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Aviation Fuel Tankering and Sustainability: The Brazilian Scenario

Peter O'Reilly
Embry-Riddle Aeronautical University, oreillyp@erau.edu
Fabricio Sulzbacher
GOL Brasil, fsulzbacher@voegol.com.br
Diogo Jardim Coutinho
GOL Brasil, djcoutinho@voegol.com.br
Maria Petrescu
Embry-Riddle Aeronautical University, petrescm@erau.edu

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The importance of sustainability has significantly increased around the globe in the last decades, with a particular focus on the aviation industry as a top fossil fuel user. As the aviation industry is considered one of the fastest-growing sources of emissions, it is necessary to focus on environmental and sustainable solutions in the equation of economic savings from fuel tankering practices in a way that could bring gains of credibility for airlines (Boussauw & Vanoutrive, 2017, 2019; Samuels, 2022; Yanto & Liem, 2022). Although airline impact on global warming has been relatively small, the impact of fuel consumption is expected to increase due to high growth rates in the industry (Scheelhaase, 2020). The growing aviation industry and air mobility are on such an ascending trend that companies are now developing autonomous air taxis (Ward et al., 2021). However, in the past, studies have mostly presented the economic benefits of fuel tankering and did not focus on practical actions to compensate for the damage caused to the environment (Hassan et al., 2021; Tabernier et al., 2021; Yanto & Liem, 2022).

At a macro level, fuel tankering accounts for approximately 23% of all airline expenses worldwide. At a meso level, as an example, the fuel expense in Brazil represents a top operational cost for airlines, and, as a result, there has been an ongoing pursuit to improve efficiency (ANAC, 2019; Fregnani et al., 2013). At the micro level, for an airline, fuel costs have been around 30-35% (Paiva, 2021) of an airline's operating expenses in Brazil.

Under these circumstances, Brazil is considered a complex and diversely regulated carbon market without an active emissions management program (Moss, 2021). Each state applies its tax rates in the Brazilian fuel scenario, ICMS. For these reasons related to sustainability and economic concerns, it is essential to verify the impact of improved fuel tankering processes on environmental sustainability and the potential for policies and regulation improvement, especially considering the evolution of regulation concepts in the transport sector (Adler et al., 2015; Beria et al., 2015).

Therefore, this project has the following research objectives:

- Provide an overview of the global evolution of fuel tankering practices at macro, meso, and micro levels;
- Explore the relation of fuel tankering to total carbon emissions;
- Evaluate and compare the Brazilian fuel tankering scenario in the context of existing global and national policies and regulations;
- Recommend support solutions for the adjustment of savings incorporating the neutralization of carbon emissions.

This study provides a starting point for additional ecosystem-based research projects incorporating macro, meso, and micro-level aviation stakeholders, including airlines, customers, employees, and society members. This research can also contribute to formulating a theoretical model that can be applied in fuel tankering and business decision-making to improve sustainability and effectiveness-related modeling. This paper recommends sustainable national measures and compares global practices for minimizing the impact of the higher emissions due to fuel tankering.

Literature Review

Fundamentally, considering the long-term perspective, the demand for commercial aviation has been driven by economic development. Considering the emerging middle class in developing countries, demographic outlook, aviation market liberalization, and climate change, global commercial passenger traffic is expected to grow by 3.2 % annually until 2039 (IATA, 2021). In this context, fuel tankering has been used globally in the aviation industry for years.

Fuel Tankering Practices

Fuel tankering is the practice of an aircraft carrying more fuel than required for its flight to reduce or avoid refueling at the destination airport (Bahia & Skorupski, 2019; Wulandari et al., 2020). This increases the aircraft's weight and fuel consumption, resulting in additional CO_2 emissions. Fuel tankering is often used by airlines to save money on fuel costs; however, it also has a negative impact on the environment, as it increases air pollution and greenhouse gas emissions (Cames, 2007; Eurocontrol, 2019; Pacheco et al., 2020; Stroup & Wollmer, 1992). According to Tabernier et al. (2021), it has been primarily used to get around the differences in fuel prices both internally and internationally.

