1. Background and Introduction

1.1 In January 2021, the Thessaloniki Forum adopted a paper which provided an overview of existing airport charging variations for environmental reasons. The paper also provided recommendations on principles for relevant, objective and transparent variation for issues of environmental interest, specifically CO2 emissions-related, noise-related, NOx emissions-related, charging schemes modulated, and other types of environmental variation of charges. The paper also considered cost relatedness in the context of environmental variations, the consultation process, and the possible assessment of the impact of the modulation, societal or otherwise. At the time of that paper's adoption, noise and NOx related charges were being applied at several member state airports. However, only one charging mechanism related to CO2 was in place, at Stuttgart Airport (STR), which had introduced a discount for aircraft using a certain percentage of alternative fuels or electric-powered flying.

1.2 The purpose of this paper is to update the January 2021 paper by including examples of new environmental legislation and new case studies of environmental and climate modulations of airport charges. In relation to new legislation, the paper includes an assessment on whether there is an impact on the ISA's oversight role in relation to airport charges and how the legislation addresses any such impact. Of the seventeen Member State ISAs that responded to the questionnaire on airport charges modulation for environmental reasons, six had examples of new modulations introduced since the previous environmental modulation paper was published in 2021.

1.3 In addition to the discussion on newly introduced modulations, this paper also includes a discussion on the different considerations when designing a modulation, including whether to use a standalone charge or a bonus-malus system. It also assesses the relationship between modulation and non-discrimination. Further to this, the paper also includes a comparative analysis of the charging schemes of 7 European Airports and the impacts of those charges (and the environmental variations present at those airports) on charges to be paid for 4 different aircraft pairings. This is to provide some insight into the scale of the current impact on airport charges of operating relatively less polluting aircraft compared to more polluting aircraft, while holding all else equal.

1.4 This paper also considers the role of the ISA regarding environmental variation and investments, including the current practice of ISAs with respect to environmental modulations and the capacity and capability of ISAs to supervise environmental modulations.

1.5 A questionnaire was shared with ISAs which requested information on new environmental legislation and airport charges modulations since the previous environmental modulations paper was developed. Seventeen ISAs responded to the questionnaire and their answers provided the foundation for this paper.

1.6 This paper has been produced by the 2023 Working Group of the Thessaloniki Forum of Airport Charges regulators, taking into consideration the views of the airport and airline communities. The ISAs who participated in the preparation of this paper are those of Denmark, France, Ireland, The Netherlands and Sweden.

1.7 This paper has been adopted by the Thessaloniki Forum in December 2023.

Caveats

1.8 The recommendations do not represent the views of the European Commission and do not in any way change the requirements of the ACD.

1.9 The scope of this paper does not include arriving at a position on whether the ACD should be reviewed, or that environmental variation of airport charges should be mandatory, or to the contrary, restricted.

1.10 This report should not be used as a limitation or constraint for Member States to apply their own methodologies when circumstances, regulation or other causes recommend it.

1.11 These recommendations will be kept under review and changed as and when deemed necessary by the Thessaloniki Forum.

2. Developments in environmental legislation since 2021

2.1 This section describes newly introduced or amended national legislation since January 2021 concerning the modulation of airport charges for environmental and climate purposes and investments for the greening of airports. In total, we have identified three examples of new national legislation.

2.2 In France, the civil aviation authority is responsible for the acoustic classification. In 2021, the authority published an updated acoustic classification in an administrative order[1], which must be used by almost all regulated airports in France. The new acoustic modulation is better suited to today's fleet of aircraft, because aircraft movements are more evenly spread across the groups in the updated classification. Under the previous classification, more than 85% of all aircraft movements fell under the quietest acoustic group, providing little incentive to update fleets to quieter aircraft.

2.3 In Sweden, an additional prerequisite regarding environmental modulation was introduced in the national legislation on airport charges in 2021. This prerequisite requires charges relating to the take-off or landing of aircraft to be differentiated according to the climate impact of the aircraft (specific climate impact levels are not defined). The differentiation must be made so that the climate impact of aviation is reduced. Following the introduction of the law, and in consultation with users, Swedavia decided to introduce a CO2 emission charge. This charge exempts fully electric aircraft powered by battery or fuel-cells from take off charge at their airports, however, no exemption is made for hybrid aircraft.

2.4 In Ireland, legislation introduced at the end of 2022 has established new statutory objectives for the ISA. The ISA must now pay due regard to the environmental and sustainability policies of the state when determining the maximum levels of the airport charges at Dublin Airport. Therefore, any future government policies in respect of, for example, environmental modulations, would need to be considered by the ISA when making a future determination.

2.5 The ISAs all noted that there are currently no specific plans for future legislation. However, the Spanish ISA noted that legislation will be introduced once the European legislation developing the “Fit for 55 measures applicable to air transport” comes into force.

2.6 The examples in this section show that new legislation can be diverse. It can amend existing charging schemes or require an airport to introduce new charging schemes considering environmental and climate objectives. In these examples, there are no changes in the formal role of the ISA.

2.7 Another approach, that we see in the Irish example, is that the scope of the assessment of the ISA is broadened. The ISA is required to take into account certain environmental and sustainability policies when assessing the airport charges. This option allocates

[1] Arrêté du 8 septembre 2021 modifiant l'arrêté du 24 janvier 1956 relatif aux conditions d'établissement et de perception des redevances d'atterrissage et d'usage des dispositifs d'éclairage sur les aérodromes publics and arrêté du 21 mars 2022 relatif à la classification acoustique des aéronefs mentionnée à l'article L. 422-56 du code des impositions sur les biens et services à prendre en compte pour le calcul de la taxe sur les nuisances sonores aériennes.

more responsibility to the ISA.

3. New climate and environmental modulations

3.1 A variety of approaches exist in respect of the variation of airport charges for environmental reasons across airports. Not all airports currently apply such variations, but many do. This section provides new case studies of variations in charges for environmental reasons. The three types of variation identified in this assessment are in relation to noise, nitrogen oxides (NOx), and carbon dioxide (CO2).

3.2 The noise-related charges in airport charging strategies typically seek to incentivise airlines to use quieter aircraft. The design and complexity of the charges vary considerably across airports (even at national level) in regard to size, application, and time of day in which they apply. For example, one airport might apply noise charges at night to incentivize daytime flights, while another might levy noise charges on noisier aircraft to incentivise the use of quieter aircraft, or utilize both approaches. There are therefore a variety of approaches to applying noise related charges. Three airports that introduced noise modulations were included in the cases studies, while information on a fourth airport was provided to the drafting team at a later date.

3.3 Two airports that have introduced NOx emissions-related charges variation were also present in the case studies. These are additional to the four examples identified in the previous paper. In both examples, the charges are applied to Landing and Take-off charges for each aircraft with the aim of reducing overall NOx emissions at the airports by charging higher charges for aircrafts with higher NOx emissions.

3.4 This paper also contains two examples of variations related to CO2 emissions, which are additional to the one identified in the previous paper.

3.5 Of the seventeen ISAs that responded to the questionnaire on airport charges modulation for environmental reasons, six identified newly introduced modulations since the previous environmental modulation paper was published in 2021. The details of the modulations are summarised below.

The scope of the new environmental and climate modulations

3.6 The new modulations differ considerably from each other in scope, design, and intent, and, as noted above, can be grouped into three modulation types: NOx, noise, and CO2.

3.7 Both Brussels Airport and Amsterdam Airport Schiphol have amended their existing landing and take-off charge formulae to include a modulation for NOx emissions. These modulations increase Landing and Take-off charges for each aircraft depending on the NOx emissions of that aircraft, and will run for several years.

3.8 Amsterdam Airport Schiphol has also modified its existing noise modulation to further reduce landing and take-off charges for quieter aircrafts. Noise related charges were also introduced at Dublin Airport, Luxembourg Airport, and at several Portuguese airports. At Dublin Airport, a noise related charging modulation system was introduced in 2022, based upon a noise quota count. The charge is intended to mitigate the level of night-time aircraft noise. At Luxembourg Airport, a landing and take-off charge - which includes an environmental factor - was introduced. It varies depending on the

maximum take-off weight of the aircraft, the type of operation (passenger/cargo), the time (day/night), and a noise factor that reflects the aircraft's individual noise performance. In April 2023, the largest Portuguese airport managing body (ANA) introduced a modulation to the landing charges at Lisbon, Porto, Faro, Azores, and Madeira Airports. The modulation varies the charge according to the noise level and maximum take-off weight of each aircraft landing at the airport.

3.9 In France, two new modulations have been introduced at two different airports. The airport operator at Cannes Airport has introduced a modulation for the use of electric airplanes which reduces landing fees based on the weight of the airplane. However, this modulation is marginal, as it only applies to small planes flying to an airport without scheduled services. The airport operator at Lyon airport introduced a CO2 modulation in 2021 which reduces or increases landing fees depending on CO2 emissions.

