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IS SUSTAINABLE AVIATION READY FOR TAKE-OFF?

AN ANALYSIS OF AIRLINE INITIATIVES AND PASSENGER VIEWS ON SUSTAINABLE BUSINESS PRACTICES IN THE AVIATION INDUSTRY

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Abstract

Purpose and Methodology Which sustainable business practices will shape the aviation industry in the future? To answer this question, this paper (i) details the three most relevant sustainable business practices in use by the industry, (ii) provides a literature review on these three areas of action, (iii) scrutinizes passengers' preferences towards airlines' different sustainable business practices and (iv) contrasts those with insights gathered from industry experts, (v) to ultimately determine the key sustainable aviation trends.

Findings We find that from the three sustainable business practices—organizational initiatives, sustainable aviation fuels, and technological innovation—the first yields the lowest additional willingness to pay by passengers. An airline's deployment of sustainable aviation fuel and technological innovation results in the highest passenger willingness to pay on short- and long-haul flights, respectively. These results match the experts' views, who forecast that sustainable aviation fuel and technological innovation are the key to decarbonize aviation, seeing only a limited long-term role for organizational initiatives. These findings yield a practical implication for airlines: they should channel investments towards the two sustainability areas mentioned above, thus obtaining the highest acceptance and willingness to pay from passengers.

Keywords Sustainable aviation, carbon offsetting, sustainable aviation fuel, technological innovation, willingness to pay, strategy.

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Abbreviations

CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
GHG	Greenhouse Gas
IATA	International Air Transportation Association
ICAO	International Civil Aviation Organization
MRO	Maintenance, Repair and Overhaul
PtG	Power-to-Gas
PtL	Power-to-Liquid
SAF	Sustainable Aviation Fuel
VCO	Voluntary Carbon Offsetting
WTP	Willingness to Pay

1 | Introduction

THE AVIATION INDUSTRY'S fast growth prior to the COVID-19 pandemic has exacerbated a dilemma. On the one hand, the industry connects people, facilitates commercial activities, and promotes cultural exchanges, all aspects highly valued by humankind. On the other hand, commercial aviation creates environmental pollution. Moreover, flying (beyond short distances) has no close substitutes, making the dilemma particularly acute and putting pressure on airlines to offer sustainability solutions that minimize the ill effects of flying.

The International Air Transportation Association (IATA) reports an annual passenger growth of approximately 7% in recent years, with industry revenue having risen by about 170% from USD 322 billion in 2003 to USD 872 billion in early 2020 (IATA, 2021a). In roughly the same period, the global number of flight movements increased by 63%, reaching a historic high of 38.9 million flights in 2019. This trend was mainly made possible by technological advances in ultra-efficient twin-engine jets—such as the Airbus A350 and the Boeing 787 Dreamliner—allowing airlines to offer more direct point-to-point flights, rather than connecting flights through major hubs. An additional contributor to the industry's rapid growth was the emergence of low-cost carriers that have made flying accessible to the broad masses, especially in emerging economies (Johnson, 2018). Airlines such as Ryanair, Air Asia, and Southwest Airlines have driven the commoditization of airline tickets. Bringing down airfares to historically low levels, these airlines attract price sensitive customers while incentivizing regular travelers to fly more.

As passengers' flying increased over the years, concerns for sustainability concomitantly grew stronger. Worldwide movements, such as "Fridays for Future", make it clear that a rising number of persons are growing concerned with the negative effects of climate change. With society recognizing the effect of man-made climate change, initiatives to reduce carbon

emissions moved to the top of governments' agendas all over the world. The Paris Agreement, signed in 2015 by 160 countries, is a prominent example of current efforts to reduce global warming to no more than 1.5°C. In the light of such agreements, discussions on potential emission mitigation measures frequently revolve around the transportation sector, *with a special focus on the aviation industry*. For example, in April 2021, the French government announced a ban on domestic flights to destinations that could be reached by train within 2:30 hours, as planes emit 77 times more CO_2 than a train travelling the same distance (BBC, 2021).

Commercial aviation contributes 2.5% of global CO_2 emissions and, at 11.6%, is the third largest emitter in the transportation sector. Moreover, greenhouse gases (GHG) emitted by airlines have increased substantially in the past (Ritchie, 2020a,b). According to IATA, emissions from commercial aviation rose by 47.9%, from 633 to 936 million metric tons of CO_2 between 2009 and early 2020 (IATA, 2021a). In 2019 alone, low-cost carrier Ryanair increased its emissions by 5.9% within one year, thus becoming Europe's seventh largest carbon emitter (Murphy, 2020). While the COVID-19 pandemic has led to a significant reduction in flight movements and thus emissions, projections of future emissions based on current policies vary between 1,162 and 1,630 million metric tons of CO_2 in 2050, which, if all sectors were to display such an emissions growth, would lead to a critically high global warming of 4°C (Climate Action Tracker, 2021).

Therefore, the industry's strong growth brings to the fore the need for measures that limit its carbon footprint. Though airlines have an intrinsic motivation to reduce fuel consumption, and thus operating costs, the perspective of passengers on airlines' sustainable business practices has only recently began to be researched. Most current literature focuses on investigating passengers' attitudes towards specific, isolated sustainable aviation mechanisms (for instance, voluntary CO_2 offsetting). Consequently, there is a gap in the literature: *what are passengers' preferences regarding different sustainable business practices when they are*

questioned about all of them simultaneously? The purpose of this paper is twofold: (i) to scrutinize passengers' preferences towards airlines' different sustainable business practices and (ii) compare those with airlines' current initiatives towards sustainability.

The paper is organized as follows. We first present the three most common methods of reducing airlines' carbon emissions by introducing actual cases. Second, we perform a literature review on sustainable technologies and business practices that the industry follows. Third, the methodology used is introduced. Fourth, an analysis of the results of a passengers' survey as well as experts' interviews is presented. The paper concludes with an analysis of some of its limitations, suggestions for future research, and a summary of its main findings.