At a macro level, regulations, and policies differ globally regarding fuel tankering. For example, the European Union introduced a new regulation that requires airlines to pay a fee for any excess carbon dioxide emissions resulting from fuel tankering, based on the price of carbon allowances in the EU emissions trading system. At a meso level, we then have regulations and policies formulated at the national and state governmental level. In Australia, the Civil Aviation Safety Authority (CASA) has issued guidelines that airlines should only carry enough fuel for a particular flight unless specific circumstances require additional fuel. The US Federal Aviation Administration (FAA) has issued guidance stating that airlines should consider fuel prices, weather, and aircraft performance when deciding whether to carry additional fuel. Transport Canada requires airlines only to carry enough fuel for a particular flight unless specific circumstances require additional fuel. The UK Civil Aviation Authority (CAA) has issued guidance stating that airlines should consider the environmental impact of fuel tankering and only carry additional fuel if it is cost effective and does not result in excessive greenhouse gas emissions.

At a micro level, airlines also formulate specific policies and strategies related to fuel tankering. For example, Delta Airlines, British Airways, and United Airlines have stated that it only engages in fuel tankering when it is cost-effective and does not compromise safety or operational efficiency. Emirates Air has

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implemented a fuel tankering policy that considers fuel prices, aircraft weight, and environmental considerations. Today, software programs are calculating the amount of extra fuel carried for each sector to be economically advantageous, emphasizing the importance of managing cost efficiency, pricing, and yield (Cames, 2007; Deo et al., 2020; Hassan et al., 2021; Oum et al., 2005; Singh & Sharma, 2016; Tabernier et al., 2021; WFS, 2023).

Environmental Sustainability Evolution

Environmental sustainability has been defined as the equilibrium of the interaction of humans with the ecosystem while fulfilling human necessities without affecting the natural regeneration of the environment (Morelli, 2011). Greenhouse gas (GHG) emissions have been the main driver of the Paris Agreement. This global agreement was composed in 2015 with the idea of limiting emissions while attempting to control global warming (Tribett et al., 2017). Participating countries were willing to reduce them by 80% by 2050 (Erickson & Brase, 2019).

Corporate social responsibility experts have been encouraging more airlines to identify opportunities to create value for their partners in the long term (Prahalad & Ramaswamy, 2004). Carbon emissions from aviation have increased significantly over the past decades. They have been expected to continue increasing at 3 to 4 percent per year (Metz et al., 2007). Moreover, jet fuel also has negative impacts and environmental issues like crop injury or pollution (Kumar et al., 2022; Quackenbush et al., 1994).

In recent years there has been an increase in the demand for companies to market their products and services with a green and ecologically effective outcome. This trend has been associated with developing organizational cultures, marketing communications, and social responsibility strategies (Cames, 2007; Gal-Tzur et al., 2014; Samuels, 2022; Singh & Sharma, 2015, 2016). A few studies have evaluated the effects of this new environmental demand and its impacts on airlines (Hagmann et al., 2015).

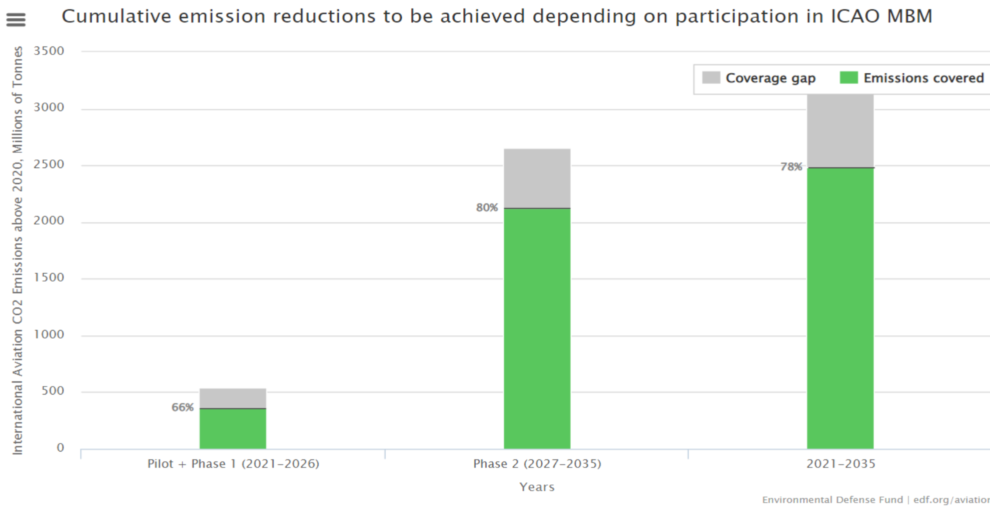
Programs and initiatives have been aimed at reducing aviation CO_2 emissions worldwide and their impact on climate consequences (Scheelhaase, Maertens, Grimme & Jung, 2018). Those emissions have been treated both regionally and globally by different agencies. In a broader approach, ICAO’s CORSIA has focused on a global scope and offsetting emissions. The main idea has been based on allowing the purchase of carbon credits from different and more adaptable industries (Scheelhaase et al., 2018).