3.10 A CO2 related modulation was also introduced at Stockholm Arlanda and Göteborg Landvetter Airports based on the CO2 emissions of the aircraft, according to the ICAO engine emissions database. The modulation is designed to be revenue neutral for the airport operator and to incentivise airlines to continuously decrease their CO2 emissions.

The functions and objectives of the charges

3.11 The objectives of the airports that have introduced NOx modulations are broadly similar. The modulation at Brussels Airport ensures that aircraft with engines showing lower standard NOx emissions pay lower landing and take-off charges, with the objective of incentivising a change to more environmentally friendly aircraft operated at Brussels airport, by the end of the regulated period (2028). Amsterdam Airport Schiphol is seeking to reduce NOx emissions as part of a government initiative to lower total national NOx levels. The airport needs to comply with an emissions ceiling. The objective of the modulation is therefore to have airlines consider NOx-emissions when allocating aircraft at the airport.

3.12 The CO2 modulations at both Stockholm Arlanda Airport and Göteborg Landvetter Airports, and Lyon airport, operate on a bonus/malus system and are revenue neutral for the airports.[2] The objectives of the modulations are to incentivise airlines to improve their CO2 efficiency.

3.13 For the airports that have introduced or amended noise modulations, the objective is to penalise the noisiest flights (specifically night time flights in one instance), while incentivising airlines to use the quietest possible aircraft. In Dublin Airport, this has taken the form of a quota count (QC) system for both arrivals and departures which varies according to the aircraft, the type of engine used and the maximum take-off weight, as well as any modifications that affect the noise of the aircraft. Only aircraft operating at night currently pay this charge. The charge will be based on a set fee per

[2] Swedavia calibrates the CO2 Emission Charge with each price decision based on the upcoming year's expected traffic pattern to ensure that the charge is kept relevant.

tonne and will be revenue neutral, as it comes within the scope of the annual price cap.

3.14 In contrast, Amsterdam Airport Schiphol has modified the existing noise modulation included in its Landing and Take-off Charge for 2022-2024. More detail on this change is provided in table 1 below, which shows the current modulation (2022-2024) compared to the old modulation (2019-2021). Category S1 is the noisiest category, whereas Category S7 is the least noisy category.

Table 1: Change to the Amsterdam Airport Schiphol noise modulation

Landing and take-off charges (%)		Category S1			Category S2			Category S3		
		Day	Night		Day	Night		Day	Night	
		Landing/ take-off	Landing	Take-off	Landing/ take-off	Landing	Take-off	Landing/ take-off	Landing	Take-off
Connected Handling	New (2022-2024)	200%	500%	600%	145%	225%	250%	100%	140%	165%
	Old (2019-2021)	180%	457%	540%	135%	189%	223%	100%	127%	150%
Disconnected Handling	New (2022-2024)	160%	400%	480%	116%	180%	200%	80%	112%	132%
	Old (2019-2021)	144%	366%	432%	108%	151%	179%	80%	102%	120%
Cargo	New (2022-2024)	104%	260%	312%	75%	117%	130%	52%	73%	86%
	Old (2019-2021)	94%	238%	281%	70%	99%	116%	52%	66%	78%

Landing and take-off charges (%)		Category S4			Category S5			Category S6			Category S7		
		Day	Night		Day	Night		Day	Night		Day	Night	
		Landing/ take-off	Landing	Take-off	Landing/ take-off	Landing	Take-off	Landing/ take-off	Landing	Take-off	Landing/ take-off	Landing	Take-off
Connected Handling	New (2022-2024)	80%	120%	145%	65%	100%	120%	50%	80%	95%	40%	65%	75%
	Old (2019-2021)	85%	108%	128%	70%	89%	105%	55%	70%	83%	45%	57%	68%
Disconnected Handling	New (2022-2024)	64%	96%	116%	52%	80%	96%	40%	64%	76%	32%	52%	60%
	Old (2019-2021)	68%	86%	103%	56%	71%	84%	44%	56%	66%	36%	46%	54%
Cargo	New (2022-2024)	42%	62%	75%	34%	52%	62%	26%	42%	49%	21%	34%	39%
	Old (2019-2021)	44%	56%	67%	36%	46%	55%	29%	36%	43%	23%	30%	35%

Source: The Netherlands Authority for Consumers & Markets

3.15 Table 1 shows the percentage of the base Landing and Take-off charge an airline has to pay, depending on the type of handling, landing or take off, time of the day (day or night) and the noise category. The percentages for the noisier categories under the new scheme have increased, while the percentages for less noisy categories have decreased. Furthermore, night flights have become relatively more expensive across all categories. Besides this, Amsterdam Airport Schiphol has also revised the classification of noise categories, making them stricter. Several more types of aircraft now fall under a higher noise categorisation than before. The combination of these changes gives airlines a stronger incentive to use quieter aircraft.

3.16 At the Portuguese airports, the modulation is intended to encourage the use of aircraft with better environmental performance by applying a discount to the landing charge for the aircraft with better noise performance and a penalty on the aircraft with worse noise performance.

Implementation of environmental modulations at airports

3.17 ISAs were asked how the airports are implementing modulations in relation to environment, but also in relation to the ACD criteria (e.g., consultation, non-discrimination, relevance, objectivity, and transparency). Their responses are outlined below.

3.18 The Belgian ISA noted that it was provided with information demonstrating how the modulation meets the traditional ACD criteria of non-discrimination, objectivity, transparency, and also that it was revenue neutral.

3.19 The French ISA confirmed that in its assessment of the modulation, it checked whether

the modulation followed the criteria mandated by the relevant national legislation, including whether it used transparent and objective criteria and whether it was proportionate to its climate objective. It confirmed that it was.

3.20 The Irish ISA noted that the charge related to the specific issue identified, in this case, noise levels, and that the charges levied to airlines will depend on the noise levels of the aircraft. It also noted that the charge will form part of the overall maximum level of Airport Charges, or price cap, which is objectively set by the ISA on a cost-related basis, and that it has been implemented transparently through consultation and publication of information. It noted that no airport user objected to the proposal in consultation, and that none have made a complaint in relation to it.

3.21 The ISA from the Netherlands noted that it ensured that the modulation was non-discriminatorily imposed on all users but also noted that indirect discrimination can be justified by an environmental objective. It further stated that it ensured that the charge is "relevant" and noted that relevance is achieved if the charge is related to an environmental objective and/or is in line with the polluter pays principle. It also ensures that the charge is modulated according to objective and transparent criteria.

3.22 The Swedish ISA noted that it assessed the modulation in regard to ACD article 3 (non-discrimination), as well as in regard to effectiveness of the climate objectives. The result of the investigation was that the modulation met the criteria and therefore is considered effective, as intended by the legislator.

3.23 The Portuguese ISA noted that before approving the charge it ensured that it was revenue neutral. It also assessed whether it would be discriminatory in any way by analysing the impact on the main users of Portuguese airports at each airport. The ISA also confirmed that it ensured that the consultation process for the modulation had complied with Article 6 of the ACD.

4. Modulation design and implementation

General considerations

4.1 The aviation sector generates positive social externalities, however, the sector also generates negative environmental externalities which directly affect other parties. The residents surrounding airports are affected by local air or noise pollution, while the entire globe is impacted by greenhouse gas emissions. Non-pecuniary externalities represent a market failure for which public intervention may be appropriate and which could potentially improve social welfare.

4.2 The internalization of external costs is well established in economic theory. Internalization mechanisms aim to ensure that actors account for the impacts that their decisions generate. The mechanisms do this by sending a price signal to actors that encourages them to adapt their behaviour, in particular, to reduce practices which are undesirable from a collective point of view. Aside from the question of whether, in principle, modulating airport charges is likely to be an effective or optimal approach to internalising a given externality, which is discussed in section 6, considering the modulation from the perspective of internalising external costs is a good way for ISAs to judge the design, proportionality, and objective justification of charging modulation.

4.3 An externality can be considered fully internalized when its full cost is borne by polluters, so that it is not “external” anymore. The economic efficiency of an internalization mechanism can be assessed by comparing the magnitude of the resulting price signal to the shadow value of the externality. These shadow values are determined by economic research and can generally be found in reference value tables compiled by institutional guides produced by the relevant public bodies.

4.4 If the price signal reflects the shadow values of all the externalities produced by airport activities, environmental impacts are therefore reduced, and collective welfare maximised, by moving the market equilibrium from the competitive equilibrium (naturally reached in a competitive market without public intervention) to the social optimum.

