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Taxation of civil aviation fuels as a source of financing for vulnerable countries

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Summary

Lifting the tax exemption for jet fuel used for international flights is a recurring demand from many stakeholders committed to sustainable development. Currently, this exemption keeps the carbon pricing of jet fuel at an excessively low level and is inconsistent with the decarbonisation objectives set by the international community. A tax of €0.33 per litre would raise €18 billion per year, while a tax of €0.1 per litre would raise €5.8 billion per year. This tax would ultimately be based on a polluter-pays principle and the concentrated structure of the sector should facilitate its collection. While international negotiations are essential for adoption worldwide, the introduction of such a tax, or at least the end of the current tax exemption, does not contradict the Chicago Convention, which has laid the foundations for international cooperation in civil aviation since 1944. Although it alone cannot finance the climate change adaptation needs of countries in the South, the taxation of civil aviation fuels is an interesting avenue for short-term funding for vulnerable countries. In the longer term, such taxation would accelerate the low-carbon transition of the international civil aviation sector.

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I. Introduction

At the end of COP 27 held in November 2022 in Egypt, 196 countries agreed to create a fund dedicated to the losses and damages caused in countries affected by climate change. Shortly thereafter, President Macron announced the organization of an international summit in Paris in June 2023, aimed at proposing a new financial pact with vulnerable countries, facilitating their access to the financing needed to deal with the consequences of recent and future crises. Among the four working groups set up to prepare for this summit, one is dedicated to mobilising innovative financing for countries vulnerable to climate change. Mobilising both the climate and development agendas, the reflections on this innovative financing should make it possible to answer many questions, particularly on the source of the resources to be mobilised and how they will be allocated.

Taxes on jet fuel and maritime transport are two potential sources of financial resources to be considered. Reflections on these issues are not new, since the Landau report (2004) already made proposals on how to raise funds to finance human development and achieve the Millennium Development Goals. Among the avenues envisaged in this report were environmental taxes, particularly on air and maritime transport, sectors that are totally exempt and not covered by the Kyoto Protocol. Furthermore, the ambition to establish a new financial pact with vulnerable countries is closely linked to the need to respond to the climate emergency. The alignment of these two issues makes the introduction of taxes on jet fuel and/or maritime transport doubly relevant, allowing the mobilisation of resources in the short term in the framework of this new financial pact, and generating long-term effects in favour of decarbonisation[1].

This paper focuses on the taxation of civil aviation fuels as a source of financing for vulnerable countries and aims to: (i) quantify the resources that can be mobilised in the short term through this instrument, (ii) highlight the distortions that are currently caused by the tax exemption for jet fuel used for international flights and (iii) document technical or legal barriers to the implementation of a tax on jet fuel used for international flights in order to facilitate the comparison with the barriers that would be faced by other financing instruments.

There are several options for levying a tax on jet fuel. The tax-targeted stage may be production in refineries, storage in airport facilities or delivery to airlines. In the scenario of a tax adopted worldwide and set at a level of €0.33 Euro per litre, a level corresponding to a CO_2 price of around €130 per tonne, the revenue collected from the consumption of jet fuel for international flights is estimated at €18 billion per year[2]. With a tax level of €0.1 per litre, the revenue is estimated at €5.8 billion per year[3]. The United States would be the main tax collector accounting for 34% of the revenue generated. If China, Canada, Russia, India, Japan and Brazil are added, these seven countries would account for more than 70% of revenues. The European Union would account for almost 10% of total revenues.

[1] See, in particular, Keen (2007; 2013) and Ökö Institut (2021).

[2] The level of €0.33/litre corresponds to the minimum rate set by the European directive regulating excise duties on fuels. The estimate presented is a short-term estimate. It takes into account the impact of the tax on prices but does not include scenarios for the longer-term development of air transport.

[3] The level of €0.1/litre corresponds to the current level of excise duties in some US states, which in some cases may even tax domestic and international flights indistinctly.

A unanimous and rapid worldwide adoption of such a tax seems unlikely. However, given the concentration of the sector, the adoption of a tax by a small group of countries may be sufficient to capture a large portion of air transport. Moreover, the exemption of jet fuel consumed on international flights is inherently the result of bilateral agreements signed between states and not due to the Chicago Convention of 1944[4]. In the case of the United States, which is a major player in the sector, these agreements are only binding on the federal government and leave the American states free to tax jet fuel regardless of the nature of the flight[5].

The average effective CO_2 price applied in the G20 countries for jet fuel is currently €8.9 per tonne. This compares with €78.7 per tonne for diesel and €67.3 per tonne for petrol. A tax on jet fuel would reduce this gap, which significantly alters price signals and distorts public and private incentives for financing, promoting or using transport modes. In addition to its environmental dimension, this gap is particularly unfair because air transport remains a service consumed mainly by the richest households in the richest countries, despite the recent development of so-called "low-cost" airlines (Büchs, 2021).

Beyond the revenues collected, a jet fuel tax can accelerate the sector's ecological transition, notably through the adoption of sustainable aviation fuels and the accelerated renewal of aircraft fleets. A tax on standard (petroleum-based) jet fuel would reduce the additional cost of using sustainable jet fuel, which is currently more expensive[6]. This tax can also accelerate the obsolescence and replacement of the least efficient aircraft or engines to the benefit of aircraft manufacturers. It would thus reinforce the initiative for the sector's carbon neutrality in 2050, CORSIA (Carbon Offsetting and Reduction Scheme for International Aviation), adopted in 2020 by the International Civil Aviation Organization (ICAO)[7]. This very ambitious initiative ignores the fiscal instrument and relies on a voluntary approach that will be largely insufficient for effective decarbonisation[8].

The implementation of a jet fuel tax does not raise any major technical difficulties because the civil aviation sector is concentrated. It involves a limited number of players at certain levels of the value chain such as jet fuel producers or aircraft manufacturers. While there are more airlines or airports in absolute terms, their respective markets are highly concentrated around a few players. Jet fuel producers, which are the major oil companies, are already taxed for most of their production, without this posing any particular implementation and control issues.

The paper is organized as follows. Section II provides background information on the civil aviation sector and its CO_2 emissions. Section III outlines the current tax treatment of jet fuel. Section IV presents an estimate of the fiscal potential and effects of a tax on jet fuel used for international flights. Section V looks at the implementation of such a tax worldwide and the technical or legal obstacles it might face. Section VI concludes.

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[4] This Convention only considers fuel loaded in the tanks on arrival in a country for tax and customs purposes. It advocates reciprocity in the possible taxation of refuelling.
[5] See Appendix A for a detailed presentation of the taxes applied in the United States on jet fuel and Fucci (1987) for a presentation of the Wardair v. State of Florida case which limits the scope of bilateral agreements.
[6] See Appendix F for more information on taxation of standard jet fuel and sustainable jet fuel.
[7] See Annex C for details of the ICAO Action Plan.
[8] Indeed, the balance that characterizes this type of voluntary participation is generally sub-optimal.

II. Air transport and CO2 emissions

A – Background information on air transport and jet fuel

Aviation has developed at a steady pace since the 1940s. The United States has had a predominant influence on this boom[9]. The size of its market, its technological progress and its fiscal federalism have served as an example to the international community. The last dimension is especially relevant for understanding the implementation of international taxation of jet fuel. In the United States, the power to tax is shared between the states and the federal government. The former have the ability to levy excise duties and sales taxes, particularly on petroleum products. This right has been upheld by the US Supreme court and the exemptions provided for in bilateral agreements with the United States only concern federal taxes. The US airline sector has therefore developed in a highly decentralised tax environment, similar to the tax environment for international air travel[10].

The Chicago Convention, signed in 1944 by 52 countries, laid the foundations for international cooperation in civil aviation. This convention also created the ICAO, which became a United Nations institution in 1947. Furthermore, in 1945, 57 airlines created the International Air Transport Association (IATA) in Havana. This association, which today brings together more than 300 airlines from 120 countries and provides 83% of global passenger traffic, is a powerful lobby group, hostile to any increase in taxation in the sector.

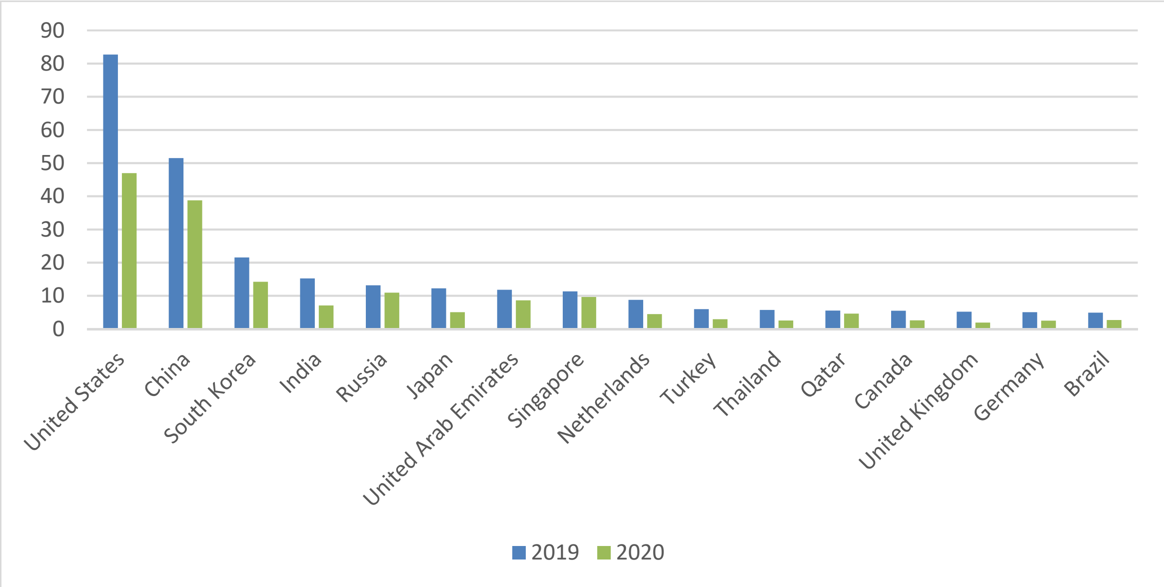
Air passenger transport is primarily an end-use product driven by leisure and tourism. Substantial academic literature analyses the relationship between tourism development and air transport[11]. Moreover, the demand for this type of travel is highly concentrated. According to Gössling and Humpe (2020), the passenger-per-capita ratio in 2018 was 3% in low-income countries, 15% in middle-income countries and 202% in high-income countries (the number of passengers was twice the population of these countries). However, even in rich countries, only a minority fraction of the population (between 35% and 45%) used air transport at least once. 10% of the most frequent travellers emit more than 50% of CO_2 from civil aviation.