The International Civil Aviation Organization (ICAO), the UN body that sets standards for international flights, aims for “carbon neutral growth from 2020” — i.e., limiting the net emissions of international flights to year-2020 levels. With enormous growth projected for this sector, that is a significant gap to close. ICAO adopted the Carbon Offsetting and Reduction Scheme for

International Aviation, or CORSIA, in 2016 (Larsson et al., 2019). It states that from 2021-2023, states will opt into a voluntary pilot phase, while from 2024-2026, states will opt in voluntarily to another phase. From 2027-2035, countries will participate if they have an individual share of international aviation activities in revenue-tonne-kilometers (RTKs) in 2018 above 0.5% of total RTKs or if their cumulative share in the list of states from the highest to the lowest amount of RTKs reaches 90% of total RTKs. Least-developed countries, land-locked developing countries, and small island developing countries will all be exempt throughout. Considering the countries that have signaled they are likely to join from the beginning, starting in 2021, Figure 1 reflects forecasted cumulative emissions and the potential impact of this program (EDF, 2023).

Figure 1

CORSIA Estimated Impact

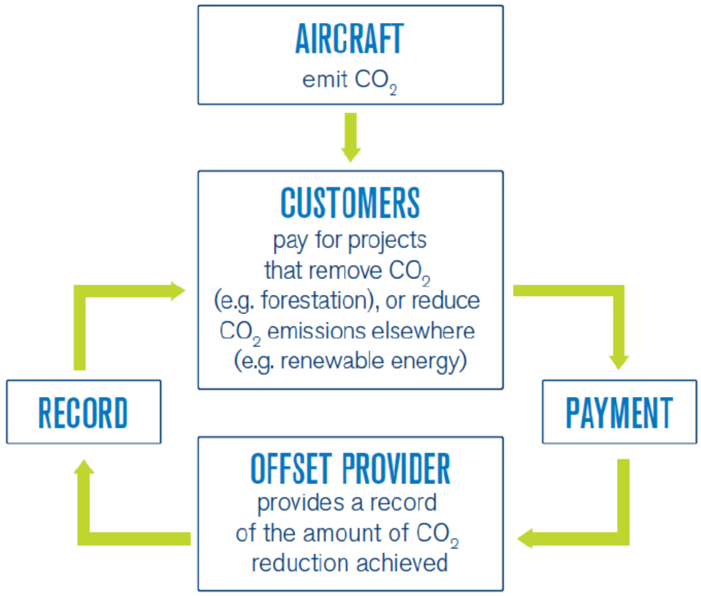


Note. Bars indicate the amount of forecasted cumulative emissions above 2020 levels this participation could be expected to cover in the voluntary phase, the mandatory phase, and the combined phases (from 2021-2035).

Moreover, a voluntary program created to set a benchmark among airlines sharing green actions is the IATA Environment Assessment (IenvA). Based on three criteria elements (daily operational activities, corporate environmental management practices, and corporate policies/ strategic planning), the program has helped identify and implement innovative practices, promoting sustainable environmental management in organizations (Abdullah et al., 2018). It also contributed to conducting an audit, analyzing, and ranking green airlines that achieve the standards to be registered to the program (IATA, 2021), as reflected in Figure 2.