4.5 In the aviation sector, three economic effects are expected from internalization mechanisms. The airlines should be incentivized to adapt their behaviours:

1. To renew their fleets with less polluting aircraft, as long as the collective benefit resulting from the decrease of pollution is greater than the cost borne by the airlines to replace the aircraft;

2. To decrease the number of flights, when the willingness to pay of the passengers and freight loaders is not sufficient to also cover the external costs, and/or alternative modes become more profitable than flights (modal shift);

3. To account for local nuisances when allocating their fleets by using less locally polluting aircraft at airports where the external costs of local population are relatively higher (e.g. at airports near more densely populated residential areas).

4.6 Airport charge modulation is one among many other potential internalization mechanisms. If well designed, a modulation penalizes the more polluting aircraft and benefits the less polluting ones, and thus encourages airlines to renew their fleets (effect 1). But, as will be explained later in this chapter, charge modulations should be revenue neutral in the context of cost oriented airport charges. Therefore, unlike certain other internalisation mechanisms, airport charge modulations do not change the average cost of aviation transport and cannot alone generate the socially optimal level of traffic (effect 2).[3] Lastly, charge modulation can contribute to reducing local nuisance as long as the external costs of this nuisance vary between airports (effect 3).

4.7 This chapter first evaluates different considerations when designing a modulation, including whether to use a standalone charge or a bonus-malus system. It then assesses the relationship between modulation and non-discrimination. The final subsection of the chapter lays out an analytical comparison of how modulation is currently used at different European airports.

Considerations on modulation design

4.8 As already stated in the first report "Airport Charges and Environmental issues and considerations", environmental modulations should be effective in achieving an intended outcome, which should be clearly defined by the airport.[4]

4.9 Theoretically, a charge modulation may be considered effective if it contributes to reaching the environmental objective pursued, as set by the airport or the legislation. For example, an effective noise modulation should lead to a lower degree of noise disturbance of residential amenity resulting from aircraft at the airport, compared to the situation without the modulation.

4.10 In this subsection, several principles and ideas are discussed for the modulation of airport charges for environmental and climate purpose. We will limit the discussion to the environmental and climate impact of noise, CO2, and NOx.

Revenue neutrality as a basic principle

4.11 A general principle of airport charges regulation is the prevention of the abuse of a dominant position. This means that the total charges should be cost oriented. Any modulation of the charges should therefore not increase the total revenue of the airport operator. Hence, modulations should be revenue neutral. As a result, modulations do not change the total average cost of aviation transport for passengers and freight, and therefore cannot alone contribute to achieving the socially optimal level of air traffic, or shift between alternative forms of transport (effect 2).[3]

4.12 Since the airport charges cannot cover more than the business costs attributable to the airport services, a modulation is, from an economic perspective, not always the most appropriate mechanism to fully internalize the external costs. If it is desired that

[3] Note that some ISAs may have no role in assessing or determining the socially optimal level of air traffic.

[4] See Thessaloniki Forum of airport charges. Airport Charges and Environmental issues and considerations", January 2021, recital 3.7.

these costs should be covered as well, other mechanisms could be more efficient, such as taxes or emission permits. However, that decision may need to be taken at a legislative level.

Standalone charge or bonus/malus

4.13 In practice, there are different options available when modulating airport charges, such as using a system of standalone charges, employing a bonus malus system, or a combination. An example of a standalone charge is the quota count (QC) system that is applied at Dublin Airport, where a specific noise charge is applied to an aircraft based on engine noise levels. An example of a bonus malus system is the modulation system that is applied at Lyon Airport, wherein landing charges are either increased or decreased depending on the CO2 emissions of the aircraft. Detailed explanations of both examples can be found in the appendix to this paper.

4.14 From a position of revenue neutrality, it does not matter whether an airport chooses a standalone charge or a bonus malus system in which the average amount of pollution modulates the standard charge, as both systems are revenue neutral.

Considerations behind the chosen tariff driver

4.15 Another consideration in modulation design is choosing the correct tariff design to achieve the desired outcome.

4.16 The most frequently used aircraft related charging parameter (by tonne of weight) may not correlate with the level of pollution. For example, an airport may wish to lower noise levels by using a modulating coefficient to adjust an existing charge (e.g., landing or take-off). In this case, if two aircraft have the exact same noise output, but one is heavier than the other, the modulating coefficient will result in the heavier aircraft paying more if the modulating coefficient is greater than 1 (or less if the modulating coefficient is less than 1) for its noise output than the lighter one, whereas their environmental impact is exactly the same.

Hypothetical numerical example.
Let's consider an environmental modulation (noise or any other form) based on a percentage coefficient and two aircraft, A and B, with the exact same environmental characteristics and operating the exact same LTO cycle at this airport, except one has a higher MTOW than the other. The following table presents the numerical assumptions and calculates the bonus/malus for each aircraft.

Aircraft	*MTOW (tons)*	*Standard charge (€)*	*Pax*	*Level of pollution*	*coefficient of modulation*	*bonus / penalty (€)*
Aircraft A	*150*	*750*	*150*	*3*	*2 %*	*15*
Aircraft B	*200*	*1000*	*150*	*3*	*2 %*	*20*

The two aircraft are in the exact same situation regarding relevant characteristics, especially environmental ones, but the maluses they must pay are different. This is due to the fact that the formula of the modulation includes the MTOW of the aircrafts, which is not linked to the environmental objective.

4.17 From an environmental modulation perspective, the Forum therefore recommends using tariff drivers that are directly related to the level of pollution. Percentage

coefficients to modulate existing charges should be avoided in a scenario where they would produce an outcome similar to the table above. Good practice would be to calculate environmental rewards, penalties, or standalone charges directly in euros (or otherwise in the national currency, where applicable).

4.18 Moreover, when designing a modulation, the tariff driver should be carefully chosen to optimally differentiate aircraft based on their environmental performance. Using a measure of the pollution emitted by an aircraft directly may not be optimal depending on the characteristics of the charging system. For example, as demonstrated in the box below, it could incentivise airlines to use a larger number of smaller and less polluting aircrafts to limit their exposure to the modulation, even if the total amount of pollution is increased.

Hypothetical numerical example.
Let's consider a revenue neutral environmental modulation (noise or any other form) driven by the level of pollution P of the aircraft: malus in euros = P – 125. A company wishing to fly 100 passengers could have two options presented in the following table:

Option for the company	***Offered seats***	***Level of pollution***	***Malus (€)***
1 – One "big" aircraft	*100*	*150*	*150 – 125 = 25 €* *i.e malus of 25 €*
2 – Two "small" aircraft	*50 each* *i.e total of 100*	*100 each* *i.e total of 200*	*For each aircraft : 100 – 125 = – 25 €* *i.e total bonus of 50 €*

100 passengers travel in both options. The total amount of pollution is higher in option 2, but the company would benefit of a bonus of €50 as a result of the modulation, whereas option 1 would be charged a malus of €25. The price signal sent in such case is badly designed since it potentially incentivizes companies to use a larger number of aircrafts and increase the total amount of pollution.

4.19 Pollution ratios should be preferred, because they more strongly correlate with the environmental impact of flights. For example, for passenger flights, the ratio of CO2 emissions per offered seat used by Lyon airport can be a good tariff driver. In particular, a charge modulation based on a ratio between the level of pollution and the capacity of the aircraft in terms of number of seats or cargo units may be suitable as it gives a strong incentive to optimize the seating arrangement of the plane and to use more efficient aircrafts in addition to reducing emissions or noise. For noise, a further refined modulation for flights at daytime or night-time can be considered depending on local demands.

4.20 Other ratios can also be considered, such as the emissions per passenger or per cargo unit actually transported. Indeed, the disadvantage of ratios based on the capacity is that they do not account for the *actual* use of the aircraft's seat or cargo capacity. Furthermore, the capacity of passenger aircraft could vary between the same type of aircraft, depending on the seating arrangements. On the other hand, a modulation based on a ratio per passenger or cargo unit actually transported would also incentivize efficient use of the maximum capacity of the aircraft and consider the capacity actually used.

Measuring the quantity of pollution

4.21 Another consideration is the measurement and assessment of the environmental impact. This can be technically challenging. For instance, noise modulations are often based on the type of aircraft, but the noise perceived by residents also depends, among other things, on the aircraft's trajectory and engine thrust settings. The total impact on residents will also vary according to population density, quality of housing, etc. Therefore, quantifying the impact of environmental disturbance requires data and expertise that may not be readily available to the airport operator or the ISA.

4.22 In general, the Forum sees that most airports use standardized measurements of emissions. For noise charges, the effective perceived noise in decibels (EPNdB) is typically used, in accordance with ICAO document Annex 16, Volume I, Chapter 3. For NOx charges, emission values of NOx are used in accordance with ICAO Annex 16, Volume II. For CO2 charges, emission values of CO2 are used in accordance with ICAO Aircraft Engine Emissions Databank, which contains information on exhaust emissions of production aircraft engines, measured according to the procedures in ICAO Annex 16, Volume II.