Considering the above characteristics of the demand for air transport, civil aviation is inherently a monopolistically competitive sector. Airlines benefit from certain geographical rents linked to the tourist attractiveness of the places they serve. This dimension is an important element to take into account in the evolution of the sector's national competitiveness if jet fuel were taxed in an uncoordinated way globally or regionally[12]. For example, the average tax burden per passenger for an international flight in Great Britain is €43.83 (European Commission, 2019) compared to €9.53 in France or €13.10 in Sweden. Yet despite this higher tax burden, Heathrow Airport remains one of the busiest airports in the world. Ivaldi and Toru-Delibasi (2018) show empirically that the introduction of the solidarity tax on airline tickets has only had a very small impact on the competitiveness of the domestic airline sector in the countries where the tax has been levied.

[9] The federal government has heavily subsidised airmail activity since the 1920s and granted monopolies to Pan American Airways with many Caribbean and South American countries.
[10] Appendix A provides details of the taxes and charges applied to jet fuel by the US states.
[11] See Papatheodorou (2021) for an introduction and a review of this literature.
[12] The characteristic of monopolistic competition has not been sufficiently integrated in the analyses consulted (Keen et al., 2013, European Commission, 2019, 2021). It requires special treatment complementary to this paper.

Upstream of the air transport value chain, jet fuel production is a concentrated activity. The main jet fuel producing countries and their production in 2019 and 2020 are shown in Figure 1[13]. These 16 countries account for 75% of world production. The top four producers (USA, China, South Korea and India) account for 50% of world production.

Figure 1: Major jet fuel producing countries (million metric tons)

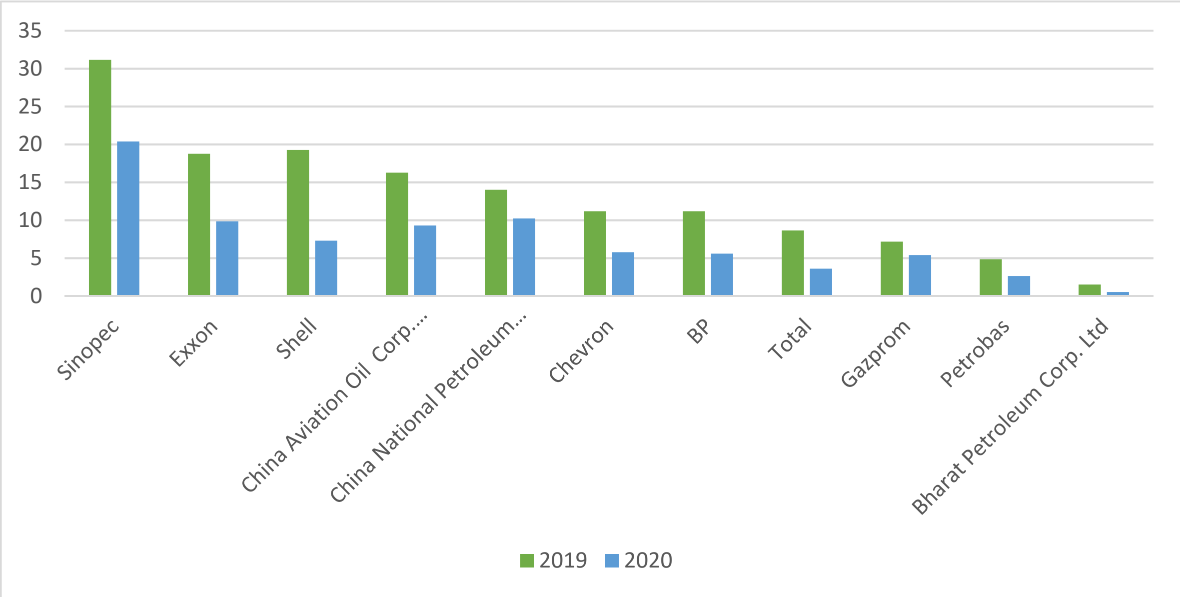


Source: UN data

At the company level, there is also significant concentration. Figure 2 below shows the production in 2019 and 2020 of eleven of the largest producers for whom information on jet fuel production is publicly available in their annual reports. The figures for 2021, although available, are not shown, given their limited representativeness due to the Covid-19 pandemic. Compared to the production figures provided by the United Nations, the volumes produced by these eleven companies represent about 40% of the world market share.

[13] See also ICAO, 2013.

Figure 2: Companies and jet fuel production (million metric tons)



Source: companies' annual reports and authors' calculations

B – CO_2 emissions from civil aviation

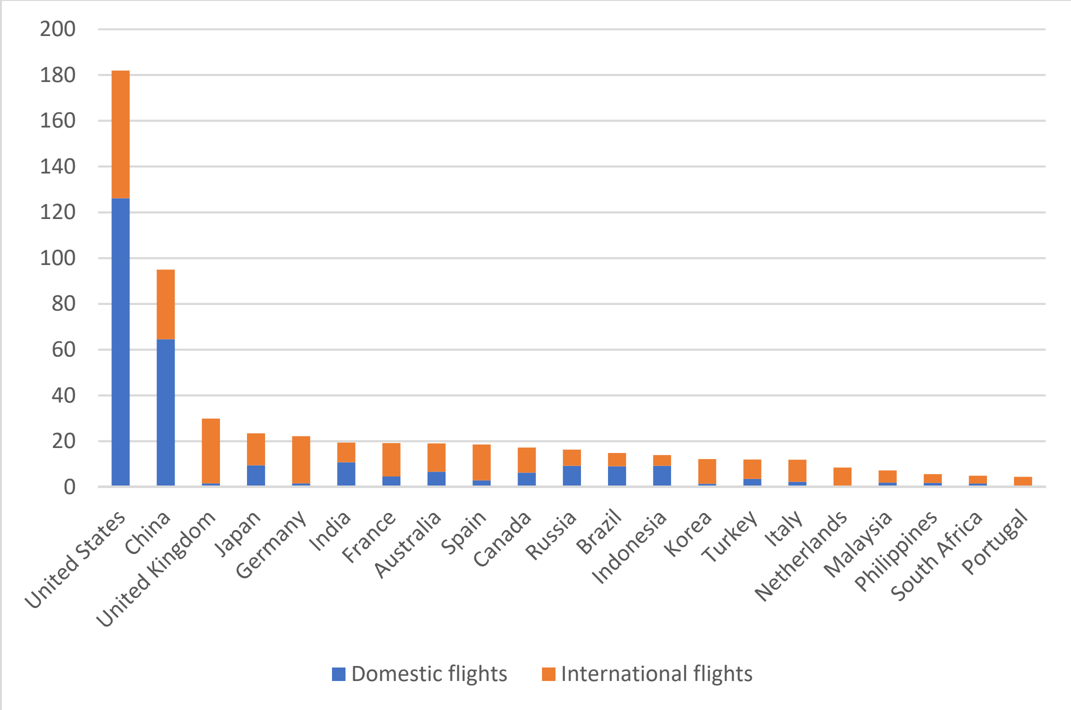
According to Lee et al. (2021), civil aviation emissions amounted to 1 billion tonnes of CO_2 in 2018. These emissions represent 2.4% of anthropogenic emissions. They are increased to 4-5% of total greenhouse gas emissions when the radiative forcing induced by the combustion of jet fuel at high altitude is included[14].

Figure 3 shows the high international concentration of CO_2 emissions associated with air transport and distinguishes for each country the share attributable to domestic flights and the share attributable to international flights. The United States accounts for nearly 30% of total emissions and US domestic flights alone account for 20% of total emissions. The top 10 countries account for 70% of emissions and the top 20 countries account for 90%. International flights account for 54% of total emissions.

Despite technological advances, CO_2 emissions associated with civil aviation have risen steadily since its inception as a result of the growth in the number of kilometres flown and the number of passengers carried. While recent years have been marked by the effects of the Covid-19 pandemic, growth prospects are back for the coming years.