Figure 2

IATA – Aviation Carbon Offsetting Guidelines for Voluntary Programs



The approaches to fuel tankering have considered their economic savings for the airlines and the most efficient way of using it. The programs and policies for reducing greenhouse gas emissions have been developed and emerged across the globe (Hagmann et al., 2015). A number of factors could explain the variation in fuel tankering rates across the world, including the cost of fuel, the distance of the flight, the type of aircraft, the airline's operating costs, the government's tax policies, and the environmental regulations. Governments that have strict environmental regulations tend to have higher fuel tankering rates. It is difficult to comprehensively compare fuel tankering rates in different countries worldwide, as reliable data on fuel tankering practices are often not publicly available; however, Table 1 includes some examples of fuel tankering rates in different regions. According to a report by the International Council on Clean Transportation (2022), fuel tankering rates among European airlines vary widely, ranging from less than 1% of total fuel consumption to as much as 25%. Also, a report by the Environmental Defense Fund (2023) says that fuel tankering is less common in the US than in Europe, due in part to the lower price of jet fuel in the US compared to Europe. However, the report notes that some airlines still practice fuel tankering, particularly on longer international routes.

Table 1

Tankering and Pollution Rates

Country	Fuel tankering rate (USD/gallon)	Pollution rate	Carbon rate
United States	$0.02	21.67%	2.17%
European Union	$0.03	23.25%	2.33%
Mexico	$0.04	24.83%	2.50%
Germany	$0.05	26.41%	2.65%
Brazil	$0.06	28.00%	2.82%
China	$0.07	29.58%	2.97%
India	$0.08	31.16%	3.14%
Japan	$0.09	32.74%	3.29%
Russia	$0.10	34.32%	3.45%
South Korea	$0.11	35.90%	3.61%
Australia	$0.12	37.48%	3.77%
Canada	$0.13	39.06%	3.93%
New Zealand	$0.14	40.64%	4.10%

Note. Approximate values - Pollution rate and carbon rate are the percentage of CO_2 emissions from the aviation industry in a particular country. The pollution rate is the amount of CO_2 emissions from the aviation industry divided by the total amount of CO_2 emissions from all sources in a country. The carbon rate is the amount of CO_2 emissions from the aviation industry divided by the total amount of CO_2 emissions from all sources in the world.

The Brazilian Scenario

South America has been considered an untapped potential. Economic advancement and its natural characteristics that often hinder travel connectivity by other modes, such as road and trains, in South America have been forecasted for air travel to grow by 5.1 % per year for the next 20 years (Boeing, 2020).

In the Brazilian scenario, the fuel prices have been most influenced by the tax rates named ICMS. They have been defined independently by each state. Brazil has been one of the participating countries in the voluntary phases of CORSIA (ANAC, 2019; Larsson et al., 2019). For Brazil to keep up with global actions in reducing emissions and regulating the carbon credit market, CNPE Resolution 8 from August 2020 has been instituted based on Law 13,576/2017 of the National Biofuels Policy (RenovaBio, 2017). This program emerged as a long-term public policy with annual goals to structure the sector. The situation concerning the Brazilian scenario has been the State taxes and other factors that encourage the airlines to maintain their use of fuel tankering to be financially solid and competitive. According to Tabernier et al. (2021), 90% of the fuel tankering in Brazil has been influenced only by fuel prices. No global or local program has involved domestic flights in the Brazilian territory. This has resulted

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in indiscriminate CO_2 emissions that counter the direction of the global path of sustainable and green consciousness. Next, we use a multi-stage methodological approach to evaluate fuel tankering effectiveness and its implications for environmental sustainability by applying it to the case of the Brazilian industry.

Methodology

The research team collected quantitative data from the top largest airlines in Brazil to explore this study's research questions and objectives. These airlines represented approximately 92% of the Brazilian domestic market share in 2019 (ANAC, 2019). Since the pandemic strongly affected the flights and the statistics related to 2020, the research team believes that 2019 represents the most recent, stable, and consistent data point.