2 | Sustainable aviation

Over the past years, sustainability in aviation substantially gained in importance. On the regulatory side, governing bodies at national and supranational level (mostly in Western countries) have intensified the pressure for reducing carbon emissions. For example, to attain the goal of reaching net zero emissions by 2050, the EU joined the voluntary "Carbon Offsetting and Reduction Scheme for International Aviation" (CORSIA), which was initiated by the International Civil Aviation Organization (ICAO) (Council of the EU, 2020). On the consumer side, a rising number of passengers feels pressured by the social phenomenon of "flight shame" to look for ways to offset their carbon footprint or to use more environmentally friendly transportation modes (Timperley, 2019). Furthermore, airlines and their key business partners are joining forces to research and develop methods to reduce the industry's environmental impact. For example, the "Sustainable Aviation" consortium is an initiative comprising about 90% of the largest players in the UK's aviation industry, aimed at establishing roadmaps to reduce emissions, decrease noise pollution, and advance the application of new, smarter technologies (Sustainable Aviation, 2021). Additionally, IATA publishes bi-monthly the "Environment Perception Monitor" to offer industry players the latest

insights into sustainability related topics in aviation (IATA, 2021b). These two initiatives aim to deliver evidence that helps airlines make more informed decisions when investing in sustainability projects. While there are plenty of different actions that can be undertaken to make flying greener, airlines' sustainable business practices can be grouped into three major categories. A description of these is provided in the following three sections.

2.1 | Organizational initiatives

This first category is aimed at indirectly making aviation greener. Organizational initiatives focus on offsetting emissions by offering CO_2 compensation programs supporting reforestation projects or purchasing CO_2 certificates. This measure finds support from advocates who argue that from all potential decarbonization measures, organizational initiatives are the easiest and least costly to implement (IATA, 2021c). This argument is based on the absence of zero emission aviation technologies, as well as the scarcity and high prices of sustainable aviation fuels (SAF). While it is certainly true that organizational initiatives are a quick and cost-effective method of achieving carbon neutrality, this sustainable business practice has several shortcomings. Firstly, most compensation organizations (such as MyClimate or Atmosfair) only focus on GHGs emitted by the airplane and disregard the even more harmful effect of condensation trails (DLR, 2021). According to the German Federal Environmental Agency, the environmental impact of condensation trails can exceed the impact of GHG threefold (Hecking and Müller, 2020). Secondly, reforestation projects offer a time-shifted effect as the trees planted need several years to absorb the emitted CO_2. As a result, the effect of reforestation projects only materializes after approximately 20 years (Compensaid, 2021). The compensation platform Compensaid, developed by Lufthansa and Swiss, tackles this issue by letting passengers decide when they wish to have their emissions offset, depending on the project they support. Thus, supporting the development of SAFs leads to faster compensation than do reforestation projects. While airline-owned or third-party compensation platforms are

one form of organizational initiative, airlines can also purchase CO_2 certificates. For example, in 2019, EasyJet announced that it would be Europe's first airline to fully offset its flights' CO_2 emissions by investing about EUR 29 million annually on purchasing CO_2 certificates (Plickert, 2019). This measure, however, focuses only on CO_2 emissions and neglects the effect of other GHGs and condensation trails. Moreover, while other compensation platforms charge around EUR 20 per ton of CO_2, critics fault EasyJet for paying only EUR 3.50 per ton of CO_2, which experts deem insufficient to achieve the United Nations' sustainable development goals (Hecking and Müller, 2020).

To conclude, a broad spectrum of compensation programs is on offer, with only a few airlines voluntarily engaging in CO_2 certificate purchases. Given the pitfalls of organizational initiatives, experts demand the deployment of SAFs, which we discuss in the next section.

2.2 | Sustainable aviation fuels

SAF differs from conventional fuel in that it is not made from fossil petroleum, but from sustainable raw materials and renewable energy. The main advantage of SAFs over fossil fuels is the potential reduction of CO_2 emissions by up to 80% (Lufthansa Group, 2021a). Furthermore, SAFs do not require major changes to airports' fueling infrastructure or the aircraft's tank and engine unit, as SAFs can be blended with conventional kerosene.

The development of SAFs stretches over three generations (Kearney, 2021). The first generation focused on biofuels, which are produced from plants such as canola, sugarcane, corn, soybeans, and palm oil. Although these fuels reduce CO_2 emissions, they may conflict with food production (land-use conflict), thus limiting the scalability and sustainability of biofuels (Lufthansa Group, 2021a). To address this issue, the second generation of SAFs uses waste materials such as used cooking oil and municipal waste, as well as water plants such as algae. The use of waste products aims to create an economic cycle, which increases the degree of sustainability. Nevertheless, land-use conflicts and limited availability prevent second

generation SAFs from becoming suitable for the mass market. The introduction of third generation SAFs tackles the aforementioned pitfalls. Through the so-called "Power-to-Liquid" (PtL) and "Power-to-Gas" (PtG) processes, renewable energy obtained through the use of wind power, water, and solar plants is used to extract water and CO_2 from the atmosphere to create synthetic kerosene through a complex chemical procedure (Lufthansa Group, 2021a). While this process is 100% carbon neutral and does not compete with food production, production levels are still too low and prices substantially above economically reasonable levels to enable its widespread use. In fact, currently, only 0.1% of approximately 300 billion metric tons of jet fuel are SAFs (KLM, 2021). Nevertheless, an increasing number of key industry stakeholders support the development of SAFs. In October 2021, Lufthansa agreed to purchase an annual amount of 25,000 liters of climate neutral e-kerosene from Germany's first PtL plant (Frankfurter Allgemeine Zeitung, 2021). In the same month, engine manufacturer Rolls Royce successfully conducted a test flight in which it supplied one engine with 100% SAF, proving the robustness and reliability of this technology (Boon, 2021). Furthermore, as part of Glasgow's COP26 Climate Change Conference in November 2021, EasyJet, aviation fuel suppliers Q8 Aviation and Neste, as well as Gatwick Airport launched an initiative to supply 42 EasyJet flights with blended SAF (Neste, 2021). In December 2021, United Airlines made history in aviation, operating the first commercial flight 100% SAF fueled (Rains, 2021).

To sum up, depending on the type, SAFs can be carbon neutral while not competing with other economic outputs (namely, food). However, research is still in progress and lacking economies of scale hinder quick market availability at competitive prices. As promising as SAFs appear to be, industry stakeholders and experts warn against pinning all hopes on one technology, and urge research efforts and investments in other areas as well. The next section further explores one of them, namely, technological innovation.