4.23 In practice the Forum also sees differences in the application of these standards for noise emissions. The most standard way is calculating the difference between a threshold value and the certified EPNdB for three measurement points: Flyover, Sideline and Approach. These differences are then added up to calculate a “cumulative margin” of EPNdB. Most airports create noise categories based on this cumulative margin. However, there is also an example of an airport operator, Swedavia, that uses other threshold values to convert the certified EPNdB to “noise units”, which determine the noise charge.

4.24 For NOx charges, there are differences in how the value is determined. Amsterdam Airport Schiphol and Brussels Airports use the value of the total mass of oxides of nitrogen emitted for each engine of an aircraft during the Landing and Take-off (LTO) cycle, whereas Stockholm Arlanda Airport uses the standard ICAO LTO-cycle but adjusting the taxi time to actual conditions (for example, 17:30 min for 2023).

4.25 Differences in measurement or application between the airports may occur depending on the practical or local circumstances. On the other hand, official national or international standards and common practice would make the modulation design more straightforward and lower the administrative burden. In general, the Forum recommends the use of official standards, being adapted to different local circumstances where possible. Insofar as those standards are not perfect or used inconsistently, the Forum recommends the revision or harmonisation of those standards and the provision of guidance from ICAO and/or the EU.

Trade-offs, portfolio effects and alignment with Corsia and EU-ETS

4.26 Environmental modulations could give rise to unintended consequences. It could be the case that stronger incentives to lower one negative external effect can lead to an increase of another negative external effect. In engine design for instance, there are technical trade-offs between CO2 and NOx. Higher fuel efficiency can be reached by higher fuel burn temperatures, but this can cause increased NOx emissions. When

environmental modulations focus on one environmental metric, it could incentivize airlines to use aircraft that may be preferable on the basis of that metric (e.g. NOx) but inferior on another (e.g. CO2).

4.27 This highlights the necessity of a full internalization of all the externalities. From an economic perspective, the trade-off should take into account the economic cost of each of them. With internalization mechanisms well calibrated, the resulting price signal reflects the shadow value of every externality, and incentivizes airlines to use the best aircraft/engines – and the industry to improve the efficiency of aircrafts/engines – in the right direction from a collective point of view. Indeed, once all externalities are internalised, the market naturally balances the different types of pollution according to the magnitude of the incentives, and solves trade-off problems. That is why it is good practice to implement a modulation for each externality not already being fully internalized by other measures. In that case, environmental variation would contribute to improving the cost-competitiveness of operating less polluting aircraft relative to more polluting aircraft.

4.28 In consequence, when designing a modulation, it is necessary to take into account the external costs that airlines already pay through other measures. For example, the marginal cost of carbon paid by airlines for an intra-European flight is given by the European Union Emission Trading System (EU-ETS). Moreover, the carbon cost implied by CORSIA is likely to change over time, and any pollution taxes in effect will also need to be accounted for. It follows that any efficient CO2 charge modulation should therefore vary with time and origin-destination in order to work in tandem with existing CO2 related initiatives.

4.29 Environmental modulations could also lead to fleet reallocation effects. In the case of global pollution modulations, these effects should be avoided. Indeed, heterogeneous type 2[5] modulations across airports may potentially end in a reallocation instead of a renewal of the fleet, as the most polluting aircraft may be moved to the airports with no or lesser modulations, potentially leading to a total increase of Greenhouse Gas emissions. For example, a certain degree of emission "leakage" occurs as modern aircraft used across the EU are much less polluting than previous generations of aircraft. However, where the previous generation aircraft are still flying in other parts of the world, and not replacing more polluting aircraft, this would lead to higher CO2-pollution levels outside of the EU. To avoid CO2 leakage, the price signal used for environmental modulations/charges should be harmonized at the European or global level. In particular, it is important to avoid a patchwork of ad-hoc measures being designed at individual airports, in isolation of each other and/or in isolation of price signals already provided by other internalisation mechanisms.

4.30 However, in the case of local pollution modulations, such a reallocation effect can be desirable because the external costs can vary across airports, depending on their location in more or less populated areas and on the willingness to pay for nuisance reduction. For example, all else equal, it is optimal from a collective economic point of view that the noisiest aircraft operate to airports with fewer local residents to be

[5] Per the 2021 paper, Type 2 modulations were defined as those which relate to global issues, especially CO2. This is discussed in the "Airport Charges and Environmental issues and considerations" paper of the Thessaloniki Forum.

disturbed, and that quieter aircraft operate to airports surrounded by more populated areas.

4.31 The Forum therefore finds that, from an economic perspective, environmental modulations are better suited to reduce local external costs such as noise and NOx, aligned in a way that all negative effects are internalized. A CO2-modulation could also be considered, especially when the cost of CO2-emissions is not yet fully internalized through other measures. But it is not the most optimal way to internalize the external costs of CO2-emissions, because of the risk of a certain degree of "carbon leakage" and the fact that a modulation will typically not internalize the emission costs of the entire flight.

Modulation and non-discrimination

4.32 Variations of airport charges, including environmental modulations, might trigger allegations of discrimination between users. Article 3 of the ACD states that airports charges should not discriminate according to airport users. The same article explicitly allows for charge modulation "*for issues of public and general interest, including environmental issues*." In the paper "Non-Discrimination under the Airport Charges Directive", the Forum gives recommendations on how to assess whether modulations comply with the ACD.[6]

4.33 For a charge modulation to qualify as an issue of public and general interest, a grounding in stated government policy is required to justify the modulation. It is for individual ISAs to determine the allowed scope of Article 3 based justifications, such as whether a grounding in any government policy is sufficient or whether it must relate specifically to an element of government aviation policy. Furthermore, the environmental modulation should meet the ACD Criteria: Relevance, Objectivity and Transparency. The aforementioned paper provides working definitions of the criteria.

Comparison of airport charging systems

4.34 This section details a comparative analysis of the charges at seven major European airports, paying specific attention to environmental variations. The purpose is to:

1. Consider to what extent environmental related charging variation exists at these airports, i.e., is it a major part of airport charges, and is there much difference between airports.

2. Assess how impactful the variations are on total charges paid in respect of different aircraft. This analysis compares the charges paid on average by eight different commonly operated aircraft models on a per passenger basis. These aircraft were grouped into four pairs for comparative purposes. These pairings are: A320 Neo vs A320, B737 MAX 8 vs B737-800, B787-Dreamliner vs B747, and A330 Neo vs A330-300. The rationale behind these groupings was to show the impact on charges of operating newer aircraft models relative to a broadly equivalent older model.

[6] Non-Discrimination under the Airport Charges Directive, Thessaloniki Forum of Airport Charges Regulators, November 2018.

4.35 The overall aim of this analysis is to develop the existing knowledge base around airport charges variations for environmental purposes, and to assess how these variations are currently applicable in practice.

4.36 The following analysis relies on several key assumptions. For example, it is assumed that charges relate to a full landing and take-off cycle at each airport, to account for the full suite of charges. It is also assumed that all flights take place at night, given that some airport operators only levy environmental charges at night. Additionally, the analysis assumes a Widebody load factor of 82%, a Narrowbody load factor of 90%, and a transfer level of 10%, as well as summer season charges. A full list of the assumptions used is set out in the appendix.

Variation at the modelled airports

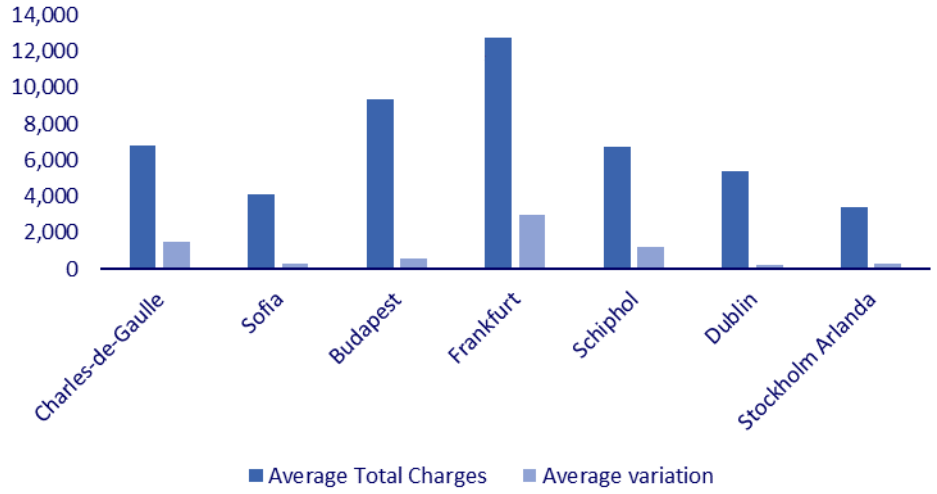
4.37 This section details the level of modulation that exists at each of the seven airports. It is not a representative modelling of the exact average charges levied by each airport to aircrafts, but is instead an average of the charges that would be levied on the eight aircraft types listed above, under specific assumptions.