The data was provided by two airlines into three categories: origin, destination, and total fuel tankering used, and one airline provided just the total amount of fuel tankering performed in 2019. The scope of the analysis has been to filter only domestic flights inside Brazilian territory and has not focused on other countries' particularities, intending to narrow down key meso, and micro-level factors specific to fuel tankering strategies rather than global and international regulations. The data was analyzed to preserve the details and specificities of each airline, and only the total amount of fuel tankering used in 2019 was considered.

Based on the total fuel tankering quantity data, we calculated the total CO_2 emitted into the atmosphere in 2019. With these values, it has been possible to know how much carbon credit must be purchased to neutralize the emissions caused by the fuel tankering practice.

Phase One – Amount of Burnt Fuel

The term "cost of weight" represents the extra expenses caused by adding weight. In this case, it has been the extra weight from the fuel to the aircraft's initial weight. This calculation was needed to understand what the extra consumption represented in terms of extra CO_2 emissions that were covered in part two.

T= (F.4,5%).T(AVG)

Where:

T = Total fuel consumed; F = Total fuel supplied for Fuel Tanking

T(AVG) = Flight time

For calculation purposes, the value of 4.5% of "cost of weight" was used for all stages. This was based on an average of between 4% to 5% mentioned for all airlines in the study (Boeing, 2016). To define the flight time of each route, the average time of authorized HOTRANs for each airline was used. "HOTRAN" is the document approved and issued by ANAC, and it has formalized the grants for the operation of regular international and domestic passenger and/or cargo airlines and postal network services.

Phase Two – Amount of Carbon Emitted

Calculating how much carbon has been emitted is crucial to this study. This value resulted from converting the extra fuel consumed due to tankering to the amount of CO_2 this consumption represented. Then, the study presented the number of carbon credits to be invested and purchased to neutralize the emissions. After the total value of how much fuel was burnt, the computation of how much carbon was emitted by the airlines part of the research project is presented in the formula (ICAO, 2018) as follows:

$$CO_2 = \sum M_f * FCF_f$$

Where:

$C = CO_2$ Emissions (in tons); M_f = Mass of fuel used (in tons); FCF_f = Fuel conversion factor of given $fuel_f$, equal 3.16 (in kg CO_2/kg fuel) for Jet-A fuel / Jet -A1 fuel.

According to ICAO's study (2018), the value of 3.16 was used as a constant when calculating the amount of CO_2 emitted by each passenger. This number has determined the relationship between a ton (1000 kg) of CO_2 emission by a ton (1000 kg) of fuel consumed. The same value was used for the calculation presented in this study.

Phase Three – Neutralizing Carbon Emission in Carbon Credits

After knowing how much CO_2 was emitted, we calculated how much carbon credit the airline must buy to neutralize the emissions arising from fuel tankering activities. The practice of carbon offset trading can be found in two ways: regulatory market and voluntary market. The carbon offsets have been sold in the regulatory market, using them as part of a compliance scheme, such as a cap-and-trade system (Kollmuss et al., 2008). On the other hand, offsets traded on the voluntary carbon market have not been part of an existing federal regulatory or compliance scheme (Taylor, 2009). Considering carbon credit as an asset, the value has varied according to the company that markets it. To perform the calculations, we used a company called Moss. This is the world's largest carbon offset platform and the first to tokenize negotiable carbon credits to offset the bitcoin market's greenhouse gas emissions since its founding in 2013 (Global Warming Focus, 2021). Moss carbon credit is a token representing the reduction of one ton of CO_2 equivalent emissions. It is an economic incentive program for companies and individuals to finance activities related to sustainability and combat climate change (Moss, 2023). To find out how much carbon credit needs to be purchased, the formula used was: $V_c = CO_2 * C_v$

Where:

V_c = Total amount in USD spent on the purchase of credits CO_2 = Total amount of CO_2 Emissions amount (in tonnes) C_v = Carbon Credit Value

After following the three steps mentioned above, it has been possible to prove the negative impacts of fuel tankering practices and quantify them. The research group analyzed more than 90% of the domestic market and exhibited the total value the three airlines should compensate. Based on the results, each airline may verify and compare their earnings from 2019. The research group could not reach the savings from the airlines since the data was confidential. The calculations and findings are presented in the results section.