2.3 | Technological innovation

Technological innovation compromises all alterations to an aircraft's hardware that improve its efficiency and sustainability through enhanced aerodynamics, reduced weight, or alternative, environmentally friendly propulsion systems. Airlines' most common approach to increase sustainability through technological innovation is fleet modernization. Lufthansa Group, for example, is pursuing a long-term strategy aimed at replacing its old long-haul fleet of quad-engine jets, such as the Airbus A380, the Boeing 747 and the Airbus A340, with more efficient twin-engine jets, such as the Airbus A350, and the Boeing 787 and 777X (Lufthansa Group, 2021b). At the moment, these aircraft types provide airlines with state of the art technologies that reduce their fleets' environmental impact. Alternatively, airlines can choose to upgrade older aircraft with sharklets or winglets (placed at the airplane's wingtips) to reduce drag and increase fuel efficiency by about 5% (Bodell, 2021). Besides, in a collaboration with BASF, Lufthansa Technik equipped Lufthansa Cargo airplanes with a bionic film called "Aeroshark" to reduce drag. This universally applicable film utilizes sharkskin technology to improve aerodynamics and reduce the fuel consumption of a Boeing 777 by 1,700 metric tons of CO_2 per year (Lufthansa Technik, 2021).

While the aforementioned hardware upgrades deliver only marginal ecological improvements, alternative propulsion systems such as battery-electric and hydrogen-powered systems could become a viable option in the long term. Electric engines have several advantages: they do not produce *any* (local) emissions, involve significantly lower maintenance efforts due decreased mechanical complexity, and operate at a substantially lower noise level (Metcalfe, 2018). However, current batteries are still too large and too heavy to be deployed on long-haul flights, thus limiting their use to smaller aircraft operating regional routes. Given this constraint and the early development stage, there are only a few examples of advanced project initiatives. Together with Rolls Royce, Airbus is conducting a test of a hybrid-electric

regional jet (Rolls Royce, 2021). Besides, efforts by the Swedish start-up Heart Aerospace to develop a 19-seater, fully electric regional jet have been backed by large scale orders by US carrier UNITED (Sider, 2021). However, experts from the German management consultancy Roland Berger suggest that in the short term, electric flying will be limited to urban areas, expecting that the future of electric flying will belong to urban air mobility startups, such as Volocopter, Lilium, or EHang (Hader & Baur, 2021).

Hydrogen-powered airplanes are also being developed. In late 2020, Airbus presented three zero-emission, hydrogen-powered concept airplanes that are expected to enter service by 2035 (Airbus, 2020). While hydrogen poses a substantially more sustainable alternative to conventional kerosene, there are several disadvantages associated with its use. Firstly, hydrogen is not available at scale, and its production is complex and energy intensive. Moreover, unlike kerosene, hydrogen must be stored at very high pressure and low temperature. Lastly, current fleets cannot be fueled by hydrogen, thus forcing airlines to invest in entirely new aircraft fleets.

To summarize, current options for technological innovation are limited to fleet modernization and hardware upgrades, while electric and hydrogen powered airplanes are not market ready yet. Having presented the technological and economic status quo, challenges, and opportunities of organizational initiatives, SAF, and technological innovation, we will next discuss how these areas have been covered in the academic literature.

3 | Literature review

Recent academic work in the aviation field focuses on sustainability-related technologies and business practices.

3.1 | Sustainable aviation

Sharma, Jakhar, and Choi (2021) offer an in-depth investigation of key drivers of airlines' carbon emissions, together with suggestions to reduce airlines' CO_2 footprint. Besides fleet

modernization, the authors explicitly recommend that airlines adopt biofuels and offer carbon offsetting programs to passengers. Sharma et al. (2021) suggest that further research should focus on customer perspectives and passenger involvement in sustainable aviation business practices. Winter, Lamb, Wallace, and Anderson (2021) obtain interesting results on the role played by "flight shaming" in determining passengers' willingness to fly, showing that passengers seem to fly less when made aware of the negative environmental impact of flying. Researchers have also investigated passengers' underlying motivations for liking sustainable air travel. Ragbir, Rice, Winter, and Choy (2021) find a desire for happiness and concern for sustainability to drive the willingness to pay (WTP) for sustainable business practices.

These findings are supported by Winter, Crouse, and Rice (2021), who investigate the role of "green airports" and conclude that the perceived value of sustainability and the perception of climate change significantly influence passengers' WTP. Several papers build on this finding and identify supporting evidence for a positive relationship between knowledge of (aviation related) sustainability and WTP, namely, Jou and Chen (2015), Amicarelli, Patruno, Bux, and Lagioia (2021), and Winter, Lamb, and Baugh (2020). Rice, Ragbir, Rice, and Barcia (2020) research operational drivers of WTP for sustainability. They conclude that the higher the magnitude of potential reductions in GHG, the larger the passengers' WTP. Rice et al. (2020) unveil an inverse relationship between WTP and flight length, with budget limitations being the main explanation for passengers' reluctance to spend more on airfares.

While this section demonstrates that research is available on cognitive and demographic drivers of WTP for products and services in sustainable aviation, several studies also analyze the impact of airlines' specific sustainable business practices on passengers' WTP. As discussed in Section 2, airlines' sustainable business practices can be roughly grouped into three categories, namely, (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation.

3.2 | Organizational initiatives

The literature on sustainable business practices in aviation with respect to passengers' WTP provides insights into the valuation of airlines' organizational initiatives, namely, voluntary carbon offsetting (VCO). Early results by Choi and Ritchie (2014) suggest that passenger WTP is linked to a passenger's perceived contribution to climate change due to air travel, as well as the self-perceived effectiveness of VCO, while socio-demographic drivers do not exert any significant influence. Support for the hypothesis that passengers' knowledge and perceived impact of VCO in turn affect WTP is obtained by Jou and Chen (2015). However, the authors' findings on the effect of monthly income contradict the results of Choi and Ritchie (2014). This controversary calls for a further evaluation of the moderating role of income on WTP for an airline's sustainable business practices. Nevertheless, with respect to the scale of WTP, Choi and Ritchie (2014) and Jou and Chen (2015) agree with each other, stating a WTP of EUR 13.68 per ton of CO_2 and EUR 13.81 per ton of CO_2, respectively. In addition, Rotaris, Giansoldati, and Scorrano (2020) report passengers' WTP to range between EUR 12.00 per ton of CO_2 and EUR 38.00 per ton of CO_2, while Sonnenschein and Smedby (2019) indicate the wider (and overall higher) range of EUR 29.21 per ton of CO_2 to EUR 49.01 per ton of CO_2. The differences among the studies are mainly due to the analysis of different route lengths, offsetting project, and geographical areas, which in turn affect passengers' WTP. Passenger WTP for airlines' organizational initiatives has been further investigated by Seetaram, Song, Ye, and Page (2018), who analyze the effects of air passenger duty (APD) on ticket demand while considering the flight length and the traveler's cabin class. The authors conclude that, generally, WTP increases with flight length and is higher for business class travelers than for economy class travelers. A major limitation of most findings mentioned above is that study layouts focus predominantly on scrutinizing passengers' attitudinal rather than behavioral WTP. To address this issue, a recent study by Schlöder, Berger, Kilchenmann, and Lenz (2021)