[14] Radiative forcing is the difference between the radiative power received and emitted by a given climate system. The altitude of CO_2 emissions from civil aviation increases their greenhouse effect. Lee et al. ((2021)) provide a comprehensive analysis of all aviation-related emissions. In addition to CO_2, high-altitude combustion of jet fuel also results in emissions of nitrogen oxides, water vapour, sulphates, soot and sulphur, which disrupt the climate through induced radiative forcing.

Figure 3: CO_2 emissions from air transport (million metric tonnes) in 2018



Source: International Council on Clean Transportation, icct.org

C – Comparison of CO_2 emissions from different modes of transport

A comparison of the carbon footprint of different modes of transport (road, rail, air) is difficult to establish. ADEME and the Congress Budget Office follow the "well-to-wheel" approach, which consists of estimating the CO_2 emissions from fuel production as well as those resulting from fuel combustion. An alternative approach would be based on a full life-cycle analysis and would include emissions from the construction of infrastructure, the production of vehicles and the various services associated with each transport mode.

Table 1 presents the results of various studies using the well-to-wheel or *well-to-wake* approach for aviation. Air transport CO_2 emissions range from 100 to 128 g CO_2 per passenger transported over one kilometre (CO_2/journey.km). These emissions are higher than rail transport emissions, but lower than road transport emissions if an average of all trips (short and long) is taken into account for road transport. In the French data, CO_2 emissions from air transport are higher than those of the other modes of transport if we restrict ourselves to long journeys for rail or road transport.

Table 1: Carbon footprint of different modes of transport

France, ADEME

	Train			Bus/Car			Car			Plane
	Avg.	SD	LD	Avg.	SD	LD	Avg.	SD	LD	Avg.
g CO_2/trip.km	7,5	5,2	8,5	74,4	132,1	58,5	155,5	177	105	128
kg CO_2/hour	0,56	0,18	1,1	3,2	1,8	6,7	7,7	6,5	7,9	90
kg CO_2/trip	0,19	0,05	1,5	1,2	0,5	2,4	2,4	2	30,6	311

SD: Short distance
LD: Long distance
http://www.chair-energy-prosperity.org/wp-content/uploads/2019/01/emissions-de-co2-par-mode-de-transport.pdf

European Union, European Environment Agency

	High speed train	Conventional train	Tram, underground	Bus/Car Avg.	Car Avg.	Plane Avg.
g CO_2/trip.km	15,8	41,22	85,96	80	143	126

https://www.eea.europa.eu/ee9b7cc6-5cb4-4acb-ad5c-6334122d9bad

United States, Congress Budget Office

	LD train	SD train	Bus/Car Avg.	Car Avg.	Plane Avg.
g CO_2/trip.km	47,91	84,55	109,92	132,47	95,83

https://www.cbo.gov/publication/58861#_idTextAnchor045

III. The current tax treatment of jet fuel

A – Domestic and international flights

The tax treatment of domestic flights differs from that of international flights, since international flights account for more than 50% of CO_2 emissions (see Figure 3 and Hemmings, 2020). Most countries levy a tax on petroleum products, including jet fuel for domestic flights, in the form of a specific or ad valorem excise duty. For example, in 2022 the United States applied a federal tax of €0.06/litre, plus similar taxes at the state level, varying from 0 to €0.04/litre, and charges, notably for storage (see Appendix A).

Jet fuel used for international flights is generally exempt from all duties and taxes. This absence of taxation is the result of a long evolution of international civil aviation relations initiated by the Chicago Convention in 1944[15]. The Convention only specified the exemption from duties and taxes on fuel contained in tanks at the time of landing on an international flight. In other words, it allowed

[15] The Convention established six principles or rights: (1) the right of a country to allow airlines of other countries to fly over a territory without landing; (2) the right to make a technical stop (change of flight crew, refuelling) to a third country; (3) the right of inbound and outbound commercial flights; (4) the right of commercial flights between third countries; (5) the right of cabotage; and (6) the exemption of fuel in tanks from taxation). See, for example, Ellis (1997) and Meijers (2005)

taxation of fuel by the country where it is loaded into the tanks and avoided double taxation by prohibiting countries where the aircraft lands from taxing fuel still in the tanks.

The main objective of this Convention was to let countries regulate their own air traffic through bilateral agreements. Today, there are more than 5,000 bilateral or multilateral agreements regulating international air transport. Several bilateral agreements have played an important role, especially in the current tax treatment of fuels. For example, the Bermuda Agreement between the United States and Great Britain signed in 1946 served as an example for almost 3,000 other agreements. It prohibits any tax discrimination that would consist in applying a tax regime on the refuelling of fuels by foreign airlines that is less favourable than that applied to domestic airlines.

The exemption for jet fuel consumed on international flights is the result of bilateral agreements and not of the Chicago Convention *per se*. This exemption is therefore considered as a tax expenditure in several countries, such as Finland, the Netherlands and Turkey. In France, the definition of the reference tax standard, which is widely debatable, includes the exemptions and reduced rates of the European Directive. Jet fuel exemptions are therefore not tax expenditures and the associated revenue losses are not evaluated by the administration because they have been decommissioned since 2009 (French Republic, 2022). Ledez and Vailles (2022) estimate the fiscal expenditures in terms of the Domestic Consumption Tax on Energy Products at €3.5 billion for 2018.

B – Carbon pricing of jet fuel

The effective pricing of CO_2 emissions from the combustion of jet fuel is measured from all the taxes applicable to the fuel and its use, taking into account the physical-chemical properties of the combustion/energy production. The OECD (2021) considers three components in its assessment of the effective carbon price measured for the civil aviation sector: fuel excise duties, carbon taxes and the price of CO_2 emission permits.

Table 2 below presents the carbon pricing of jet fuel and its evolution between 2018 and 2021 in some countries[16] based on available OECD data (2022) and applying the emission rates of French regulations[17]. For all countries, the average effective pricing is €9.6/tonne CO_2 in 2021 compared to €7.7/tonne CO_2 in 2018. CO_2 pricing linked to jet fuel consumption has thus increased on average 24% between 2018 and 2021. This increase is mainly due to an increase in emission permits, particularly for the Member States of the European Union (+235%)[18]. Between 2018 and 2021, some countries such as South Africa introduced a carbon tax, which logically translates into an increase in their effective pricing. Others, such as India and Russia, significantly reduced excise duties on jet fuel (by 18% and 15% respectively) and consequently recorded a decrease in their effective pricing.

[16] See Appendix B for analysis of countries for which data are available.
[17] See https://www.legifrance.gouv.fr/loda/id/JORFTEXT000026702697 The coefficients are calculated according to the "well to wheel" or "well to wake" approach. We take 86.7 kg CO_2/GJ for jet fuel , 91.5 kg CO_2/GJ for diesel and 88.3 kg CO_2/GJ for petrol respectively.
[18] The pricing reported in Table 2 are average effective prices. In doing so, it takes into account the distinction between domestic and international flights and the exemptions that apply to the latter. Since the share of international flights varies from country to country, the levels of pricing reported for different EU countries vary even though they apply the same emissions permit system.

Table 2: Effective pricing of jet fuel CO_2 in 2021 and variation since 2018 (Euro/tonne CO_2)

	Effective pricing (2021)	Effective pricing (2018)	Variation	Excise duty	Variation	Carbon tax	Variation	Emission permits	Variation
All countries (1)	9,594	7,733	24,06%	7,018	2,71%	0,844	198,69%	1,733	180,49%
G20 (1)	8,894	7,435	19,63%	7,050	2,99%	0,733	369,94%	1,112	156,47%
OECD (1)	13,774	10,795	27,59%	9,857	4,37%	1,248	212,74%	2,670	180,49%
Recipient countries of official develop	1,953	2,161	-9,62%	1,847	-11,51%	0,106	43,58%	0,000	
Germany	16,405	4,903	234,57%	0,000		0,000		16,405	234,57%
Australia	7,293	7,358	-0,89%	7,293	-0,89%	0,000		0,000	
Belgium	1,076	0,224	379,49%	0,790	Intr.	0,000		0,286	27,34%
Brazil	0,000	0,000		0,000		0,000		0,000	
Canada	29,804	12,469	139,02%	14,098	62,02%	11,526	741,34%	4,180	74,33%
China	0,000	0,000		0,000		0,000		0,000	
Korea	4,797	4,940	-2,90%	0,000		0,000		4,797	-2,90%
Spain	27,598	8,249	234,57%	0,000		0,000		27,598	234,57%
United States	8,676	8,732	-0,64%	8,676	-0,64%	0,000		0,000	
France	31,470	9,406	234,57%	0,000		0,000		31,470	234,57%
Indonesia	0,000	0,000		0,000		0,000		0,000	
India	4,370	5,369	-18,60%	4,370	-18,60%	0,000		0,000	
Japan	51,748	51,537	0,41%	49,857	0,41%	1,891	0,41%	0,000	
Philippines	23,671	22,184	6,70%	23,671	6,70%	0,000		0,000	
United Kingdom	15,940	4,526	252,17%	0,000		0,000		15,940	252,17%
Russia	0,854	1,006	-15,09%	0,854	-15,09%	0,000		0,000	
Switzerland	231,363	220,025	5,15%	228,643	4,08%	0,000		2,720	691,43%

1: weighted average

Source: OECD (2022) and authors' calculations.