Results

All the conclusion points were completed through data provided by the three leading Brazilian airlines, and for confidentiality reasons, these data were not stratified by the airline but as a single data to demonstrate the general conclusions of the research. The results emphasize the level of financial investments necessary to neutralize the carbon emission from fuel tankering practices. Also, they show the difference between states' ICMS taxation as one of the root causes of fuel tankering existence and the environmental consequences.

Financial Investments to Neutralize Carbon Emissions

The data from the three largest airlines in Brazil were gathered by interviewing the teams responsible for fuel control. For confidentiality reasons, Table 2 shows the total fuel tankering in kilograms used by all three airlines combined in 2019. This amount has represented an extra fuel burned, which can be translated into 1,074,417 carbon credits required to neutralize the 2019 fuel tankering practice in the Brazilian aviation industry. The economic savings of the airlines were not part of this study's scope as fuel prices have been confidential and part of the airlines' business strategy.

Table 2

Fuel and Carbon Credits

Total Fuel Tankering	Extra Total fuel burned	Carbon Credits
377,783,583	34,000,522	1,074,417

The total amount spent to neutralize can vary according to the carbon credit quotation. The company used in the study as a reference was MOSS. Their quotation can vary from $7 to $20, depending on the amount purchased. It is essential to explain that the research group has used data on fuel tankering from 2019 because it was the most recent year unaffected by any global externality. On the other hand, the carbon credit quotation has represented the most recent prices from 2021. That was because the study intended to show the required investments for the future using the most current carbon credit price values.

The research group has created three scenarios that presented a simulation of different quantities of fuel tankering carried by airlines for one year. For each case, minimum, median, and maximum values of $7, $13, and $20 were presented according to Table 3: ***Scenario 1:*** Airline A using 200,000,000 kg of Total Fuel Tankering; ***Scenario 2:*** Airline B using 100,000,000 kg of Total Fuel Tankering; ***Scenario 3***: Airline C using 50,000,000 kg of Total Fuel Tankering.

Table 3

Carbon Credit Expenses

Expenses with the purchase of carbon credit			
Total Fuel Tankering	$ 7	$ 13	$ 20
377,783,583	$ 7,520,919	$ 13,967,421	$ 21,488,340
200,000,000	$ 3,981,600	$ 7,394,400	$ 11,376,000
100,000,000	$ 2,986,200	$ 5,545,800	$ 8,532,000
50,000,000	$ 995,400	$ 1,848,600	$ 2,844,000

The Impact of the Difference between ICMS Taxation

According to Brazilian taxation policy, the ICMS taxation is a state value-added tax (VAT) that affects the final consumer of the products by increasing the final price considering the circulation process (PWC, 2021). The ICMS has varied from 7% to 35%, and depends on several factors, such as the state from which the product has been issued, the state to where it would be received, and how essential the product would be (Jornal Contabil, 2020).

The values have constantly been changing and negotiated by the parties involved. In 2019, the tax burden applied to the fuel for the commercial aviation business in the northern states of Brazil was around 3%, and 7% for other states. The State of São Paulo specifically applied 10% for the fuel to the airlines (Confaz, 2019). This value can fluctuate according to negotiations by each airline with a particular state. There have also been other factors that affect the fuel prices, such as local taxes, distribution methods, size of the airline fleet, and others. Also, airlines have other reasons for performing the fuel tankering practice: disruptions, technical problems with refueling at the destination, and refueling to avoid delays (Deo et al., 2020; Marla et al., 2017; Tabernier et al., 2021).

Environmental Consequences and Account Savings

To analyze the economic and environmental impact of fuel tankering, simulations were carried out with Eurocontrol BADA (Base of Aircraft Data) models based on typical types of aircraft flying in ECAC airspace, considering the distribution of ECAC flights by distances flown and at fuel prices negotiated by two majors' European airlines. The payload has been calculated with a load factor of 80.3% and 124 kg/passenger, as used in the European Aviation Environmental Report 2019. The simulations used one month of ECAC traffic data (June 2018).

