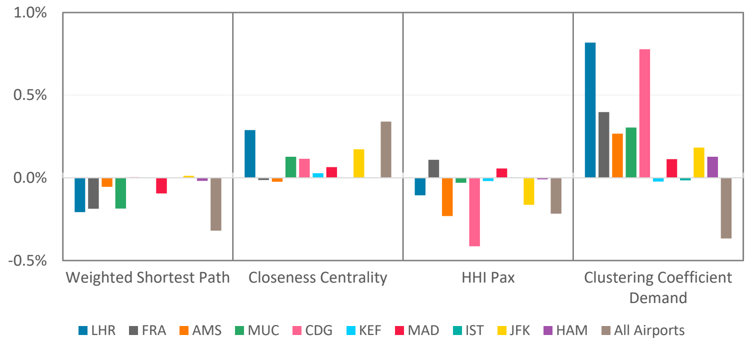

Fig. 4. Network effects as changes for network indices for all routes

6. Summary

In this analysis, a variety of sophisticated and complex models - including airline network models, trajectory calculation models, climate cost models, and passenger preference models - have been used to analyze possible non-CO_2 charges in the EU ETS for three geographical scopes. These charges are analyzed in the context of possible absolute charges, ticket price increases as well as demand and airline network changes. We found varying costs highly dependent on route and operated fleet, inducing even more differentiated effects in ticket prices and demand. From the airline network perspective, this correlates with shorter paths and increased airport centrality and clustering. Future work should explore whether results hold across additional markets.

However, this study highlights the trade-off between environmental impact and economic feasibility. The findings illustrate the feasibility of internalizing non-CO_2 costs into airline pricing, while the analysis of demand and ticket prices underscores the importance of integrating these measures into airline market strategies.

References

Albers, S., Bühne, J. A., Peters, H., 2009. Will the EU-ETS instigate airline network reconfigurations?. Journal of Air Transport Management 15(1), 1–6. doi: 10.1016/j.jairtraman.2008.09.013.

Castino, F., Yin, F., Grewe V., Yamashita, H., Matthes, S., Dietmüller, S., Baumann, S., Soler, M., Simorgh, A., Mendiguchia Meuser, M., Linke, F., Lührs, B., 2024. Decision-making strategies implemented in SolFinder 1.0 to identify eco-efficient aircraft trajectories: application study in AirTraf 3.0. Geoscientific Model Development 17(9), 4031–4052. doi: 10.5194/gmd-17-4031-2024.

Dahlmann, K., Grewe, V., Frömming, C., Burkhardt, U., 2016. Can we reliably assess climate mitigation options for air traffic scenarios despite large uncertainties in atmospheric processes?. Transportation Research Part D: Transport and Environment 46, 40–55. doi: 10.1016/j.trd.2016.03.006.

Ehlers, T., Kölker, K., Lütjens, K., 2024. The Route Specific Cost Impact of the European Union Fit-For-55-Measures and their Effect on Air Travel Demand. 27th ATRS World Conference.

DuBois, D., Paynter, G. C., 2006. "Fuel Flow Method 2" for Estimating Aircraft Emissions. SAE Transactions 115, 1–14. doi:10.2307/44657657.

Grewe, V., Stenke, A., 2008. Airclim: an efficient tool for climate evaluation of aircraft technology. Atmospheric Chemistry and Physics 8 (16), 4621–4639. doi:10.5194/acp-8-4621-2008.

Kölker, K., Ehlers, T., Lütjens, K., 2023. Preisinduzierte Nachfrageveränderungen durch Fit-for-55-Instrumente in der Luftfahrt. Wirtschaftsdienst 103 (10), doi: 10.2478/wd-2023-0192.

Kölker, K, Lütjens, K., Gollnick, V., 2024a. Analyzing global passenger flows based on choice modeling in the air transportation system. Journal of Air Transport Management 115. doi: 10.1016/j.jairtraman.2023.102530.

Kölker, K., Zengerling, Z., Kühlen, M., Lütjens, K., Linke, F., 2024b. Assessing the Impact of Contrail Avoidance through Rescheduling on Airline Network Flows: A Case Study of North Atlantic Flights. Transportation Research Part A: Policy and Practice 187. doi: 10.1016/j.tra.2024.104155.

Kölker, K., Stoebke, E., Lütjens, K., 2025. In the Flow of Connectivity: A Dynamic Network Exploration of Europe's Air Transportation System. Journal of the Air Transport Research Society 3. doi: 10.1016/j.jatrs.2024.100055.

Linke F., Grewe V., Gollnick V. 2017. The Implications of Intermediate Stop Operations on Aviation Emissions and Climate. Meteorologische Zeitschrift 26 (2). doi: 10.1127/metz/2017/0763.

Lührs, B., Niklaß, M., Froemming, C., Grewe, V., Gollnick, V., 2016. Cost-Benefit Assessment of 2D- and 3D Climate and Weather Optimized Trajectories, AIAA 2016. doi: 10.2514/6.2016-3758.

Malina, R., McConnachie, D., Winchester, N., Wollersheim, C., Paltsev, S., Waitz, I. A., 2012. The impact of the European Union Emissions Trading Scheme on US aviation. Journal of Air Transport Management 19, 36–41. doi: 10.1016/j.jairtraman.2011.12.004.

Niklaß, M., Zengerling, Z., et al., 2025. Implementing Non-CO2 Policies in Aviation: Strategies to Address Uncertainties and CO2e Pricing in Flight Planning, Transport Policy. (in publication).

Nuic, A., Poles, D., Mouillet, V., 2010. Bada: An advanced aircraft performance model for present and future atm systems. Int. J. Adapt. Control Signal Proces 24, 850–866. doi:10.1002/acs.1176.

Oesingmann K., Kölker, K., 2025. Price Elasticities in Aviation: Novel Estimates from Structural Gravity Modelling and Instrumental Variables Approach. Euro Working Group on Transportation 27th Annual Conference. (submitted)

Pagoni, I., & Psaraki-Kalouptsidi, V., 2016. The impact of carbon emission fees on passenger demand and air fares: A game theoretic approach. Journal of Air Transport Management 55, 41–51. https://doi.org/10.1016/j.jairtraman.2016.04.004.

Sabre, 2025. Sabre AirVision Market Intelligence. Sabre Airline Solutions. www.sabreairlinesolutions.com.

Scheelhaase, J. D., Grimme, W., Schaefer, M., 2010. The inclusion of aviation into the EU emission trading scheme—Impacts on competition between European and non-European network airlines. Transportation Research Part D: Transport and Environment, 15(1), 14–25.

Weder C. M., Linke F., Gelhausen M., 2025. DLR 3D emission inventory for worldwide passenger air traffic and a forecast scenario of traffic volume and emissions until 2050. (in preparation).

Zengerling, Z. L., Linke F., Weder, C. M., Dietmüller S., Matthes S., and Peter, P., 2023. Flying low and slow: Application of algorithmic climate change functions to assess the climate mitigation potential of reduced cruise altitudes and speeds on different days. Meteorologische Zeitschrift 33 (1), 1–15. doi: 10.1127/metz/2023/1194.

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