C – Comparison of carbon pricing of different fuels

Table 3[19] below shows the details of carbon pricing for jet fuel, diesel and petrol in 2021. It shows a carbon pricing deficit for jet fuel consumption, and therefore air transport, compared to other fuels[20]. The weighted average for the world is €9.6 per tonne of CO_2 for jet fuel compared to €79.6/tonne of CO_2 for diesel and €71.2/tonne of CO_2 for petrol. If we restrict ourselves to the G20 countries, the averages are €8.9 per tonne of CO_2 for jet fuel compared to €78.7/tonne of CO_2 for diesel and €67.9/tonne of CO_2 for petrol.

This very significant difference in average pricing between jet fuel and other fuels results from two phenomena: (i) a more favourable tax treatment of jet fuel compared to other fuels when used for domestic flights and (ii) the tax exemptions applicable to jet fuel used for international flights.

[19] See Table B.2 for all countries for which data are available in Appendix B.

[20] See also Dequiedt (2020).

Table 3: Effective CO_2 pricing for jet fuel, diesel and petrol in 2021 (Euro/tonne CO_2)

	Jet Fuel				Diesel	Petrol
	Excise duty	Carbon tax	Emission permits	Effective pricing	Effective pricing	Effective pricing
All countries (1)	7,018	0,844	1,733	9,594	79,572	71,158
G20 (1)	7,050	0,733	1,112	8,894	78,750	67,901
OECD (1)	9,857	1,248	2,670	13,774	102,381	79,807
Recipient countries of official developme	1,847	0,106	0,000	1,953	49,886	58,302
Germany	0,000	0,000	16,405	16,405	163,373	247,041
Brazil	0,000	0,000	0,000	0,000	0,000	5,423
Canada	14,098	11,526	4,180	29,804	61,064	78,847
China	0,000	0,000	0,000	0,000	47,823	68,950
United States	8,676	0,000	0,000	8,676	37,279	36,993
France	0,000	0,000	31,470	31,470	172,061	237,289
Indonesia	0,000	0,000	0,000	0,000	4,625	6,594
India	4,370	0,000	0,000	4,370	110,546	130,180
Japan	49,857	1,891	0,000	51,748	81,803	149,466
United Kingdom	0,000	0,000	15,940	15,940	205,043	234,159
Russia	0,854	0,000	0,000	0,854	27,032	39,017

1: weighted average

Source: OECD (2022) and authors' calculations.

IV. The potential and effects of a jet fuel tax

A - The fiscal potential

Table 4 presents a simple simulation of the expected revenues based on the breakdown between domestic and international flights and the jet fuel consumption observed in 2018. With an excise duty on jet fuel consumed by international flights alone of €0.1/litre, the revenue is €6 billion (column 4). An excise duty of €0.33/litre would raise almost €20 billion (column 5). Given the concentration of air transport activity, most of the revenue from a jet fuel tax would be collected by a few countries, including the United States, China and Canada. EU Member States would account for slightly more than 9.5% of total revenues.

To estimate the potential revenue from an excise duty, we consider the following conversion rates: one tonne of jet fuel corresponds to 1250 litres, generates 46 GJ of energy and produces 3160 kg of CO_2. With these rates, a price of €40/tonne corresponds to an excise duty of €0.1/litre. The European Directive regulating excise duties, on fuels in particular, sets a minimum rate of €0.33/litre, which would correspond to a price of €130 per tonne of CO_2 (see Appendix D). The €0.33/litre tax scenario is the intermediate scenario chosen in the report submitted to the European Commission in 2021. This is our preferred scenario as it is consistent with the EU's commitments to decarbonise economic activity.

The scenario of a €0.1/litre tax is a minimum scenario, far from the levels of CO_2 pricing that the European Union has set for itself, but which could result from difficulties encountered during the international negotiations that will be necessary to introduce such a tax. It is worth noting in particular that the level of €0.1/litre is already applied by some American states. The application of such a rate on jet fuel for international flights should therefore logically meet with less reluctance from the United States.

This estimate does not take into account a possible change in behaviour and therefore in volumes consumed once the excise duty is implemented. Similarly, it does not take into account the anticipated growth in air traffic, estimated by the aircraft manufacturers Boeing[21] and Airbus[22] at around 4% per year for the next 20 years. The proposed estimates are therefore an approximation that may over- or underestimate the potential revenue from the excise duty studied. The analysis is complemented by an assessment of the fiscal impact of a jet fuel tax in subsection B below.

Table 4: Potential revenue from excise duty on jet fuel for international flights

	Potential taxable base (TJ)				Revenue (millions Euros)				
	1	2	3	4	5	6	7		
	Domestic flights	International flights	Total	Effective tax rate Euro /GJ	Domestic flights (1*4)	International flights €0.10 Euro/l.	International flights 0.33/litre	Percentage of total revenue (€0.33/litre)	Cumulative percentage
United States	1 705 781	754 844	2 460 625	1	1 291 335	2 051	6 769	33,92%	33,92%
China	680 871	320 445	1 001 316	0	0	871	2 874	14,40%	48,32%
Canada	102 959	180 206	283 165	1	111 307	490	1 616	8,10%	56,42%
Russia	135 216	103 305	238 521	0	11 790	281	926	4,64%	61,06%
India	103 535	82 497	186 033	0	48 190	224	740	3,71%	64,77%
Japan	59 417	88 521	147 938	4	265 492	241	794	3,98%	68,75%
Brazil	85 993	55 833	141 826	0	0	152	501	2,51%	71,26%
Indonesia	88 480	45 033	133 513	0	0	122	404	2,02%	73,28%
Australia	45 982	85 357	131 339	1	29 335	232	765	3,84%	77,12%
Spain	14 233	77 443	91 676	1	10 179	210	694	3,48%	80,60%
France	16 637	53 715	70 352	1	13 568	146	482	2,41%	83,01%
Korea	6 560	49 861	56 421	0	2 809	135	447	2,24%	85,25%
Turkey	15 601	37 676	53 277	0	0	102	338	1,69%	86,95%
South Africa	15 197	36 244	51 441	0	4 577	98	325	1,63%	88,57%
Great Britain	1 870	35 100	36 969	0	734	95	315	1,58%	90,15%
Italy	6 929	29 668	36 597	1	4 656	81	266	1,33%	91,48%
Germany	1 861	25 143	27 004	0	791	68	225	1,13%	92,61%
Egypt	1 611	25 065	26 676	0	0	68	225	1,13%	93,74%
Argentina	9 213	15 785	24 998	4	39 319	43	142	0,71%	94,45%
Total						**6 047**	**19 955**		

Source: OECD (2022), authors' calculation

B - Fiscal impact

Price elasticity - the introduction of a tax on jet fuel for international flights will have an effect on the price of this fuel. The cost of fuel represents about 25% of the price of tickets sold by airlines and a larger proportion of their costs. An increase in the price of fuel will therefore have an impact on the price of the air transport service and the total number of international flights.

The literature review conducted in Appendix E leads us to favour the hypothesis of a price elasticity for international flights equal to -1, which means that a 1% increase in ticket prices will lead to a 1% decrease in the consumption of international flights. This is a more penalizing assumption for the fiscal potential than the -0.8 price elasticity assumption chosen by the European Commission in its

[21] https://boeing.mediaroom.com/2022-07-16-As-Air-Travel-Rebounds,-Boeing-Forecasts-Demand-for-More-than-41,000-New-Airplanes-by-2041

[22] https://www.airbus.com/en/products-services/commercial-aircraft/market/global-market-forecast

2019 study. Assuming a jet fuel price excluding taxes equal to €0.9/litre[23] and considering that fuel represents 25% of the ticket price, application of a €0.1/litre tax would lead to a 2.7% increase in ticket prices and the application of a €0.33/litre tax would lead to a 9.2% increase in ticket prices. These estimates are made under the assumption that the tax has a 100% fiscal impact on the price of jet fuel (i.e. the amount of the tax is reflected in an identical increase in the selling price of jet fuel) and that this increase in the price of jet fuel is fully passed on to the ticket price. These assumptions automatically increase the negative effect of the jet fuel tax on the demand for air transport and reduce the tax revenues obtained. A partial absorption of the cost increase by refiners in their jet fuel sales prices or by airlines in ticket sales prices is possible but difficult to quantify. Such absorption would tend to increase tax revenues.

Under the above assumptions and with a price elasticity of -1, a downwardly revised estimate of excise duty revenue can be calculated. This new estimate takes into account the decrease in jet fuel consumption linked to the increase in the price of international flights[24]. For a tax of €0.1/litre, the total revenue would be €5.8 billion; for a tax of €0.33/litre, as retained in our preferred scenario, the total revenue would be €18.1 billion[25].

Reallocation effects - Beyond the effect on prices and quantities, a jet fuel tax on international flights can have other reallocation and incentive effects. Such a tax changes the trade-offs that the various players in the sector will have to make. In particular, it could lead to:

- greater efficiency of aircraft in their jet fuel combustion (engine, wings, etc.), which could accelerate the renewal of aircraft fleets owned or leased by airlines, with the risk of a rebound effect appearing limited[26];
- the development and adoption of sustainable aviation fuels, particularly if they receive preferential tax treatment compared to conventional petroleum-based jet fuel (see Appendix F);
- the development and adoption of alternative fuels such as electricity or hydrogen (see Appendix C);
- the use of fuel tankering, which consists of taking on board more fuel than necessary for the flight in countries where the price of fuel is lower. This practice leads to an increase in the weight carried, thus additional energy consumption and more CO_2 emissions. This practice could be an important means of international tax competition.