Table 4

Fuel Consumption

Round trip distance (each leg)	Practice	Fuel consumption (kg)		% Extra fuel burnt for A-B trip	Extra fuel burnt for A-B trip (kg)	Extra CO_2 emitted for A-B trip (kg)	Cost of fuel burnt (€) for A-B trip
		A-B Trip	B-A Trip				
300 NM	no tankering	2037	2037				
	full tankering	2082	2037	2.21	45.1	142	24.8
600 NM	no tankering	3592	3592				
	full tankering	3760	3592	4.66	167.5	528	92.1

Table 4 (A-B trip and the return B-A trip) presents the extra cost and CO_2 by performing fuel tankering and its cost for 300 NM and 600 NM maximum range trips, representing 30% and 50% of all ECAC flights. As a result, in ECAC, fuel tankering would represent 136 kg of additional fuel burnt per flight (costing 75€), generating 428 kg of additional CO_2 (i.e., 9€ in purchased CO_2 allowances). Nevertheless, despite the additional cost, fuel tankering would still result in a net saving of 126€ per flight ton on average (Eurocontrol, 2019). Notwithstanding the economic advantages acquired in the fuel tankering practice, it was possible to verify that the three airlines studied did not consider the environmental impact generated by this practice; therefore, they did not consider the purchase of CO_2, or any other action, to neutralize the extra emissions generated.

Carbon Emission Compensation/Neutralization Policies

Although emission compensation would have three stages of implementation (two voluntary ones from 2021 to 2023 and 2024 to 2026) and a compulsory one between 2027 and 2035, the Brazilian iNDC has determined emission reduction goals of 37% by 2025 and 43% by 2030, based on 2005 levels (ABEAR, 2021). For Brazil to follow up on the global scenario, RenovaBio, the National Biofuels Policy, has been implemented and created decarbonization credits to contribute to Brazil’s commitments under the Paris Agreement under the UNFCCC.

Even with CORSIA’s influence on the Brazilian aviation market, the focus of aid and support for airlines has been directed to the fuel tankering practice to provide financial savings without considering the carbon emission compensation/ neutralization. An action example that has been taken to neutralize carbon emissions, a Brazilian airline, in partnership with MOSS, the most significant environmental carbon credit platform in the world, made the first flight in the world to have its carbon footprint fully offset through a Green Token cryptocurrency MCO_2. This flight, with the destination to Fernando de Noronha Island, has aimed to collaborate with reducing 25% of the island's emissions, once more than half of the total emissions were generated by air transportation on the island (Aviación al Día, 2021).

The three Brazilian airlines used as the basis for this research have committed to the "net zero" under the SBTi, and the airlines have up to two years to develop a long-term emissions reduction strategy and submit their plans for approval. Actions such as the purchase of carbon credit have been presented as a sustainable measure option and possible entry into the plans proposed by the airlines; indeed, the purchasing emission units have been currently more reasonable than other actions, as carbon offset prices have been much lower, and current availability in the market (Capaz et al., 2020). In this context, it is essential to consider the effectiveness of incentive regulation in the aviation industry (Adler et al., 2015). Other factors compromising structured actions have been the lack of standardized policies since government agencies have been waiting for airlines to take action to ensure their long-term position in a sustainable society. In contrast, airlines have had the same perception and have been awaiting regulation, incentives, and best practices that would not generate additional costs or compromise competitiveness.

Conclusions

We formulated an overview of the global evolution of fuel tankering practices at macro, meso, and micro levels, incorporating the global, national, state, and airline-related levels of analysis in our review. We also explored the relationship of fuel tankering to total carbon emissions and applied different fuel tankering scenarios in the context of the Brazilian aviation industry. Following this analysis, we recommend solutions for the adjustment of savings incorporating the neutralization of carbon emissions and for the formulation of theoretical and practical models incorporating multiple stakeholders in the fuel tankering ecosystem.