4.38 Similarly, the environmental variation shown in the charts below is not the amount added to the overall charge from the environmental modulation at each airport. It is instead the proportion of the overall charges subject to variation. For example, the model shows that landing and take-off represents 23.3% of charges for aircraft on average at Frankfurt Airport, as these charges are subject to modulation (i.e., these charges vary according to the noisiness of the aircraft engines). The level of variation at the airport is given as 23.3%.

4.39 The degree of modulation varies across airports. Dublin Airport, for example, applied one form of modulation (noise), while Stockholm Arlanda Airport applied three (Noise, NOx, and CO2). The design of the modulation also varies, with a standalone charge employed at 5 of the airports and a bonus malus system in operation at 2. Modulations at each airport were applied to aircraft related charges only.

4.40 Chart 1 shows the average total charges, and average amount of charges subject to environmental variation, at each airport, estimated across each of the sample aircraft for the relevant charging period. These vary considerably across airports, with Sofia Airport having the lowest average charges and Frankfurt having the highest (as well as the highest level of variation).

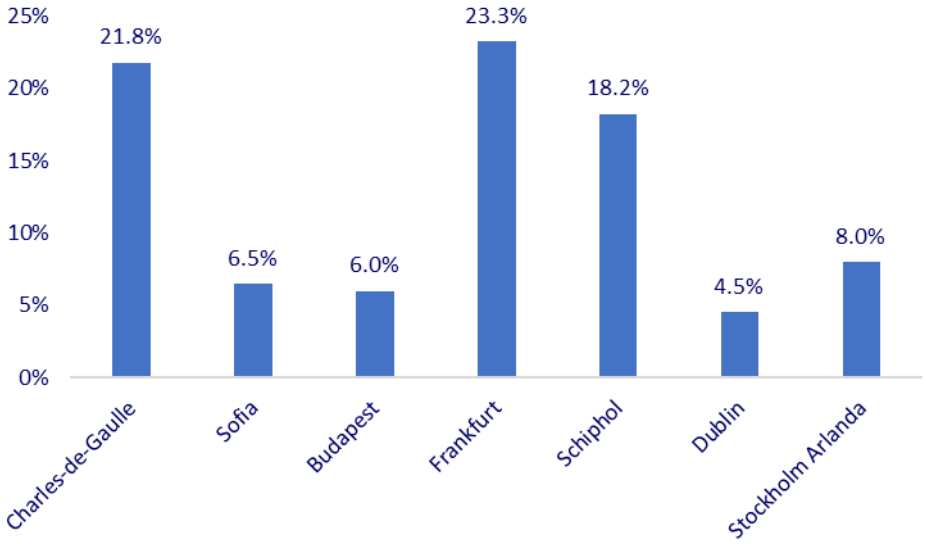
Chart 1: Average total charges and average environmental variation at each airport, €



Source: Drafting team calculations based on the 2022 Charging schemes from each airport listed above

4.41 Chart 2 shows that the proportion of the total charges that were subject to environmental variation, for the sample aircraft, was also very different across airports, at over 18% at three airports (Frankfurt, Charles-de-Gaulle, and Schiphol), and 8% or below for the remainder (with 4.5% at Dublin Airport representing the lowest).

Chart 2: Proportion of charges subject to environmental modulation at each airport



Source: Drafting team calculations based on the 2022 Charging schemes from each airport listed above, applied to the sample aircraft listed above.

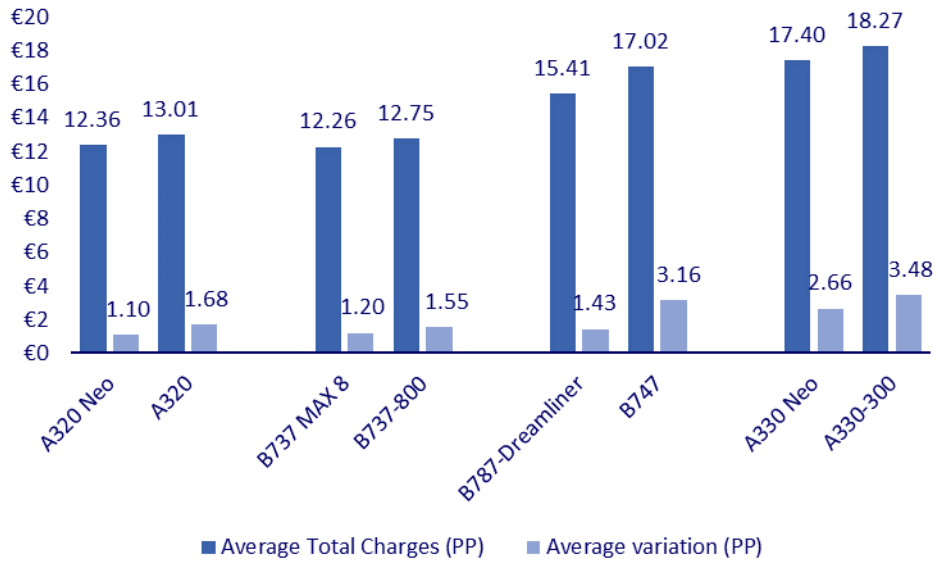
The impact of environmental variation on different aircraft types

4.42 This subsection considers the above analysis at an aircraft level across the modelled airports. It pays specific attention to the differences within aircraft comparators, both at a total charges level and with respect to environmental variation. The analysis shows that both total charges and total environmental variation differs within the aircraft groupings.

4.43 While the environmental variations vary significantly within the comparator groupings,

the impact they have on overall charges is relatively modest. For example, while environmental related charges are significantly lower for newer aircraft (42% lower on average), newer aircraft models[7] are only paying an average of 5.8% less in total charges than the older aircraft. As Chart 3 shows, this difference is approximately equivalent in magnitude to the difference between the environmental variations in each grouping.

Chart 3: Charges paid on average by each aircraft (at a per passenger level)

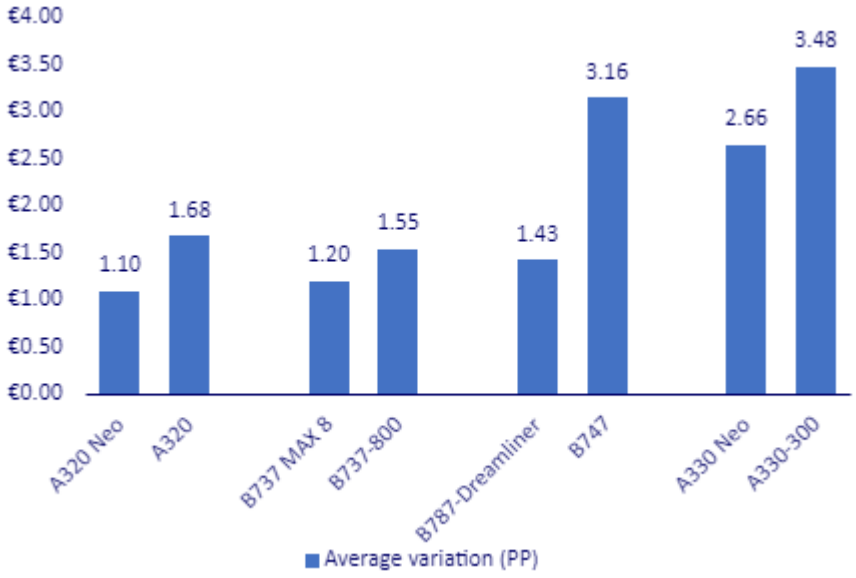


Source: Drafting team calculations based on the 2022 Charging schemes from each airport in the analysis

4.44 Chart 4 further illustrates the magnitude of the environmental variations for each aircraft. Environmental variations represent a smaller proportion of newer aircraft total charges than for the older aircraft, however, this difference varies significantly between groupings. The most significant difference was between the B787-Dreamliner and the B747, for which twice as much of its charges were varied than the B787-Dreamliner. It is also worth noting that the average proportion of charges that are varied for the B787-Dreamliner is lower than for the newer narrowbody aircraft, something that is not true for the A330 Neo.

[7] The 'newer' aircraft are the A320 Neo, B737 Max 8, B787 Dreamliner, A330 Neo. The 'older' aircraft are the A320, B737-800, B747, and A330-300.