Some effects, such as the development of sustainable aviation fuels or fuel tankering, can be encouraged or restricted by regulations in addition to taxation. For example, since 2022, French regulations have required fuel suppliers to include at least 1% sustainable fuels in their jet fuel deliveries. The French government has set a substitution target of 2% by 2025, 5% by 2030 and 50% by 2050.

[23] https://www.indexmundi.com/fr/matieres-premieres/?marchandise=carburant-aviation&mois=60 . The price of jet fuel retained is 3.63 USD per gallon, observed on 30/01/2023. It should be noted that the price of jet fuel is volatile and that the quantification exercise conducted here is by nature an approximation.

[24] According to a simplifying assumption, a decrease in flights results in a corresponding decrease in the quantity of jet fuel used.

[25] These amounts, calculated taking into account the price elasticity of demand, are announced in the summary and introduction to this paper.

[26] In his 1865 book *The Coal Question*, William Stanley Jevons analysed how the improved use of coal for steel production in Scotland between 1830 and 1863 led to an increase in coal demand and not a generally expected decline. Energy efficiency gains reduce the cost of producing a good or service such as air transport. This can be reflected in lower prices and higher demand for the good or service.

These reallocation effects are difficult to assess. Therefore, we consider that the previously provided estimates can be retained in order to quantify the short-term fiscal potential of a tax on jet fuel used for international flights. In the medium to long term, substantial behavioural changes are expected to limit the consumption of standard petroleum-based jet fuel. The revenue from the tax will be negatively impacted but the effect on air transport related CO_2 emissions will be positive.

V. Implementation of a jet fuel tax

A – Legal constraint

Beyond the fiscal potential and the effects of introducing a tax on jet fuel consumed during international flights, the constraints that may affect its conceptualisation and implementation should be considered. The 1944 Chicago Convention on International Civil Aviation is often seen as a legal constraint on the introduction of a tax on jet fuel used for international flights. However, the Convention does not prohibit the taxation of jet fuel. As noted above, Article 24 of the Convention only specifies an exemption from duties and taxes on fuel contained in tanks when an international flight lands but allows for taxation of fuels by the country where the fuel is loaded into the tanks. For example, there is nothing to prevent countries that have already adopted taxation on their domestic flights, such as Brazil, the United States, Japan, Norway or the Netherlands, from signing bilateral agreements to tax international flights between them.

Faber and O'Leary (2018) analyse the legality and consequences of EU Member States taxing fuel consumed on intra-European flights. They suggest that a de minimis rule based on the amount of fuel purchased in a Member State, the number of flights made, or CO_2 emissions, would allow a tax to be levied on fuel consumed on intra-EU flights without exposing the risk of litigation, particularly with US airlines protected by the US-EU bilateral agreement. Another way to facilitate the introduction of fuel taxation within the EU would be for the EU to repeal the exemption from fuel taxation provided for in international agreements. The Open Sky agreement between the European Union and the United States exempts fuel from taxation only on the basis of reciprocity, which can be withdrawn at any time to allow either party to impose taxes.

B – Political opportunity

The appropriateness of introducing a tax on jet fuel is particularly debated in Europe. After considering the introduction of such a tax in the early 2000s, and then abandoning the idea in the face of resistance from sector players, the EU adopted the energy tax directive in 2003 (see Appendix D). A group of EU countries responsible for more than 50% of emissions from the European aviation sector (Belgium, Bulgaria, Denmark, France, Germany, Italy, Luxembourg, the Netherlands and Sweden) invited the European Commission in 2019 to review and take forward the debate on civil aviation pricing.

Recognising that the tax exemption for international aviation is no longer adapted to today's climate challenges, the EU has started to revise the 2003 directive so that it is in line with the Green Pact for

Europe, which aims to reduce net greenhouse gas emissions by 55% in 2030 compared to 1990 levels. Article 14 of the proposed "RED III" directive paves the way for taxation of jet fuel for intra-European flights, with a gradual alignment with road transport taxation within 10 years, while sustainable fuels would benefit from a minimum rate of zero to promote their adoption. The “Fit for 55” programme was presented in July 2021, and its progress was monitored during the French Presidency of the EU Council. Unsurprisingly, these proposals meet with strong opposition from sector players, represented in particular by the International Air Transport Association (IATA).

France, for its part, is in favour of the introduction of a European-wide jet fuel tax, as Bruno Le Maire has indicated on several occasions in recent years. Amendments aimed at taxing jet fuel had been tabled as part of the law on the orientation of mobilities in 2019 but were finally rejected, with Elisabeth Borne, then Minister for Ecological Transition and Solidarity, indicating that the climate challenge had to be taken up at European and global levels. In 2005, France also adopted a solidarity tax on airline tickets, also known as the Chirac tax[27], to finance the international organization Unitaid.

Regardless of the scale considered, European or global[28], the implementation of a jet fuel tax will require, above all, broad political support, which could be encouraged by the dual challenge of mobilising resources for vulnerable countries and combating climate change.

Some economic actors in the sector may support the adoption of such a tax. Aircraft manufacturers are expected to be favourable as this tax will accelerate the renewal of the aircraft fleet. Fuel producers may also find some interest in this as the development of sustainable fuels creates opportunities for new market shares. Airlines seem to be the most hostile stakeholders to this type of taxation since they are directly exposed to a possible drop in demand following the increase in the price of their transport service induced by the tax.

C – Technical implementation

The technical design of a jet fuel tax is not particularly difficult. Fuel taxation generally takes several forms: specific taxes, ad valorem taxes or a combination of both. In general, specific taxes have a greater impact on prices than ad valorem taxes[29].

The choice of the generating event as well as the choice of the stage in which the tax is payable throughout the life cycle of jet fuel are decisive for the success of the tax in terms of revenue. The tax can be levied at any of the various stages from production to consumption of paraffin: from the time it is produced and leaves the refinery gate, when it is imported, when it is stored in airport facilities, or when it is delivered to airlines. For example, if the tax were levied at the time of storage of jet fuel at an airport, it could be treated as a local tax, as is the case in some American states.

An alternative approach to the tax would be to present the jet fuel levy as a charge for environmental services rendered by the atmosphere. This acts as a "landfill" by absorbing the by-products, in this

[27] Adopted in 2005 by five countries (Brazil, Chile, Norway, the United Kingdom and France) and increased in France since 2020 by an eco-contribution.

[28] It should be noted here that implementation in Europe alone may raise issues relating to competitiveness and intra-European trade. These issues are complex and it is beyond the scope of this paper to analyse them in detail.

[29] In general, producers can absorb ad valorem taxes into their profit margins more than specific taxes.

case the CO_2 produced by the main air transport activity. By virtue of its different status from a tax, this fee could be simpler to implement legally.

Finally, whichever approach is chosen, the mechanism for allocating the proceeds of the tax to the fund for vulnerable countries will need to be clarified.

VI. Conclusion

The tax exemption for jet fuel consumed on international flights appears today as a budgetary and environmental anomaly. This exemption is the product of the multitude of bilateral agreements governing air traffic between countries and not of a principle established by the Chicago Convention. It is comparable to a tax expenditure because it is based on a deliberate national policy[30].

A tax on jet fuel consumed on international flights of €0.33/litre would raise €18 billion per year, while a tax of €0.1/litre would raise €5.8 billion per year. This tax would reduce the carbon pricing differential currently enjoyed by air transport. It would be particularly fair in view of the profile of the travellers concerned. Finally, it would also provide an incentive to decarbonise the sector by favouring sustainable fuels and the most efficient aircraft. It would thus complement the voluntary approach (CORSA) initiated by the ICAO.

The highly concentrated structure of the sector considerably simplifies the collection of this tax, whether it is payable at the jet fuel refining, storage or delivery level. The main difficulty is political. In the absence of global coordination, which would be the best solution, the adhesion of a few countries, including the United States, the European Union, Japan, China, India and Brazil, would be sufficient to capture nearly three quarters of the sector's CO_2 emissions. The monopolistic competition characterising the sector would limit the damaging effects of the unilateral adoption of such a tax on competitiveness[31]. This last point would require further analysis.

[30] By considering a reference tax system based on the taxation of petroleum products and not the French tax standard which is more legal than economically justified.
[31] Air transport is mainly driven by tourism, which itself is linked to the geographical sites visited.

Bibliography

Bosch, J., de Jong, S., Hoefnagels, R. and E. Slade, 2017, «Aviation biofuels: Strategically important, technically achievable, tough to deliver», *Grantham Institute Briefing Paper No 23*.

Brons, M., Pels, E., Nijkamp, P. and P. Rietveld, 2022, «Price Elasticities of Demand for Passenger Air Travel: A Meta-Analysis» *Journal of Air Transporting Management, 8(3)*, 165-175.

Büchs, M. and G. Mattioli, 2021, «Trends in air travel inequality in the UK: From the few to the many?» *Travel Behaviour and Society, 25*, 92-101.

Dequiedt, B., 2020, «La tarification des émissions de CO2 en France», Rapport annuel 2020 du Haut Conseil pour le Climat.

Direction générale de l'aviation civile – DGAC, 2020, «Les émissions gazeuses liées au trafic aérien en France en 2020», Rapport Ministère chargé des transports.

Ellis, J., 1997, «Aviation: The Politics and Economics of a Boom», *Foreign Policy, 109*, 141–154.

European Commission, 2021, «Study on the taxation of the air transport sector» Final report.