uses an anonymized sample of 63,520 actual bookings from a European airline. Their findings substantially contradict those of Choi and Ritchie (2014), Jou and Chen (2015), Rotaris et al. (2020), and Sonnenschein and Smedby (2019). The behavioral data collected by Schlöder et al. (2021) indicate a mean WTP of approximately EUR 1.00 per ton of CO_2, with offsetting price, ticket price, and climate vulnerability of destination location all not being predictive of a passenger's offsetting decision. This massive divergence in results calls for further investigations of behavioral data.

3.3 | Sustainable aviation fuel

With SAF being widely classified as the most promising near-term solution, several studies on this topic have emerged recently (Lee and Mo, 2011). Deane and Pye (2016) provide important insights into the technological feasibility, economic viability, and political implications of the use of biofuels. However, given the fairly limited application of SAFs at the time of writing, the authors do not provide any insights on passenger WTP for this technology. The issue was picked up by Rains, Winter, Rice, Milner, Bledsaw, and Anania (2017), who find that an airline's use of biofuels increases passenger WTP by approximately 13%. The results from Rains et al. (2017) are moderated by passengers' emotional attitude towards and knowledge of sustainability, which as discussed earlier is supported by the findings of Ragbir et al. (2021) and Winter et al. (2021). Filimonau, Mika, and Pawlusińsk (2018) and Løkke, Aramendia, and Malskær (2021) provide further support, stating that passengers display a positive attitude towards SAFs, with the degree of support being closely tied to passengers' knowledge of the application and safety of SAFs. A follow-up study by Godin, Andersson-Franko, and Lagerkvist (2018) focusing on air business travel in Sweden, also finds that an airline's use of SAF increases passengers' WTP (by 11.9%), thus confirming the results of Rains et al. (2017). However, the authors emphasize the practical limitation that current customers' extra WTP remains insufficient to make the use of SAF economically viable.

3.4 | Technological innovation

Regarding technological innovation, Winter, Thropp, and Rice (2019) find general passenger support for the use of sustainable materials and sustainable procedures in aircraft manufacturing aimed at developing fuel-efficient airplanes. Han, Yu, and Kim (2019) analyze passengers' attitudes towards electric aircraft compared to conventional aircraft. They conclude that increasing product knowledge and reducing perceived risk significantly increases passengers' likelihood of traveling on an electric aircraft. Al Haddad, Chaniotakis, Straubinger, Plötner, and Antoniou (2020) researched the emerging field of urban air mobility and come to the same result, that safety plays a major role in passengers' attitude towards alternative propulsion systems. Based on this, Winter, Lamb, and Baugh (2020) studied customer views on alternative propulsion systems, finding that passengers prefer fuel propulsion systems (kerosene/biofuels), followed by battery/electric systems, and lastly solar-powered systems.

To conclude, the literature review reveals several key insights. First, across all three sustainable business practice categories, technology-specific knowledge and attitude towards climate change are the main drivers behind a passenger's additional WTP for sustainable air tickets. Second, passengers' attitude towards technological innovation stands out as being mostly driven by risk and security concerns. Third, passengers' perception and WTP have been well studied for organizational initiatives and SAFs, but the literature on technological innovation is still fairly limited. As the literature reveals a gap regarding the identification of which of the three sustainable business practices yields the strongest effects on passengers' WTP, the next section presents the methodology to investigate this issue.

4 | Methodology

The paper's empirical research involves both a quantitative and a qualitative approach. Data was collected from consumers through a survey. Qualitative data was collected through interviews with industry experts.

A questionnaire involving 15 questions (see Appendix A.1) gauges passengers' views on airlines' sustainable business practices. The survey was pre-tested on several individuals and modified based on the received feedback. Afterwards, the survey was distributed via the social media channels LinkedIn, Instagram, and Facebook. Moreover, the direct messaging service WhatsApp was used to reach additional participants.

In the survey, participants are introduced to the three concepts of organizational initiatives, SAFs, and technological innovation by means of short descriptions. Then, participants are asked to indicate the average frequency of flights taken per year, the purpose of their flights, and to what extent they agree with the statement that "emissions from flying is an important issue", together with an open question that requests the respondent to elaborate further on the ticked response.

Afterwards, participants are presented with a fictional scenario in which they are about to purchase a short-haul, round trip flight ticket from Frankfurt to Lisbon costing EUR 60 (without any additional services) with an airline that pays no heed to environmental issues. Alternatively, the participant could book an equally convenient ticket with a sustainable airline. Regarding the latter, three scenarios are introduced. In each, the sustainable airline engages in one of the three sustainable business practices introduced earlier. The participant is then asked to indicate her or his additional WTP for each scenario. The same thought experiment is repeated for a long-haul, round trip flight from Frankfurt to New York costing EUR 800, with everything else being held equal. A section on the participant's demographics concludes the survey.

In total, 201 participants answered the survey. The gender distribution is relatively balanced with 47% male and 52% female participants, while 1% preferred not to reveal their gender (see Appendix A.2, Figure 10). The mean and median age in the sample are 27 and 24 years, respectively, indicating that participants are mostly young (see Appendix A.2, Figure 11). In

fact, 86% of the participants are below 30 years old. One infers that most participants are still attending school or have just graduated. This hypothesis is corroborated by the income distribution. While participants from 21 nationalities answered the survey, the sample is heavily biased towards German participants, who represent 72% of respondents, followed by Portuguese participants (6%), and Austrian participants (4%) (see Appendix A.2, Figure 12). Roughly half of the participants earn EUR 1,499 or less per month, which suggests that budget limitations might be an influencing variable (see Appendix A.2, Figure 13). About 30% earn between EUR 1,500 and EUR 3,999, while only 20% make more than EUR 4,000 per month. In terms of educational level, 45% and 44% hold a Bachelor's and a Master's degree, respectively (see Appendix A.2, Figure 14). The large majority of participants is currently pursuing a higher-education degree or has just concluded it. This survey is quite biased towards one country. Moreover, it over represents the viewpoints of young persons. This limitation, on the other hand, is perhaps less troublesome if one bears in mind that younger respondents are more likely to shape future market preferences as a result of their longer life expectancy.