Chart 4: Average amount of charge subject to variation, per aircraft



Source: Drafting team calculations based on the 2022 Charging schemes from each airport in the analysis

4.45 The analysis suggests that overall, the newer aircraft are being charged less per passenger than the older aircraft, at 5.9% on average (or €0.90 per passenger). This difference is primarily being driven by the environment related charging modulations, which are 62% (or €1.27 per passenger) higher for the older widebody aircraft than the newer one, and 40% (or €0.46 per passenger) higher for the older narrowbody aircraft than the newer one.

5. Role of the ISA regarding environmental variation and investments

The traditional role of ISAs and environmental modulations

5.1 While the traditional role of an economic regulator has not been to assess or account for environmental aspects, aviation services currently generate negative environmental externalities that are not accounted for in the capital and operating costs of production. Therefore, user prices may not reflect the "true" social cost of providing these services. However, should user prices be made to better reflect these costs, it should be done in a cost neutral manner for the airport operator, because the negative externality is not a cost borne by the airport, and they should therefore not benefit financially as a result.

5.2 This can lead to a conflict between the perspective of setting airport charges on a cost-related basis, and the perspective of the state or society. The perspective of the regulator has traditionally been to replicate an outcome of competition, without taking negative externalities into account, whereas society should aim for a socially optimal outcome in which these externalities are taken into account.

5.3 This conflict could potentially be solved by legislation better coordinating the responsibilities of the regulator and the State. One possible solution is that airports and ISAs get a clearer mandate to take certain negative externalities into account, as well as rules to do so, with the aim to replicate the socially optimal prices while applying economic regulation. Another solution would be to fully address the negative externality through measures other than airport charges, and consequently, airport charges should not also be modulated on the basis of the same externality.

5.4 Most of the ISAs regulate airport charges based on their economic merits alone. Therefore, they use the same criteria when assessing charge modulations of an environmental nature as when assessing any other modulation: the charge modulation must be relevant, objective and transparent.

5.5 Hence, in the view of ISAs, there is no specific rule or law governing the ISA oversight of environmental modulation and the ACD criteria should be applied when assessing any modulation.

5.6 These ISAs also see environmental modulations as a part of the regular consultation process where the modulation is subject to agreement by airport managing bodies and airport users. However, the parties that suffer from the negative externalities are not included in the consultation process. In some cases, airport operators need to communicate a series of information to stakeholders and to the ISAs, such as the objective being pursued by the modulation, indicators that can be used to track the impact of the modulation, as well as a provisional impact assessment. This information is used by the ISAs during their assessment of new charge modulations.

Current practice of ISAs with respect to environmental modulations

5.7 ISA oversight of charge modulation is heterogeneous. While some ISAs only investigate modulations when there is a disagreement, others have the role of certifying all charges and modulations proposed by airports.

5.8 Several ISAs noted that they have a mandate to assess a modulation ex post. For example, where there is disagreement, a modulation can be appealed, and that the ISAs then perform an assessment. They also noted that they apply the ACD criteria in their assessment.

5.9 At present, only a few ISAs investigate whether the environmental modulations are effective in reaching their environmental objectives. The majority consider that it is beyond their roles and believe that, instead, this assessment is a prerogative of other national or European authorities. The following paragraphs summarise the views of the ISAs which do assess the environmental aspect of charge modulations.

5.10 The Irish ISA will supervise the application of a noise modulation policy and examine its impacts, if necessary, particularly if a complaint is made. The ISA intends to carry out this supervision once the policy has been in operation long enough for such an assessment to be made.

5.11 The Portuguese ISA is responsible for supervising the compliance with operational restrictions on aircraft noise. Any additional measures taken by the airports to reduce the level of the noise near to the airport are supervised by the Portuguese ISA jointly with the Portuguese environmental agency (APA).

5.12 In Switzerland, under certain circumstances, the airport operator may be required to implement noise charges that have an actual steering effect in changing behaviour. The Swiss ISA notes that this is a difficult task, as causality is hard to prove. The ISA also notes that the most recent noise charges decision relied on an external study which tried to determine the level of charge necessary to influence airline behaviour. However, it also stated that despite the study, discussions about the correct level of noise charges is still ongoing.

5.13 The French ISA started to assess whether charge modulations are commensurate with the environmental/climate objective. It does so by comparing the price signal of the modulation with the reference shadow values of the environmental externalities compiled by institutional guides produced by the relevant public bodies, while considering potential additional economic schemes with the same objective, such as a noise tax when assessing noise modulations, or the EU-ETS system when assessing CO2 modulations.[8]

5.14 Noise and NOx related modulations are in force in Germany, where a law is in place which requires noise modulation and which recommends NOx modulation. The modulations are mainly based on international standards and are mostly stand-alone charges. Classification used for noise-related modulation have been refined in the last years in order to reflect local circumstances. The German ISA is responsible for approving the charge modulation, provided they adhere to standards established in the national law, that they are based on an appropriate criteria (e.g. ICAO standards), and that they align with the ACD.

5.15 In some countries, airport operators need to track the impact of charge modulations

[8] The French ISA never externalized the results of the studies on noise and the conclusion on whether a noise-modulation is commensurate or not, because the technical aspects still have to be consolidated.

after they have been implemented. The ISA can use this information to investigate the effectiveness of the modulation when it is renewed, or for updated modulations. However, measuring the impact of environmental modulations is complex, meaning that ISAs seldom use this power.

Capacity and capability of ISAs to supervise environmental modulations

5.16 There is no consensus among ISAs as to whether the ISA is the best entity to supervise whether charges modulation effectively contributes to reaching the environmental objective of the airport or the objective set by the legislation.

5.17 Many ISAs believe they are the best entity to supervise whether the charges modulation effectively contributes to reaching the environmental objective. For example, the ISA from the Netherlands believes that since they have experience in aiming to replicate the outcomes of competition, they should be equipped to aim for a social optimal outcome, accounting for environmental objectives. However, some other public entities may be even better equipped for this task, such as organisations that specialise in undertaking (social) cost-benefit analyses.

5.18 Some ISAs believe that this is not the role of the ISA. For example the German ISA believes that as long as the modulations incentive effects are officially recognised and that the criteria of relevance, objectivity, non-discrimination, and revenue neutrality are observed, it is not necessary for the ISA to investigate the effectiveness of the modulation with reference to its intended purpose. For example, as noted by the Bulgarian ISA, in respect of assessing aviation noise at an airport, it may be an authority other than the ISA which is competent.

5.19 Some ISAs also believe that certain environmental emissions should be tackled at an international level, such as the French ISA which believes that a modulation based on CO2 emissions is not the most effective mechanism for reaching climate change goals, as these are best addressed by national and international measures.

5.20 The Swedish ISA is of the view that assigning this role to a body other than the ISA would lead to a fragmented matrix of oversight responsibility. Any fragmentation in that respect is undesirable. Thus, a holistic view of airport compliance should be within the ISA scope, with assistance from other entities when necessary.

5.21 During the investigation of modulations, ISAs can ask for any relevant justification, document, and data from the airports. Obtaining the relevant data and information from airport operators to assess environmental modulations thus should be possible for ISAs.

5.22 However, ISA staff typically comprises economists, data scientists, auditors and lawyers, but most ISAs do not have specific expertise in environmental matters, and often rely on external experts for these assessments. Extensive knowledge of existing legislation that is beyond the scope of airport regulation, e.g., governmental objectives in reducing pollution, emission permits at the European level, also does not lie in the field of expertise of most ISAs. As such, many ISAs believe they will have to cooperate with other governmental agencies or ask for external help if they need to assess the environmental effectiveness of charge modulations at the regulated airports. One

issue that may then arise in this case is the duplication of powers between different public authorities for the supervision of airport activities.

Modulation revenue neutrality and environmental effectiveness

5.23 ISAs were asked to what extent they investigated or assessed the new modulations in terms of revenue neutrality and their effectiveness in reaching environmental and/or climate objectives.

5.24 Several ISAs noted that they did not investigate or assess environmental modulations in terms of their effectiveness in reaching environmental and/or climate objectives.