European Commission, 2019, «Taxes in the field of aviation and their impact» Final report.

European Court of auditors, 2022, «Energy taxation, carbon princing and energy subsidies», Report of the European Court of auditors.

Faber, J. and A. O'Leary, 2018, «Taxing aviation fuels in the EU», CE Delft report.

Fageda, X. and J. Teixido, 2022, «Pricing carbon in aviation sector: Evidence from the European emissions trading system», *Journal of Environmental Economics and Management, 111*.

Fucci, F. R., 1987, «Allowing State Taxation of Foreign Carrier's Fuel: Wardair Canada, Inc. v. Florida Department of Revenue», *The Tax Lawyer, 40(419)*.

Fukui, H. and C. Miyoshi, 2017, «The impact of aviation fuel tax on fuel consumption and carbon emissions: The case of the US airline industry», *Transportation Research Part D: Transport and Environment, 50*, 234-253.

Gössling S. and A. Humpe, 2020, «The global scale, distribution and growth of aviation: Implication for climate change», *Global Environmental Change*, 65, 102194.

Hemmings, B., Pache, E., Forsyth, P., Mundaca, G., Strand, K. and P. Kageson, 2020, «Taxing Aviation Fuel in Europe. Back to the future?», Report.

International Civil Aviation Organization, 2022, «Report on the feasibility of a long-term aspirational goal (LTAG) for international civil aviation CO2 emission reductions», ICAO report

International Civil Aviation Organization, 2013, «The air transport value chain: Industry features in the past decade», Montréal Conference

International Transport Forum, 2021, «Decarbonising Air Transport: Acting Now for the Future», Édité par OECD Publishing. *International Transport Forum Policy Papers*, No. 94.

Ivaldi M. and T. Toru-Delibaşı, 2018, «Competitive impact of the air ticket levy on the European airline market», *Transport Policy*, Nov 15;70:46-52.

Keen, M. and J. Strand, 2007, «Indirect Taxes on International Aviation» *Fiscal Studies, 28(1)*, 1-41.

Keen, M., Parry, I. and J. Strand, 2013, «Planes, ships and taxes: charging for international aviation and maritime emissions», *Economic Policy, 28(76)*, 701-749.

Landau, J.-P., 2004, « *Les Nouvelles contributions financières internationales* ». La documentation française.

Ledez, M. and C. Vailles, 2022, « *Dépenses fiscales défavorables au climat : Quelles sont-elles et combien coûtent-elles?* », I4CE, Point Climat N°70.

Lee, D.S., Fahey, D.W., Skowron, A., Allen, M.R., Burkhardt, U., Chen, Q., et al., 2021, «The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018», *Atmos. Environ. 244*.

Meijers, D., 2005, «Tax Flight, an investigation into the origins and development of exemptions from various kinds of taxation of international aviation», *International Center for Integrative Studies, Working paper I05-E001*.

Ministère de la Transition Ecologique et Solidaire, 2018, «Information GES des prestations de transport, Guide méthodologique», Rapport

OECD, 2021, «*Effective Carbon Rates 2021. Pricing Carbon Emissions through Taxes and Emissions Trading*», OECD Series on Carbon Pricing and Energy Taxation, OECD Publishing.

OECD, 2022, «*Pricing Greenhouse Gas Emissions: Turning Climate Targets into Climate Action*», *OECD Series on Carbon Pricing and Energy Taxation.* OECD Publishing.

Öko-Institut, 2021, «Options for regulating the climate impacts of aviation», Öko-Institut report

Papatheodorou, A., 2021, «A review of research into air transport and tourism: Launching the Annals of Tourism Research Curated Collection on Air Transport and Tourism », *Annals of Tourism Research*, Volume 87, 103151.

République Française, 2022, Annexe au Projet de loi de finances pour 2022 – « Evaluation des voies et moyens. Les dépenses fiscales », Tome II.

Appendix A: Taxation of jet fuel in the United States

Authorities	Jet Fuel Euro/litre	Comments
Federal	0.0607	Additional taxes: Leakage charges for underground tanks: \$0.001/gal. or €0.00027/litre Fractional ownership program aircraft surcharge: \$0.141/gal or €0.0391/litre Commercial jet fuel tax rate: \$0.044/gal. or €0.0122/litre
Alabama	0.0097	
Alaska	0.0089	
Arizona	0.0085	
Arkansas		Sales Tax 6.5% Petroleum Environmental Insurance Fee: \$0.003/gal. or €0.0008/litre Local tax: \$0.01/gal.
California	0.0055	Underground tank charge: \$0.02/gal. Oil Spill Response, Prevention, and Administration fee: \$.0015/gal. Jet Fuel Sales Tax: \$0.18/gal. or €0.05/litre
Colorado	0.0111	
Connecticut		Petroleum products gross earnings tax (PPGET): 8.1%
Delaware	0.0139	
District of Columbia	0.0652	
Florida	0.0118	Pollution taxes: Coastal Protection, \$0.02/barrel; Inland Protection, \$0.8/barrel; Water Quality Assurance, \$0.05/barrel.
Georgia		Environmental Insurance fee: \$0.005/gal. Sales Tax: 4%
Hawaii	0.0028	
Idaho	0.0166	Transfer fee: \$0.01/gal.
Illinois		Sales Tax: 6.25%. Underground storage fee: \$0.003/gal Environmental impact fee: \$0.008/gal
Indiana	0.0555	Potential excise duty Inspection fee: \$0.01/gal
Iowa	0.0139	
Kansas		
Kentucky		Sales Tax: 6%
Louisiana		Sales Tax: 4% Inspection fee: \$0.00125/gal.
Maine	0.0094	Maine Coastal and Inland Surface Oil Clean-up Fund fee: \$0.03/bbl
Maryland	0.0194	Oil Transfer License fee: \$0.0018/gal.
Massachusetts	0.0386	Local tax according to municipal votes
Michigan	0.0083	Sales Tax: 6% Environmental protection fee: \$0.001/gal.
Minnesota	0.0416	Petroleum Inspection fee: \$0.001/gal Tank cleaning fee: \$0.02/gal
Mississippi	0.0146	Environmental fee: \$0.0004/gal

Missouri		Agricultural Inspection fee: $0.0007/gal Transport Load fee: $0.0035/gal.
Montana	0.0111	Aviation fuels are subject to the Petroleum Storage Cleanup fee: $0.0075/gal.
Nebraska	0.0083	Petroleum Release Remedial Action fee (PRF): $0.003/gal.
Nevada	0.0028	Potential local taxes
New Hampshire	0.0055	Oil Pollution Control Fund fee: $0.00125/gal Oil Discharge, Disposal and Cleanup Fund fee: $0.015/gal.
New Jersey	0.0166	Airport security fund tax: $0.02/gal. Petroleum Products Gross Receipts tax (PGRT): $0.04/gal. Compensation and Control Tax: $0.0005/gal.
New Mexico		Potential revenue tax.
New York	0.0194	Petroleum testing fee: $0.005/gal. Fee for Aviation fuels subject to Oil Spill Prevention, Control and Compensation License: $0.095/bbl ($0.0019/gal) with a $0.0425/bbl ($0.0029/gal) surcharge.
North Carolina		Inspection fee: $0.0025/gal.
North Dakota	0.0222	Excise duty (potential): 4%.
Ohio		Sales Tax: 5.5%.
Oklahoma	0.0002	Underground storage fee: $0.01/gal.
Oregon	0.0083	Loading fee: $10.00 per tank fill-up (100 gallons or more).
Pennsylvania	0.0055	Underground Storage Tank Indemnification Fund (USTIF) fee: $0.011/gal.
Rhode Island		Uniform Oil Response and Prevention fee: $0.05/barrel ($0.0012/gal) Environmental Protection Regulatory fee: $0.01/gal.
South Carolina		Inspection fee: $0.0025/gal. Environmental charge: $0.005/gal.
South Dakota	0.0111	Tank Inspection fee: $0.02/gal.
Tennessee	0.0028	Environmental insurance fee: $0.004/gal.
Texas		
Utah	0.0250	Environmental insurance fee: $0.005/gal.
Vermont		Sales Tax: 6% Petroleum distributor fee: $0.01/gal.
Virginia	0.0139	
Washington	0.0499	Oil Spill Administration Tax: $0.04/barrel ($0.0009523/gal). Oil Spill Response Tax: $0.01/bbl ($0.000238/gal). Hazardous Substance tax on petroleum products: $1.20/bbl ($0.0286/gal). Petroleum Products Tax (PPT).
West Virginia	0.0422	
Wisconsin	0.0166	Petroleum Inspection fee: $0.02/gal.
Wyoming	0.0139	
American Samoa	0.0028	
Guam	0.0416	
Northern Mariana Islands		Ad valorem tax: 3%
Puerto Rico	0.0083	
Us Virgin Islands		

Source: EIA and authors' calculations

Appendix B: Details of estimates for all countries for which data are available

Table B.1: Effective CO_2 pricing of jet fuel in 2021 and change since 2018 (Euro/tonne CO2)