Regarding the interviews with industry experts, five individuals were queried. Interviews were conducted via Microsoft Teams (see Appendices A.3 to A.5). Three interviews were conducted in English, while two were conducted in German and then translated to English. In the first part of the interview, experts were asked how sustainability impacted airlines and passengers in the past. Next, the effect of past, present, and future regulations was discussed. Afterwards, experts were requested to evaluate organizational initiatives, SAFs, and technological innovation. This section was followed by an assessment of the aircraft manufacturers' and airlines' current sustainability efforts and motives to become sustainable. The interviews were concluded with questions on the attitude towards political intervention, an assessment of the relevance of sustainability for specific traveler groups, and an evaluation of whether a fully sustainable airline was foreseeable in the future.

The first interview took place with Luís Rodrigues, CEO of SATA Group, the parent company of SATA Air Açores and Azores Airlines. Prior to his engagement at SATA Group, Mr. Rodrigues held a position as an executive board member at the Portuguese flagship carrier TAP Portugal. The second expert is Nico Buchholz, founding partner of Flightlevel500, a management consultancy specialized in aviation. In addition to his position as Executive Vice President of Lufthansa Group's fleet management, Mr. Buchholz worked at Airbus, engine manufacturer Rolls Royce, leasing firm GOAL, Bombardier, and Delta. Furthermore, Mr. Buchholz holds several advisory board member positions and is a mentor at the Sustainable Aero Lab in Hamburg, Germany. The third interviewee is Valter Fernandes, current CEO of TAP Portugal Express. Given his engineering background, Mr. Fernandes worked as an aircraft maintenance manager in Portugal and Brazil. The fourth expert is Florentina Buchholz, Lufthansa Group's Director of Sales Northwest USA. Her main activities revolve around contract and agency management in the field of B2B sales. Moreover, she recently took responsibility for Lufthansa's sustainability activities. The last interviewee is the Managing Director and Partner at the Lisbon office of a large international consultancy. He has a strong expertise in the aviation industry, focusing especially on European full-service carriers, having conducted several efficiency and transformation projects, with further experience in commercials (i.e. revenue distribution management) and MRO (maintenance, repair, and overhaul). The four interviewees explicitly named consented in having their identities revealed, while the fifth did not and must thus remain anonymous. The next section will analyze, discuss, and compare the findings from the survey and the expert interviews.

5 | Results and discussion

5.1 | Airlines' sustainability concerns

The experts express diverging views regarding the degree of the industry's sustainability concerns in the past. While Mr. and Mrs. Buchholz argue that the concern for sustainability has

been certainly growing recently, Mr. Rodrigues adds that these concerns have slowed down due the pandemic. According to Mr. Rodrigues, "*aviation has been in survival mode* […]*, that easily takes out the focus of what needs to be done in the long term*". Mr. Fernandes and the Managing Director and Partner build on this argument, stating that sustainability has not played a major role in the past, but will become more important in the future. To better analyze which drivers are mainly responsible for airlines' pursuit to become sustainable, we investigated the role of different motives. With four out of five experts pointing out economic and regulatory requirements as the critical drivers, marketing effectiveness and doing good for the planet were the second most frequently highlighted motivators. It can thus be inferred that the pressure faced by airlines to satisfy different stakeholders—shareholders, regulators, and passengers—will result in an increasing attention being devoted to sustainable aviation.

5.2 | Passengers' sustainability concerns

All experts agree that passengers have become more aware of their carbon footprint. Nevertheless, the experts also note that, despite this attitudinal change, they cannot observe a reduced flight demand or higher WTP for sustainable tickets. This observation can be explained by the passengers' statements that a "*low price is a more important component*" and that flying "*is simply the most convenient way*" to travel. Moreover, respondents displaying a low concern for flight emissions refer to other sectors such as agriculture, textile, automotive, or energy, as emitting substantially more GHGs. Even some passengers who show concern for flight emissions state that "*flying definitely contributes to the emissions, but* […] *other sources* […] *have a bigger impact*". Based on these statements and having offered compensation programs at TAP for over ten years, Mr. Fernandes observes a paradox that "*people want to be green, but* […] *they don't want to spend more*". We find partial support for this argument. In fact, 88.6% of the participants at least somewhat agree with the statement that "emissions from flying is an important issue" (see Appendix A.2, Figure 3). We find that these passengers

frequently show a high awareness of climate change and a good knowledge of the aviation sector's proportional contribution towards global emissions ("*2-3% of global CO_2 emissions [stem from] flight traffic*"). Despite their concern, respondents also recognize the dilemma of "*protect[ing] the environment while maintaining mobility*" and "*the lack of alternative transportation modes*", thus classifying flying as "*a luxury emissions*".

We find contradictory results regarding Mr. Fernandes' views on the additional WTP. The data shows an additional WTP of up to 24.3% and 11% of the original ticket price for the short- and long-haul flight, respectively (see Appendix A.2, Table 1). One reason for this conflicting observation is that the experiment's layout provided passengers with detailed background information on the sustainable business practice deployed. Hence, our survey's results offer further proof of the relevance of passenger knowledge with respect to sustainable business practices in aviation, thus supporting the findings from Filimonau et al. (2018) and Løkke et al. (2021).

5.3 | Regulatory requirements and political intervention

Beside airlines' initiatives and passengers' behavior, the future of the industry is also determined by regulatory bodies. When asked about past regulations, all experts point out stricter reporting obligations (e.g., carbon emissions) as part of the CORSIA agreement and noise regulations to penalize airlines with aging fleets. Currently, all experts agree that CO_2 taxation and certificates are the most relevant cost drivers. However, Mr. Buchholz stresses that these measures differ greatly from country to country and can change rapidly. Given Mrs. Buchholz's profound knowledge of the US market, she confirms this statement, emphasizing the different approach taken by the US versus European governments. While Germany and France tend to shape the industry through bans and taxes, the US government deploys tax incentives to support airlines' sustainability initiatives. In the future, the EU's plan to reach net zero by 2050 is seen as a main regulatory driver, with the experts forecasting rising CO_2 taxes

and more bans on domestic flights. The Managing Director and Partner anticipates mandates on the use of SAF, an end to free carbon allowances, and tariffs on unsustainable, non-European airlines, to protect local airlines from foreign competition during the transformation phase.