5.25 The French ISA noted that during the investigation of the charge at Lyon Airport, it checked whether the CO2 modulation followed the criteria mandated by the state legislation, including whether the modulation used transparent and objective criteria and whether it is proportionate to its climate objective. For the first two points, the modulation met the criteria. For the third point, the ISA compared the cost of carbon embedded in the modulation with the shadow value of carbon used by the state. To do this, it took a given aircraft operating over an LTO cycle, and considered a scenario whereby that route was operated by a hypothetical aircraft with the exact same characteristics except that the level of CO2 emissions was one ton higher. The difference of charges paid between the two aircraft was the marginal cost of carbon embedded in the modulation.[9]

5.26 The ISA noted that as the modulation was calculated by multiplying the standard charge by a coefficient, the cost of carbon embedded in the modulation differed among aircraft and LTO cycles, since the standard charge depended on the MTOW of the aircraft. The ISA concluded that as it has no link with the objective of general interest, the MTOW was not a relevant criterion for an environmental modulation, and that the use of coefficients multiplying the standard charge for the purpose of a modulation should be avoided to fully comply with the ACD. Moreover, the French ISA finds that such a modulation might be discriminatory since it could have different effects towards airlines operating LTO-cycle in the same situation regarding the objective of general interest. For example, two aircraft in the exact same situation (e.g., emissions, seats, LTO-cycle, time of the day, etc.), where one has a higher MTOW than the other, would be affected by the modulation by a different amount.

5.27 Nonetheless, the investigation of the French ISA concluded that the CO2-modulation was not disproportionate for the most frequently operated aircraft at the airport, even when considering existing national and international CO2 mitigation mechanisms. The ISA therefore approved the modulation but noted that airport charge modulations may not be the best tool to address global climate issues. The decision also called on the airport operator to carefully assess the financial and environmental impacts of the

[9] See calculation details in Appendix 3.

modulation, as this is a legal obligation.[10]

5.28 The Irish ISA noted that it ensured revenue neutrality by ensuring that noise related modulation would be subject to the audited annual price cap compliance calculation, i.e., that the overall level of airport charges must remain cost related as determined by the ISA. The ISA also reviewed the proposed charge and noted that it directly relates airport charges to noise output on a scaled basis and specifically addresses a noise problem identified by the noise regulator. The ISA has not yet carried out a review as to how effective the modulation is likely to be in relation to influencing airline behaviour. It noted that this is likely to be a difficult question to answer, particularly over the medium/longer term as the airport intends to introduce this on a phased basis. It did not receive any complaint in respect of this modulation. However, it is something that it may consider for the future.

5.29 The ISA from the Netherlands noted that it received a complaint about the newly introduced NOx charge. This complaint stated that the charge conflicts with the European objective to reduce CO2 emissions in that there is a technical trade-off in aircraft for CO2 emissions and NOx emissions.

5.30 The Netherlands ISA examined the revenue neutrality of the charge and found it to be revenue neutral, but it has not investigated the effectiveness of the NOx charge in reaching (national or European) environmental and/or climate objectives, as this is not a requirement in the Member State legislation. It noted that the charge must be relevant, objective and transparent. The term "relevant" in the Member State legislation and earlier cases is interpreted as requiring the charge to be in line with the "polluter pays" principle and in line with an objective of the airport. This means that the ISA examines whether the charge is differentiated according to this principle. With the NOx charge, aircraft engines that emit more NOx, pay higher charges in proportion with the standard LTO engine NOx emissions, since it is a linear charge. The charge was deemed to fit within the objective of the airport to reduce NOx emissions. Therefore, the charge has been found relevant. The ISA also found the charge to be objective, because it is based on the data in the ICAO Aircraft Emissions Database. Lastly, the charge is deemed to be transparent, as it is known to all users and the calculation is based on the ICAO Aircraft Emissions Database, which is publically available.

5.31 Finally, the Swedish ISA noted that the CO2 modulation was appealed, and that it had therefore assessed the modulation mechanism in regard to article 3 (non-discrimination) as well as in regard to effectiveness of climate objectives. The criteria, according to the ISA, for the climate objectives was that aircraft within the same category with more emissions are penalized in comparison to aircrafts within the same category with less emissions. The result of the investigation was that the appellant had not been able to show that the modulation model they advocated for led to a better result in respect of the objectives of the legislation (all parameters considered) than the airport operator's model. Therefore, the airport operator's model was considered

[10] Article R224-2-2 du code de l'aviation civile (French law) states that before the introduction of a new modulation, the airport has to define the monitoring indicators corresponding to the environmental objective, and to assess the predicted impact of these modulations regarding the use of the airport.

to be consistent with the criteria as intended by the legislator.

Investments

5.32 Only one of the surveyed ISAs has answered that they have a specific mandate or role to oversee and assess the airports environmental strategy (including environmental investments). The Irish ISA is required to take account of the policies of its government on aviation, climate change and sustainable development, when making an airport charges determination (which includes making decisions on the inclusion or otherwise of airport investments in the cost base for airport charges).

5.33 However, in nearly all instances the relationship between investments and environmental strategies is not assessed; investments are usually only assessed according to the ACD criteria.

5.34 As with modulations, there is heterogeneity in the involvement of ISAs regarding investments. Some ISAs are responsible for approving all investment proposed by airports while others only intervene ex post when there is a disagreement.

5.35 Regarding the environmental expertise to assess environmental investments (for example during the consultation process or during an appeal process), there is no consensus among ISAs concerning whether the ISA is the best entity to analyse and decide on environmental investments. A few of the ISAs responded that there are other departments within the agency who can assist with expertise, or external consultants.

5.36 The above notwithstanding, the Forum reaffirms the view set out in section 3 of the previous paper from January 2021 on this topic that ISAs can play a role in investigating the environmental impact of investments if the motivation for the investment is environmental. However, this will depend on the ISAs level of involvement in assessing investments and the information the ISA has access to.

6. Recommendations regarding the use of environment related variation and the assessment of environmental investments

Assessing the impact of environmental modulations

6.1 As noted in the previous paper on this subject, it is not the ISAs responsibility to set global environmental or social objectives to be achieved, but this should not prevent the ISA from assessing the justification for the modulation or evidence provided. In this way, it can ensure that any modulations are proportionate to their objectives and are thus permissible under the ACD. Should the modulation be deemed insufficient or ineffective to achieve its objectives, this may also pose a challenge in terms of meeting the objectives set in the ACD under Article 3; if it is not likely to be effective, it may simply distort the market.

6.2 ISAs should be able to request relevant data from the airport operator in order to assess the effectiveness. The Forum also encourages airport operators to investigate for themselves how large the savings are between different aircraft models and determine if the modulations in place are large enough to achieve their stated goals. This is a complex question, which requires a deep understanding of how incentives are likely to impact airline decision making, and the wide variety of factors motivating fleet renewal decisions.

6.3 Aside from the question of effectiveness, when it comes to assessing the economic efficiency of environmental modulations in terms of the price signal produced, the Forum recommends comparing the incentive produced, where possible, with the shadow value of the externality, taking into account potential other internalization mechanisms. For an example of this, see appendix 3.

Assessing the environmental impact of investments

6.4 As noted above, there is heterogeneity in the involvement of ISAs regarding investments, with some ISAs responsible for approving investments and with others only intervening if there is a disagreement. Depending on ISAs level of involvement in assessing investments, we reaffirm the principles set out in section 3 of the previous paper on this topic that there can be a role for some ISAs in investigating the environmental impact of investments if the motivation for the investment is environmental.

Recommendations for future modulations

6.5 This paper also lays out a series of additional recommendations in respect of designing modulations to provide an economically efficient price signal:

1. The Forum recommends using tariff drivers that are directly related to the level of pollution. Percentage coefficients to modulate existing charges should be avoided in a scenario where they would produce an outcome similar to the table outlined in section 4. Good practice would be to calculate environmental rewards, penalties, or standalone charges directly in euros (or otherwise in the national currency, where applicable).

2. In order to better provide for an efficient price signal, the magnitude of the environmental modulations should be designed to reflect the shadow value of the externality, taking into account the external costs that airlines already pay through other measures.

3. The tariff driver used for modulations could be a ratio of the level of pollution to the passenger/cargo capacity of the aircraft, or to the actually transported level of passengers/cargo.

4. To estimate the level of pollution of the aircraft on an objective basis, airport operators should use recognised standards, adapted to different local circumstances where possible. To the extent that those standards are not perfect or are used inconsistently, they should be revised or harmonised, under the guidance of ICAO and/or the EU. This should be accompanied by an assessment of the likely effectiveness of the modulation in achieving its objective(s), which could be reviewed periodically.

5. To avoid the risk of CO2 leakage in case of heterogenous CO2-modulations, whereby more polluting aircraft are reallocated to airports with no modulations (or less restrictive ones), the price signal used for CO2 modulations should be harmonized at the European or global level.

6.6 The Forum recommends that, from an economic perspective, environmental modulations are better suited to reduce local external costs such as noise and NOx, aligned in a way that all negative effects are internalized. In line with the 2021 paper, the forum considers that CO2 related modulations may not be an effective tool to mitigate emissions from aviation, because of the risk of a certain degree of "carbon leakage" in case of heterogenous CO2-modulations and the fact that a modulation will generally not internalize the emission costs of the entire flight. CO2 emissions from aircraft are not directly related to the airport local environment and should be addressed at the European or global level. Nevertheless, a CO2 modulation could be considered when the cost of CO2 emissions is not yet fully internalized through other measures.