	Effective pricing (2021)	**Effective pricing (2018)**	*Variation*	**Excise duty**	*Variation*	**Carbon tax**	*Variation*	**Emission permits**	**Variation**
All countries (1)	9,594	7,733	24,06%	7,018	2,71%	0,844	198,69%	1,733	180,49%
G20 (1)	8,894	7,435	19,63%	7,050	2,99%	0,733	369,94%	1,112	156,47%
OECD (1)	13,774	10,795	27,59%	9,857	4,37%	1,248	212,74%	2,670	180,49%
Recipient countries of official deve	1,953	2,161	-9,62%	1,847	-11,51%	0,106	43,58%	0,000	
South Africa	5,059	3,474	45,63%	3,637	4,68%	1,422	Intr.	0,000	
Germany	16,405	4,903	234,57%	0,000		0,000		16,405	234,57%
Argentina	42,104	49,224	-14,46%	37,793	-14,46%	4,311	-14,49%	0,000	
Australia	7,293	7,358	-0,89%	7,293	-0,89%	0,000		0,000	
Austria	4,921	1,471	234,57%	0,000		0,000		4,921	234,57%
Belgium	1,076	0,224	379,49%	0,790	Intr.	0,000		0,286	27,34%
Brazil	0,000	0,000		0,000		0,000		0,000	
Canada	29,804	12,469	139,02%	14,098	62,02%	11,526	741,34%	4,180	74,33%
Chile	0,000	0,000		0,000		0,000		0,000	
China	0,000	0,000		0,000		0,000		0,000	
Korea	4,797	4,940	-2,90%	0,000		0,000		4,797	-2,90%
Ivory Coast	0,000	0,000		0,000		0,000		0,000	
Denmark	60,871	56,167	8,38%	49,965	3,29%	6,773	3,29%	4,133	234,57%
Spain	27,598	8,249	234,57%	0,000		0,000		27,598	234,57%
United States	8,676	8,732	-0,64%	8,676	-0,64%	0,000		0,000	
Finland	13,058	3,903	234,57%	0,000		0,000		13,058	234,57%
France	31,470	9,406	234,57%	0,000		0,000		31,470	234,57%
Indonesia	0,000	0,000		0,000		0,000		0,000	
India	4,370	5,369	-18,60%	4,370	-18,60%	0,000		0,000	
Ireland	3,150	0,942	234,57%	0,000		0,000		3,150	234,57%
Iceland	15,184	4,538	234,57%	0,000		0,000		15,184	234,57%
Israel	0,000	0,000		0,000		0,000		0,000	
Italy	25,931	7,750	234,57%	0,000		0,000		25,931	234,57%
Japan	51,748	51,537	0,41%	49,857	0,41%	1,891	0,41%	0,000	
Norway	63,188	48,604	30,00%	0,000		49,674	11,46%	13,514	234,57%
New Zealand	24,422	8,889	174,75%	0,000		0,000		24,422	174,75%
Netherlands	1,310	0,391	234,57%	0,000		0,000		1,310	234,57%
Philippines	23,671	22,184	6,70%	23,671	6,70%	0,000		0,000	
Poland	30,151	9,012	234,57%	0,000		0,000		30,151	234,57%
United Kingdom	15,940	4,526	252,17%	0,000		0,000		15,940	252,17%
Russia	0,854	1,006	-15,09%	0,854	-15,09%	0,000		0,000	
Sweden	20,617	6,162	234,57%	0,000		0,000		20,617	234,57%
Switzerland	231,363	220,025	5,15%	228,643	4,08%	0,000		2,720	691,43%

1: weighted average

Source: OECD (2022) and authors' calculations.

Table B.2: Effective CO2 pricing of jet fuel, diesel and petrol in 2021 (Euro/tonne CO2)

	Jet Fuel				Diesel	Petrol
	Excise duty	Carbon tax	Emission permits	Effective pricing	Effective pricing	Effective pricing
All countries (1)	7,018	0,844	1,733	9,594	79,572	71,158
G20 (1)	7,050	0,733	1,112	8,894	78,750	67,901
OECD (1)	9,857	1,248	2,670	13,774	102,381	79,807
Recipient countries of official development assistance (1)	1,847	0,106	0,000	1,953	49,886	58,302
South Africa	3,637	1,422	0,000	5,059	106,144	123,305
Germany	0,000	0,000	16,405	16,405	163,373	247,041
Argentina	37,793	4,311	0,000	42,104	38,660	63,933
Australia	7,293	0,000	0,000	7,293	67,494	92,966
Austria	0,000	0,000	4,921	4,921	120,794	167,482
Belgium	0,790	0,000	0,286	1,076	154,787	211,047
Brazil	0,000	0,000	0,000	0,000	0,000	5,423
Canada	14,098	11,526	4,180	29,804	61,064	78,847
Chile	0,000	0,000	0,000	0,000	16,773	95,655
China	0,000	0,000	0,000	0,000	47,823	68,950
Korea	0,000	0,000	4,797	4,797	118,913	188,989
Ivory Coast	0,000	0,000	0,000	0,000	56,837	44,957
Denmark	49,965	6,773	4,133	60,871	132,328	222,005
Spain	0,000	0,000	27,598	27,598	115,317	175,098
United States	8,676	0,000	0,000	8,676	37,279	36,993
Finland	0,000	0,000	13,058	13,058	171,957	263,940
France	0,000	0,000	31,470	31,470	172,061	237,289
Indonesia	0,000	0,000	0,000	0,000	4,625	6,594
India	4,370	0,000	0,000	4,370	110,546	130,180
Ireland	0,000	0,000	3,150	3,150	156,813	215,211
Iceland	0,000	0,000	15,184	15,184	157,507	201,735
Israel	0,000	0,000	0,000	0,000	229,406	272,966
Italy	0,000	0,000	25,931	25,931	187,854	252,960
Japan	49,857	1,891	0,000	51,748	81,803	149,466
Norway	0,000	49,674	13,514	63,188	154,533	218,202
New Zealand	0,000	0,000	24,422	24,422	32,060	188,870
Netherlands	0,000	0,000	1,310	1,310	161,164	285,324
Philippines	23,671	0,000	0,000	23,671	31,730	59,304
Poland	0,000	0,000	30,151	30,151	98,824	127,736
United Kingdom	0,000	0,000	15,940	15,940	205,043	234,159
Russia	0,854	0,000	0,000	0,854	27,032	39,017
Sweden	0,000	0,000	20,617	20,617	142,177	230,875
Switzerland	228,643	0,000	2,720	231,363	223,971	246,935

1: weighted average

Source: OECD (2022) and authors' calculations.

Appendix C - Details of the ICAO Carbon Neutrality Action Plan

ICAO has developed an action plan to achieve carbon neutrality in air transport by 2050 (International Civil Aviation Organization, 2022). The main actions are the adoption of sustainable aviation fuels, the renewal of more efficient aircraft (wings and fuselages) and non-conventional operating measures (such as formation flying). Three scenarios are developed and vary according to the investments made (see Table C.1). A significant part of carbon neutrality relies on the use of sustainable fuels produced from biomass, gaseous waste or atmospheric CO_2 . The use of hydrogen remains marginal and confined to scenario 3, the most ambitious. The investments considered over the period 2020-2050 are significant and mainly undertaken by fuel suppliers (around 30%) and airlines (around 40%). The State, aircraft manufacturers and air navigation service providers are also affected by this plan, but to a lesser extent. None of the scenarios proposes a revision of fuel taxation.

The ICAO approach to decarbonising air transport is not based on an obligation for States, but essentially on each State's voluntary participation. Major markets such as Brazil, China, India and Russia are not joining the process.

Table C.1: ICAO Action Plan Scenarios

ICAO			
Scenarios	**1**	**2**	**3**
CO_2 emissions in 2050 (million tonnes)	950	500	200
Reduction from scenario 0	39%	68%	87%
of which			
Aircraft technologies	20%	21%	21%
Operations	4%	6%	11%
Fuels	15%	41%	55%
Capital expenditures (billions USD)			
States (research and development)	15-180	75-870	75-870
Aircraft manufacturers	150-380	260-1000	260-1000
Fuel suppliers	1300	2300	3200
of which			
Fuels produced from biomass	480		950
Fuels produced from gaseous waste	710		1700
Fuel with lower CO_2 emissions	50		60
Fuels produced from atmospheric CO_2			460
Hydrogen			55
			3225
Airports	2-6	2-6	100-150 (2)
Air navigation service providers	11-20	11-20	11-20
Airlines			
Reduced operating expenses on fuel			
Technology improvements	710-740	710-740	710-740
Operational measures	210-490	210-490	210-490
Costs	1100	2700	4000
Fuels produced from biomass	300		1600
Fuels produced from gaseous waste	770		1800
Fuel with lower CO_2 emissions	50		600
Fuels produced from atmospheric CO_2			60
Hydrogen			10

Source: ICAO (2022)

1: Scenario 0 represents emission reductions resulting from the replacement of airplanes by 2018 production.
2: Cost related to the development of hydrogen aircraft

Appendix D - Conventions, Treaties and Regulations

Article 11 of the bilateral Treaty between the EU and the United States:

1. Upon arrival in the territory of the other Party, aircraft used by air carriers of one Party to perform international air services, as well as their normal equipment, ground equipment, fuels, lubricants, consumable technical supplies, spare parts (including engines), aircraft stores (including, but not limited to, food, beverages and alcohol, tobacco and other products intended for sale to passengers or for consumption in limited quantities during the flight) and other items intended for the operation or maintenance of aircraft operating an international air service or used solely for such purposes shall be exempt, on a reciprocal basis, from any import restrictions, property taxes, capital levies, any customs duties, excise duties and any taxes or charges which are: (a) imposed by national authorities or the European Community; and (b) are not calculated based on the cost of the services provided, provided that such equipment and supplies remain on board the aircraft.