Thus, adherence to regulations will entail higher carbon taxes, investments in quieter and more efficient airplanes, as well as an intensified use of SAFs. Therefore, from a regulatory perspective, we conclude that all three areas—organizational initiatives, SAFs, and technological innovation—will become highly relevant sustainability instruments for airlines.

We also researched the industry's attitude towards political engagement, finding mixed views on political intervention. Mr. Rodrigues strictly opposes constraints and penalization, as it "*simply increases the cost of flying"*. Mr. Buchholz, Mr. Fernandes, and Mrs. Buchholz also criticize overregulation and politicians' limited industry knowledge. They express a preference for stable conditions to enhance predictability, claiming that airlines' financial motivation to become green will eventually decarbonize aviation. In contrast, the Managing Director and Partner endorses government funding to support the transformation process.

To conclude, based on the interviews, we observe a conflict between an increasing number of regulations and a negative attitude on the part of the industry towards a too strong political interference.

5.4 | Alternative sustainable business practices

All experts agree that the three areas subject to analysis represent the key pillars through which airlines can become more sustainable. As for other means through which airlines can become more sustainable, all experts point out operational enhancements. These include, among others, optimizing flight plans, climbing rates, cruise speeds, as well as weight and waste reduction. Mrs. Buchholz adds that Lufthansa focuses on inter-modality, offering passengers "train-to-flight" tickets to its major hubs in Frankfurt and Munich to reduce the demand for domestic flights. While other activities such as continuous decent approaches and Airbus' newly tested

formation flights promise further emission reductions, regulatory hurdles imposed by Eurocontrol, Europe's air traffic management agency, slow down the implementation or limit their applicability, depending on geographic factors. Although these operational improvements reduce emissions, Mr. Fernandes notes that such measures have become standard, as airlines strive to reduce costs. Nevertheless, the relevance of operational enhancements increases the importance of technological innovation, implying that lighter and more efficient aircraft are a crucial element of airlines' sustainability strategy.

5.5 | Economic impact of organizational initiatives and passengers' WTP

The future viability of a sustainable business practice is predicated on its economic impact. With respect to organizational initiatives, all experts agree that it is the least costly area to invest in. However, Mr. Fernandes and Mrs. Buchholz point out that purchasing CO_2 certificates or offering compensation programs is a service rather than a revenue stream. While the Managing Director and Partner underlines the cost efficiency of this investment, as airlines can split costs with passengers, Mr. Buchholz notes that this can rapidly change, as airlines are exposed to the idiosyncratic policies of local governments regarding CO_2 prices.

Although all experts agree on the cost efficiency of organizational initiatives, they hold opposing views on the potential economic advantages thereof. Mr. Rodrigues states that organizational initiatives are "*easiest to sell to customers*", arguing that passengers lack the technological knowledge to evaluate an airline's degree of sustainability based on the aircraft type or the fuel used. Conversely, Mr. Buchholz and the Managing Director and Partner perceive organizational initiatives as an expenditure with limited marketing effectiveness.

The data on passenger perceptions reveals that the average additional WTP is lowest for organizational initiatives. For both short- and long-haul flights, respondents indicated an additional average WTP of EUR 9.7 (+16.2%) and EUR 55.2 (+6.9%), respectively (see Appendix A.2, Table 1). With the compensation platform atmosfair.de indicating an

approximate required compensation payment of EUR 16 and EUR 57 for the short- and long-haul flight, respectively, the reported WTP barely covers the required payment (Atmosfair, 2021). Therefore, the results obtained from industry experts and respondents suggest that engagement in organizational initiatives is a low-return strategy.

5.6 | Economic impact of sustainable aviation fuel and passengers' WTP

The majority of the experts rank SAF as the second largest investment area to be pursued by airlines. This argument is mainly based on the fact that currently, SAFs cost approximately four to five times more than conventional kerosene. According to Mr. Buchholz, fuel costs represent 30% to 50% of an airline's operating costs. Hence, SAFs are currently not an economically viable business option. Based on this economic obstacle, Mr. Fernandes even rates SAFs as the most expensive sustainability measure. Moreover, Mrs. Buchholz underscores the low production levels that prevent airlines from purchasing SAFs in sufficient quantities to feed their operations.

Despite the fact that most experts generally agree that SAFs represent an expensive sustainability measure for airlines, they hold opposing views with respect to its economic advantage. On the one hand, Mr. Buchholz and the Managing Director and Partner tend to see SAFs as a pure expenditure with no additional revenues arising from it. On the other hand, despite seeing SAFs as an expensive investment, Mr. Fernandes believes that "*SAFs could be highly attractive to customers, as they will know that specifically their flight was operated using highly environmentally friendly fuels*". Moreover, it is noted that if airlines are taxed according to their emissions, deploying SAFs is in fact a cost reducing measure as they produce up to 80% less CO_2 than conventional kerosene, thus reducing taxable emissions.

Our data confirms Mr. Fernandes' statement. In both cases (short- as well as long-haul flight), respondents indicate an average additional WTP of EUR 14.6 (24.3%) and EUR 85.3 (10.7%), respectively (see Appendix A.2, Table 1). Hence, SAFs result in the highest additional

WTP for short-haul flights and the second highest additional WTP for long-haul flights. Thus, with respect to the relative WTP, our results match the findings of Rains et al. (2017) and Goding et al. (2018), at least for long-haul flights, while yielding an even higher WTP on short-haul flights. Note however that Rains et al. (2017) and Goding et al. (2018) did not differentiate between short- and long-haul flights. Whether this additional WTP suffices to recoup the investment made by the airline will ultimately depend on the purchasing price. However, as economies of scale increase over time, the price of SAF will decrease.

To conclude, while SAF does not represent a direct additional revenue stream, it has the potential to reduce expenses on carbon taxes, while showing a high potential to attract customers. We thus find evidence for a positive economic impact of an airline's use of SAF.

5.7 | Economic impact of technological innovation and passengers' WTP

Technological innovation, in particular the acquisition of modern aircraft, is ranked as the most expensive investment by most experts. Mr. Rodrigues explains that this category includes substantial amounts of physical assets, as purchasing a new aircraft can easily reach a three-digit amount (measured in millions of EUR). With respect to additional revenues generated from passengers, he states that technological innovation is difficult to "sell" to customers, since passengers seldomly base their decision on which airline to fly on the aircraft type assigned to the flight, despite the fact that they enjoy flying on new airplanes.