The investigative capabilities of ISAs with regard to environmental issues

6.7 The lack of environmental expertise has been noted by many ISAs. Given the increased need for airports to undertake environmental mitigation measures, ISAs could potentially need to consider ways of improving access to these technical resources, in instances where ISAs have the power to assess environmental issues. A solution could be to build multi-disciplinary teams within the ISA, or to recruit staff with mixed/multiple skillsets (i.e., environmental economists) or obtain external support. ISAs may also rely on official recognised effects and use an appropriate abstract mechanism.

7. Appendix 1: Assumptions underpinning analytical model

7.1 The analysis detailed in section 4 is underpinned by several assumptions that are used in one or more airport charging strategies and are outlined in this summary note. The key goal of this analysis is to isolate the charging effect of operating the relatively environmentally friendly aircraft compared to the unfriendly aircraft, while holding all else equal. Thus, it is necessary to use comparable assumptions across the airports.

7.2 **The LTO cycle:** All analysis is based on an LTO cycle for completeness, as many charges are levied over the LTO cycle.

7.3 **Load Factors:** The load factor in the model is set at 82% for widebody aircraft and 90% for narrowbody aircraft. While this is based on historical assessments of average load factors by aircraft type, an element of judgement was also used to arrive at load factors that are comparable across aircraft sizes.

7.4 **Transfer v Point to Point (P2P):** Transfer passengers are assumed to be 10%. The proportion of transfer passengers varies considerably across airports and so 10% was chosen for comparability as it fell approximately in the middle of the range.

7.5 **Incentives and discounts:** Any global discounts which are not applicable in respect of an individual LTO cycle, but apply to multiple aircraft movements, such as with reference to an annual traffic level, are not factored in to the model.

7.6 **Night vs day:** The model is set to night time only as some environmental charges apply only at night (e.g. noise).

7.7 **Summer vs winter charging:** The model is set to summer only as most of the charging schemes assessed do not vary by season.

7.8 **Aircraft specifications:** The specifications for each aircraft are given below.

	A320 Neo	A320	B737 MAX 8	B737-800	B787-Dreamliner	B747	A330 Neo	A330-300
Engine	LEAP-1A26E1	V2527-A5	CFM LEAP-1B27	CFM56-7B26E	TRENT 1000-J2	CF6-80C2B5F	Trent772	TRENT 772B-60
Seats	180	168	197	186	344	529	272	262

MTOW	77	74	76	79	253	413	251	242

8. Appendix 2: Example of modulations in operation

Example standalone modulation: Quota Count (QC) system Dublin Airport.
The charges are intended to account for the amount of noise being produced as the QC is based on the decibel level of the aircraft. The quota count charges for 2022 are outlined below. It uses information already provided by the airlines as part of the 'Aircraft Fleet Declaration Form'.

Noise Charges 2022	
QC	*Set fee per Tonne (€)*
0	*0*
0.125	*0*
0.25	*0*
0.5	*0*
1	*0*
2	*3*
4	*4*
8	*6*
16	*8*

*An example of an aircraft that would pay noise charges at Dublin is the B747, which has a landing QC of 1 and a takeoff QC rating of 2. This means that across a full rotation it would pay €3 multiplied by the aircraft MTOW (413 tonnes): €3*413 = €1,239. These charges currently only apply to aircraft landing or taking off during the nighttime hours (23:00-07:00 local).*

*The charge is related to the full rotation and calculated on each flight individually. The aircraft in this example has a landing QC of 1 and so the charge is 0, per the table. If the aircraft had a take-off QC of 2 and a landing QC of 2 then the charge for a full rotation would be (€3*413)+(€3*413) = €2,478.*

Example bonus malus CO2 charge modulation on Aéroport de Lyon-Saint Exupéry.
The standard fee (standard charge = without modulation) is calculated based on the maximum take-off weight:

STANDARD FEES	All destinations
0 T to 8 T	52.77 €
9 T to 20 T	116.09 €
21 T to 25 T	116.09 €
26 T to 75 T (per additional T)	5.064 €
> 75 T (per additional T)	6.120 €

*The modulation is based on the quantity of CO2 emitted by the aircraft over a standard landing and take-off. The CO2 modulation is calculated as follows: bonus / penalty (in €) = standard charge * coefficient*

for passenger flights: coefficient = (Kg CO2 per Offered Seat (OS) – 15,1) / 200, capped at 12%
for cargo flights: coefficient = (Kg CO2 per MTOW – 36) / 200, with a minimum of -12% or a maximum of 12%

<u>Numerical examples for passenger aircraft:</u>

Aircraft	MTOW (tons)	Standard charge (€)	Amount of CO2 emissions produced per LTO cycle (T)	Offered seats	Kg CO2 per Offered Seat	coefficient of modulation	bonus / penalty (€)	Total charge
AIRBUS A320-200	77	381,53	2,5704	174	14,77	-0,16%	-0,62	380,91
Boeing 777-300ER	297	1727,93	9,1563	468	19,56	2,23%	38,58	1766,51
Boeing 747-8i	442	2615,33	11,0124	364	30,25	7,58%	198,16	2813,49

The values used to design the modulation are:

- *15,1 = fixed value for passenger flights to ensure that the modulation is revenue neutral (the average ratio kgCO2 per seat at the airport).*
- *36 = fixed value for cargo flights (the average ratio kgCO2 per tonne of MTOW at the airport).*
- */ 200 = this value is sets the "magnitude" of the modulation, since it doesn't influence the revenue neutrality of the modulation. If this value is low, the modulation is large and the incentive is strong.*

9. Appendix 3: Example of economic efficiency assessment of a modulation

To assess the economic efficiency in terms of the price signal produced by the CO2-modulation on Aéroport de Lyon-Saint Exupéry, the French ISA made the following computations of the cost of carbon embedded in the modulation:

Aircraft	MTOW (tons)	Standard charge (€)	Amount of CO2 emissions produced per LTO cycle (T)	Offered seats	Kg CO2 per Offered Seat	coefficient of modulation	bonus / penalty (€)	Total charge
AIRBUS A320-200	77	381,53	2,57	174	14,7724138	-0,16%	-0,62	380,91
hypothetical AIRBUS A320-200	77	381,53	3,57	174	20,5195402	2,71%	10,34	391,87
Marginal cost of carbon embedded in the modulation (€/T):								**10,96**
Boeing 777-300ER	297	1727,93	9,16	468	19,5648923	2,23%	38,58	1766,51
hypothetical Boeing 777-300ER	297	1727,93	10,16	468	21,7016444	3,30%	57,04	1784,97
Marginal cost of carbon embedded in the modulation (€/T):								**18,46**
Boeing 747-8i	442	2615,33	11,01	364	30,2538462	7,58%	198,16	2813,49
hypothetical Boeing 747-8i	442	2615,33	12,01	364	33,0010989	8,95%	234,09	2849,42
Marginal cost of carbon embedded in the modulation (€/T):								**35,92**

For a given aircraft operating a given LTO, the ISA considered that the LTO was operated by an hypothetical aircraft with the exact same characteristics, except the level of CO2 emissions which is one ton superior. The difference of charges paid between the two aircraft is the marginal cost of carbon embedded in the modulation.

For most aircraft, the cost of carbon embedded in the modulation was between €10 and €40.

- The Forum recommends comparing the incentive produced – that is the cost embedded in the modulation – with the shadow value of the externality, taking into account potential other internalization mechanisms.

At the time, the EU-ETS market valued the ton of carbon around €80 (only the intra-EU flights were included in the system and had to pay for extra CO2 emissions). The Corsia mechanism was ineffective since the traffic levels were below those of 2019.

So the total marginal cost carbon the airlines had to pay – the addition of the incentive given by the modulation and by other mechanisms – was around €90-€120 per ton of CO2.

The shadow value of the ton of carbon taken from the French economic literature and institutional guides[11] was €127.14 in 2022, which was higher than the total cost carbon the airlines had to pay. Therefore, the French ISA concluded that the modulation was not disproportionate, even when considering existing national and international CO2 mitigation mechanisms, and therefore approved the modulation.

[11] Quinet, Alain, et al. "La valeur de l'action pour le climat." France stratégie (2019): 3624-3648.

https://www.strategie.gouv.fr/sites/strategie.gouv.fr/files/atoms/files/fs-2019-rapport-la-valeur-de-laction-pour-le-climat_0.pdf

The shadow value of CO2 computed by France Stratégie is based on abatement cost: the value that should be given to a ton of CO2 while implementing relevant actions/decisions in order to achieve the zero net emissions objective in 2050.