2. The following shall also be exempted, on a reciprocal basis, from the taxes, duties, charges and fees referred to in paragraph 1 of this Article, with the exception of fees calculated on the basis of the services provided:

a) aircraft stores brought into or supplied in the territory of a Party and carried, in reasonable quantities, on board a departing aircraft owned by an airline of the other Party providing international air services, even if these items are intended to be consumed on the portion of the flight performed over the said territory;

b) ground equipment and spare parts (including engines) brought into the territory of a Party for the purpose of servicing, maintaining or repairing aircraft of an airline of the other Party providing international air services;

c) fuel, lubricants and consumable technical supplies brought into or supplied in the territory of a Party for use on board an aircraft owned by an airline of the other Party providing international air services, even if these supplies are intended for use on the portion of the flight performed over that territory;

d) printed matter, in accordance with the customs legislation of each Party, brought into or supplied in the territory of one Party and carried on board a departing aircraft belonging to an air carrier of the other Party providing international air services, even if these items are intended for use on the portion of the flight over the territory of the Party in which they were taken on board.

3. Equipment and supplies referred to in paragraphs 1 and 2 of this Article may be required to be placed under the supervision or control of the competent authorities.

4. The exemptions provided for in this Article shall also be granted where the airlines of one Party have contracted with another airline, benefiting from the same exemptions from the other Party, for the purpose of lending or transferring to the territory of the other Party the items referred to in paragraphs 1 and 2 of this Article.

5. Nothing in this Agreement shall prevent a Party from imposing taxes, duties, fees or charges on the sale of items not intended for consumption on board an aircraft on a portion of the air service between two points in its territory where embarkation and disembarkation are permitted.

6. Where two or more Member States are considering removing the exemption provided for in Article 14(1)(b) of Council Directive 2003/96/EC of 27 October 2003 for fuel supplied in their territory to aircraft of United States carriers, for flights between those Member States, the joint committee shall examine this matter in accordance with Article 18(4)(e).

7. A Party may request the assistance of the other Party, on behalf of its airline(s), to obtain an exemption from taxes, duties, fees and charges levied by national or local authorities on the goods referred to in paragraphs 1 and 2 of this Article, as well as an exemption from fuel distribution charges, under the conditions set forth in this Article, except to the extent that such charges are based on the cost of the service provided. In response to such a request, the other Party shall inform the competent authorities of the comments of the requesting Party and recommend that due account be taken thereof.

Draft Energy Taxation Directive (ETD)

"Regarding aviation, the Union has negotiated, on its own behalf and on behalf of the Member States, horizontal air services agreements as well as comprehensive air transport agreements with third countries. In addition, Member States have also concluded a bilateral air services agreement with third countries. Horizontal air services agreements allow the EU to amend a number of provisions in bilateral agreements concluded by Member States. Comprehensive air transport agreements replace the bilateral agreements concluded by individual Member States with third countries. In most cases, these agreements allow taxation of fuel supplied within the territory of the Member States and intended for use in aircraft operating flights within the Union. "

“The collection of a fuel tax in the aviation sector should not pose administrative problems. Member States already have experience in charging fuel taxes in other modes of transport (mainly road transport). It is expected that a tax on aviation fuel would be collected in the same way, with fuel suppliers collecting the tax when supplying jet fuel at airports, before transferring the corresponding funds to the relevant tax authorities."

"The Union and the Member States have concluded multilateral air services and air transport agreements or bilateral agreements with third countries. These agreements include provisions on the taxation of aviation fuel. Aviation fuel has traditionally benefited from a preferential tax regime. In order to achieve the objectives of the Directive, it is necessary that, without prejudice to those international agreements, energy products and electricity intended for intra-EU air navigation, with the exception of flights reserved for the transport of freight, be taxed. It is appropriate to maintain the exemption for fuel used for cargo-only flights in the absence of more efficient alternatives."

"Regarding extra-EU air navigation, without prejudice to international obligations, and extra-EU waterway navigation, including fishing, Member States may apply exemptions or the same levels of intra-EU taxation, depending on the type of activity."

Appendix E - Elasticity of demand in the air transport sector: a brief review of the literature

Brons et al. (2002) analyse the price elasticity of demand for air passenger transport by conducting a meta-analysis of 37 studies. The average price elasticity is -1.146, which means that a 1% increase in price leads to a 1.146% decrease in demand, with a standard deviation of 0.619. Business class passengers are less sensitive to a price increase, with a price elasticity of around -0.52.

Fukui and Miyoshi (2017) analyse the effect of an increase in jet fuel taxation on the reduction of jet fuel consumption and CO_2 emissions in the United States over the period 1995-2003. They conclude that the elasticity varies from -0.350 to -0.166. A fuel tax increase of 4.3 cents reduces CO_2 emissions by 0.14-0.18% in the short term (1 year) and by 0.008-0.01% in the long term (3 years).

Fageda and Teixido (2022) analyse the effect of the European carbon market on the emissions of the air transport sector and its evolution. They show that the application of European environmental regulation to air transport reduces emissions by 4.7% on average and the number of flights by -4.9%. If only flights that are short enough to compete directly with rail transport are considered, the reduction in emissions is 10.7% and the reduction in flights is 8.9%. The authors performed a difference analysis of differences that exploits the change in regulation of European emission permits. In 2012, all flights arriving or departing from a Member State were covered by the emissions trading scheme. The EU Commission had to revise its position in 2013 and apply emissions permits only to intra-European flights. This change in regulation allows the appearance of a counterfactual to assess the effect of this environmental regulation.

The European Commission (2019) develops a partial equilibrium approach to estimate the effect of specific taxation applied to air transport on demand, the number of flights, jobs (direct and indirect), GDP, tax revenues, CO_2 emissions and noise. The authors make the following assumptions:

- The pass-through rate from cost to price varies between 50% and 100%;
- The elasticity of demand for economy class flights is -1.23 for short intra-European flights, -1.12 for long intra-European flights that have no alternative mode of transport and -0.8 for intercontinental flights. A coefficient of 0.552 (Brons 2002) is applied to determine the elasticity of demand for first class and business class. The latter is less elastic.
- A 1% decrease in air travel demand implies a 1% decrease in the number of flights (assuming maximum aircraft load).
- A 1% decrease in the number of flights implies a 1% decrease in CO_2 emissions.

The effect of the tax on GDP is deduced by assessing the change in value added and multiplying it by a coefficient (sectoral value added/GDP).

From this literature review we find that the price elasticity for international flights is estimated to be between -0.8 and -1.15. In the body of this paper, we reassess the fiscal potential by considering a price elasticity equal to -1.

Appendix F - Standard jet fuel and sustainable jet fuel

Standard jet fuel is derived from petroleum. Sustainable jet fuel can be derived from several processes or feed stocks such as used cooking oil or wood residues. The reduction in CO_2 emissions varies from 17% for the pyrolysis process from forest residue to 93% by gasification of forest residue (Bosch, 2017). These sustainable fuels are more expensive to produce than standard jet fuel and are more expensive. This price premium ranges from 0.4 USD for jet fuel from saturated fatty acids and oils (HEFA-SPK) for a barrel to 50 USD. Sustainable fuels such as HEFA (*Hydroprocessed Esters and Fatty Acids*) or gasification fuels (Fischer-Tropsch[32]) are already being marketed or close to being marketed (Bosch, 2017). Other fuel types are less technologically mature.

The taxation of conventional petroleum-based jet fuel would encourage the adoption of sustainable jet fuel, which is less or not taxed at all. Using the EU Directive's minimum excise duty rate on jet fuel (€0.33/litre or 0.347 USD/litre), Table F.1 presents theoretical excise duties on sustainable fuels according to their carbon content. The difference in excise duty covers part of the price difference between the different sustainable fuels and conventional fuel. According to the International Energy Agency, the subsidies needed for sustainable paraffin consumption at 5% of total fuel consumption would be 6.5 billion USD. Taxing fossil jet fuel at a higher rate than other types of jet fuel is an alternative to subsidies.

Table F.1: Standard and sustainable jet fuels

				g CO_2e/MJ	CO_2 reduction	Theoretical excise duty (USD/l.)
Cost of barrel of oil (USD)		50	100			
Fossil jet fuel (USD/l.)		0,3	0,6	86,7		0,347
HEFA-SPK	Rape oilseed	0,7	1,6	40-108	20-54%	0.152-0277
	Jatropha			55	0,365629	0,220
	Cameline			47	0,457901	0,188
	Used cooking oil			27	0,688581	0,108
From sugar to gasol	Cane sugar	1	2,5	72	0,16955	0,288
	Corn	1	2,5	50	0,423299	0,200
	Corn stover			35	0,596309	0,140
From alcohol to gas	Sugar cane			26	0,700115	0,104
Pyrolysis	Forest residue	1	2,5	72	0,16955	0,288
	Energy crops	1	2,5	9-13	54-75%	0.083-0.152
Gasification and Fis	Forest residue			6	0,930796	0,024

HEFA: Hydroprocessed Esters and Fatty Acids

Sources: Bosch et al. (2017), authors' calculations,
https://www.iea.org/commentaries/are-aviation-biofuels-ready-for-take-off

[32] Fischer-Tropsch is a process to produce synthetic hydrocarbons by catalytically reducing carbon monoxide (CO) with hydrogen (H2).

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