While agreeing with the difficulty to "sell" modern aircraft to clients, Mr. Buchholz and the Managing Director and Partner see other advantages in investing in technological innovation. According to Mr. Buchholz, "*technological innovation represents the most measurable economic impact as every Euro saved in fuel costs goes directly into the bottom line of the airline's financial statements*". Based on this, technological innovation yields significant sustainability gains, while delivering the most visible economic advantages to airlines.

Bridging the experts' arguments with the data, we find a positive indication that passengers' additional WTP on tickets from airlines engaging in technological innovation is comparable to the results obtained on SAF. While on short-haul flights, passengers indicate a WTP of EUR 13.9 (+23.2%), the WTP reaches EUR 88.2 (+11%) on long-haul flights (see Appendix A.2, Table 1). We infer that with increasing flight distance, passenger appreciation of modern aircraft rises too. This yields the practical conclusion that specifically for airlines operating on long-haul routes, passengers are willing to pay more for their ticket if a modern and fuel-efficient aircraft is deployed.

5.8 | The path and main drivers towards sustainable aviation

Having discussed the views of experts and passengers, the question remains which sustainable business practice will become most relevant for the industry in the future. As, according to Mr. Fernandes, "*not flying is not the answer*", "*we need to create alternative methods and means to fly with way less emissions*" until a zero emission technology is found. Mr. Rodrigues admits that it is too early to pinpoint one area that will dominate the future, but claims that "*it will be a mix of all of them in the long run*". Based on the expert interviews and passenger preferences, we predict an approximate timeline of the relevance of each area in the upcoming decades.

Based on the experts' statements, operational enhancements have become standard in the industry, making them the currently most prominent emission reducing activity. This is simultaneously accompanied by technological innovation through smaller hardware upgrades and constant fleet modernization, with the latter being highly supported by passengers, given the additional WTP identified. According to Mr. Buchholz, constant fleet modernization will stretch over time and is even a "*must-have category*" to guarantee economic survival and adherence to regulations. In the next five years, stronger interference by regulatory bodies is expected, which is forecasted to enhance the importance of organizational initiatives, especially for airlines with less environmentally friendly fleets. However, our results suggest limited

passenger support in terms of WTP for such engagement. In the upcoming five to ten years, we predict SAF to become the key instrument to reduce emissions in aviation, provided that price and production quantities reach competitive levels. Given passengers' high WTP and based on the interviews, SAF represents the economically and environmentally most promising interim solution until a carbon neutral technology achieves market readiness. This technology (e.g., hydro-electric propulsion systems), represents the last stage of "net zero" in aviation. Substantial research efforts and infrastructural changes explain why this degree of technological innovation is predicted to become relevant only in the long term (approximately in 2035 to 2040).

With respect to the aircraft manufacturer's role along this timeline, all experts unanimously agree that Airbus, due to its commitment to advance hydro-electric flying, is the current leader of sustainable aviation. Boeing, occupied by the 737 MAX crisis and delays in the 777X program, is lacking behind in the development of new, disruptive technologies. Nevertheless, in the short to mid-term, the experts forecast both manufacturers to be major accelerators of technological innovation, primarily through fleet modernization.

Lastly, we evaluated whether the concept of a "sustainable airline", as an additional axis to the low-cost and premium carrier continuum, could induce momentum to the industry's transformation phase. While Mr. Fernandes refers to current efforts to introduce a labelling system to standardize airlines' degree of sustainability, the other experts are rather unconvinced. The main reasons for this skepticism are that the concept of a "sustainable airline" is rather a "*marketing gag*", the "*industry is still driven by price and destination*" and "*we will rather see an upscaling of the current product rather than a standalone sustainable airline*". Nevertheless, Mrs. Buchholz states that, in the near future, sustainability could be an entry barrier to becoming a legitimate player in the industry.

6 | Limitations and suggestions for future research

This paper is a first step to unite the views of industry experts and passengers on multiple sustainable business practices in the aviation industry. Several limitations assail our study.

The findings of this study are limited by the resources available. First, the passenger survey is not entirely representative of the actual air passenger population, given the strong bias towards young and German participants. Second, despite having interviewed five experts from different backgrounds, their views might not fully reflect all opinions on sustainable aviation held in the industry. Third, given the survey layout, the respondents' choices with respect to their WTP might be influenced by framing effects and anchoring biases.

Based on the aforementioned limitations we propose the following suggestions for future research. First of all, a more representative sample should be used in future work. If one assumes that younger generations have a higher awareness of the negative effects of air travel on the climate, a more balanced sample would probably entail different results. Beyond that, the high proportion of German participants somewhat gears the results toward the German market. This calls for a more diverse sample.

The results obtained on the passengers' WTP should be validated using behavioral data. As these often differ from attitudinal data, we suggest replicating the experiment in an actual booking situation, building on the methodology of Schlöder et al. (2021). Additionally, using behavioral data allows for eliminating framing effects, offering the opportunity to test the results' robustness through different price starting points, thus addressing the potential interfering effect of anchoring biases. Furthermore, a closer investigation of the underlying drivers behind passengers' decision to pay extra for a sustainable flight ticket for each of the three areas would be illuminating. Insights into these motivators could reduce an airline's risk of investing in areas not valued by the flying public.

7 | Conclusion

This paper investigates the (currently) prominent sustainable business practices in aviation and conflates airlines' initiatives with passenger attitudes to predict the most relevant areas in sustainable aviation, yielding four key results. First, organizational initiatives, SAFs, and technological innovation are the main future areas through which airlines can become more sustainable, while organizational enhancements have already become standard. Second, concerns spurred by climate change will rapidly advance sustainable aviation as soon as the COVID-19 pandemic is overcome. Third, passengers display the highest WTP for airlines engaging in SAF and technological innovation on short- and long-haul flights respectively, showing the lowest WTP for organizational initiatives in both scenarios. Fourth, we found that operational enhancements, fleet modernization, and organizational initiatives will be the short-term solutions to make aviation greener, while SAFs and technological innovation (i.e. through electric or hydrogen planes) represent mid- and long-term solutions, respectively.