Recommendations for Practitioners

Our results show that the Brazilian aviation industry can sustainably neutralize the carbon emissions from the fuel tankering practice. The study shows that the fuel tankering practice has been highly profitable. Although the political aspects have not been the primary purpose of this study, the difference in ICMS taxes has made the aviation industry less efficient and more polluting. Our recommendation aims to level the state taxes to reduce the airlines' need to apply procedures that negatively affect the environment. To consider the environmental impact and include financial savings on the fuel tankering practice, the Brazilian airlines could consider the purchase of CO_2 credits or any other actions to neutralize the extra emissions generated by this practice. A solution includes implementing carbon emission compensation/neutralization policies in the Brazilian aviation market using part of the financial savings obtained with the fuel tankering practice.

To make fuel tankering sustainable, airlines must allocate part of the savings generated to purchasing carbon credits, which each airline could perform separately. To offset the carbon emitted, airlines must first know the total amount of carbon emitted, and with this total, they must hire a company that has been selling carbon credit.

These companies have not fixed a CO_2 value (different values according to the amount purchased), so airlines must buy in enormous quantities, and a good strategy would be the purchase once a year, calculating the total fuel tankering savings and converting them into the purchase. This method could not only be economical as it would be easier to calculate the “expense” for the following year’s budget since it would be a crucial part of financial health.

The fuel tankering practice may not be extinguished completely. There have been a few satisfactory reasons for carrying more fuel than the minimum required for a safe flight. The lack of facilities, supply, or specific operational strategies is an essential motivation. However, a deliberate and uncontrolled emission of pollutants into the atmosphere should not be considered reasonable nowadays. Each airline has different taxes applications in different States according to negotiations, and when there has been a slight difference between state taxes, the fuel tankering practice has become financially interesting to the airlines but environmentally impactful.

This recommendation focuses on the improbable but necessary leveling of ICMS taxes in Brazil. It would bring an essential change in how the airlines deal with the environment daily. Reducing part of this study’s extra and avoidable emissions would make the aviation industry more sustainable. The Brazilian airlines already understand that sustainable measures have been necessary to meet a social appeal for a less carbon-polluted world.

To consolidate themselves as green organizations and precursors in sustainable actions, it has been essential that they consider the costs of offsetting carbon emissions in the economic savings of the fuel tankering practice. As shown in this investigation, there have been alternatives for airlines to offset the carbon emitted, bringing financial savings to invest in neutralizing the carbon emitted. According to Hagmann (2015), a passenger’s willingness to pay more to fly with a green airline influences the airline’s choice in ticket booking.

Among specific actions to be implemented, the most important one includes using part of the financial savings obtained with the fuel tankering practice to fund the carbon emission compensation/neutralization policy developed for the Brazilian aviation industry in an environmentally responsible mindset.

Recommendations for Research and Academia

This study represents the starting point for additional ecosystem-based studies incorporating Brazilian airlines, customers, employees, and society members. The findings of this paper emphasize a lack of concerted analyses and approaches to fuel tankering strategies and practices, including considering the entire ecosystem in which the aviation industry functions. Considering the implications for private business organizations, as well as public groups such as local and federal government, educational and non-profit associations, and the community, the results reflect the need for an ecosystem approach to fuel management, incorporating elements from the service-dominant logic in service management, as well as public service logic in the management of public service (Osborne et al., 2022; Petrescu, 2019).

One of the limitations of our study is represented by the restrained context in which we tested our model, specifically the Brazilian market. Future studies could focus on all members of the aviation ecosystem and environmental and external factors, including the fuel tankering post-pandemic scenario and its evolution in an inflationary, unstable global economy. Also, a more thorough analysis from a practical and theoretical point of view is needed for public policies related to the development of biofuels and the Brazilian carbon credit market. The possible leveling of the ICMS in Brazil and its impacts on the fuel tankering practice, as well as a comparison between sustainability and emissions neutralization policies through carbon credits of Brazilian airlines, can present additional insights.

Finally, a global, cross-country analysis of fuel tankering strategies and the factors that affect this decision-making and the managerial process could bring insights related to cultural, social, and economic impacts. A limitation of this study is related to the lack or inconsistent quality of data regarding fuel tankering, pollution, and carbon rates; therefore, a multi-national detailed study could help clarify significant aspects related to the impact of fuel tankering.

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