To put it in a nutshell, on the one hand, through the power of their purchasing decisions, passengers partially determine the commercial success or failure of a sustainable business practice in aviation. On the other hand, this paper also shows that technological and economic readiness, as well as regulatory pressure, play an equally critical role. We come to the conclusion that sustainable aviation is making its way, but that progress will be protracted and demand large investments in R&D as well as hardware. How and when the industry will reach net zero will ultimately depend on the interplay between stakeholder commitment and technological and economic feasibility.

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Appendices

A.1 | Consumer survey template

Start of Block: Welcome!

Dear Participant,

As part of my Master's thesis at Nova School of Business and Economics, I am conducting a survey on passenger perceptions of novel sustainable aviation trends. I would like to take about 4 minutes of your time to answer this survey. All answers are anonymous and will be used solely for my master thesis.

Thank you for your participation!

End of Block: Welcome!

Start of Block: Information on sustainable business practices

Please read carefully

In recent years, airlines have undertaken several steps to increase the degree of sustainability of their operations. Airlines' sustainable business practices can be grouped into **three** categories:

Organizational Initiatives

Airlines can reduce their carbon footprint by buying CO_2 certificates or offering passengers the possibility of contributing to CO_2 offsetting programs that support reforestation projects.

Sustainable Aviation Fuels

Sustainable aviation fuels reduce CO_2 emissions. They can be made from biological materials such as algae, cooking oil, or municipal waste.

Technological Innovation

Technological innovation is embedded into modern aircraft that achieve fuel efficiency through light materials, fuel-saving engines, drag-reducing design, or alternative propulsion systems.

End of Block: Information on sustainable business practices

Start of Block: Introduction questions

On average, how many flights do you take per year (take a round trip as consisting of two flights)?

- ○ 0
- ○ 1 – 4
- ○ 5 – 8
- ○ 9 – 12
- ○ More than 12

What is the main purpose of your flights?

- ○ Leisure only
- ○ Business only
- ○ Both

To what extent do you agree with the following statement?
"Emissions from flying is an important issue."

- ○ Strongly disagree
- ○ Somewhat disagree
- ○ Neither agree, nor disagree (neutral stance)
- ○ Somewhat agree
- ○ Strongly agree

Why do you <u>strongly disagree</u> with the sentence "Emissions from flying is an important issue"?

_____

Why do you <u>somewhat disagree</u> with the sentence "Emissions from flying is an important issue"?

_____

Why do you <u>neither agree, nor disagree (neutral stance)</u> with the sentence "Emissions from flying is an important issue"?

_____

Why do you <u>somewhat agree</u> with the sentence "Emissions from flying is an important issue"?

_____

Why do you <u>strongly agree</u> with the sentence "Emissions from flying is an important issue"?

_____

End of Block: Introduction questions

Start of Block: Short-haul flight

*You are planning to book a trip from **Frankfurt (FRA)** to **Lisbon (LIS)** and back in two months time. The connection that suits you best costs **60€** for a round trip. However, the airline that you selected pays no attention to environmental issues. The ticket price only includes the flight without any other additional services.*

*Alternatively, you can take an equally convenient flight operated by the sustainable airline **Green Air**. In the section below, you will be presented with three alternative scenarios. Please indicate how much you would be willing to pay extra for each scenario.*

Scenario 1
Green Air engages in **organizational initiatives** that enhance sustainability, such as purchasing CO_2 certificates to compensate for its carbon emissions.
How much more would you be willing to pay (in addition to the initial 60€) to fly with **Green Air**?

Scenario 2
Green Air uses **sustainable aviation fuels.** It uses only biofuels that emit less carbon than conventional kerosene.
How much more would you be willing to pay (in addition to the initial 60€) to fly with **Green Air**?

Scenario 3
Green Air engages in **technological innovation.** It operates with the most modern and fuel-efficient aircraft.
How much more would you be willing to pay (in addition to the initial 60€) to fly with **Green Air**?

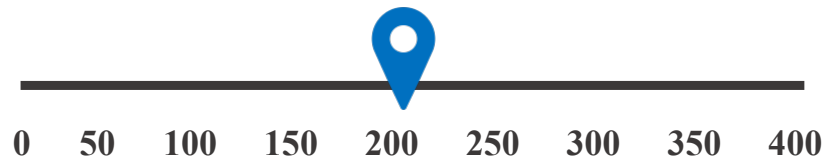
End of Block: Short-haul flight

Start of Block: Long-haul flight

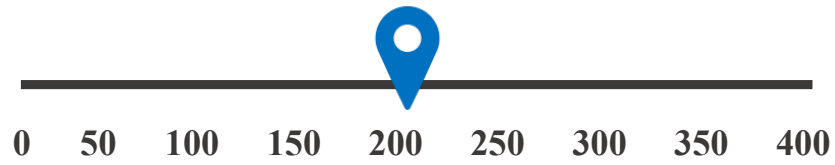
*You are planning to book a trip from **Frankfurt (FRA)** to **New York (JFK)** and back in two months time. The connection that suits you best costs **800€** for a round trip. However, the airline that you selected pays no attention to environmental issues. The ticket price only includes the flight without any other additional services.*

*Alternatively, you can take an equally convenient flight operated by the sustainable airline **EcoFly**. In the section below, you will be presented with three alternative scenarios. Please indicate how much you would be willing to pay extra for each scenario.*

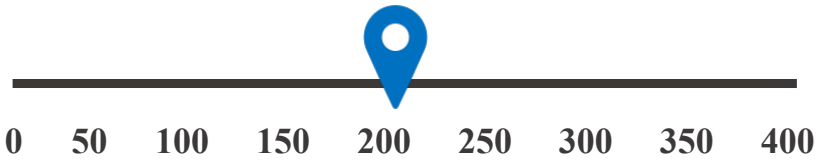
Scenario 1
EcoFly engages in **organizational initiatives** that enhance sustainability, such as purchasing CO_2 certificates to compensate for its carbon emissions. How much more would you be willing to pay (in addition to the initial 800€) to fly with **EcoFly**?



Scenario 2
EcoFly uses **sustainable aviation fuels**. It uses only biofuels that emit less carbon than conventional kerosene.
How much more would you be willing to pay (in addition to the initial 800€) to fly with **EcoFly**?



Scenario 3
EcoFly engages in **technological innovation**. It operates with the most modern and fuel-efficient aircraft.
How much more would you be willing to pay (in addition to the initial 800€) to fly with **EcoFly**?



End of Block: Long-haul flight

Start of Block: Demographics

What is your gender?

- ○ Female
- ○ Male
- ○ Non-binary/third gender
- ○ Prefer not to say

What is your age (in years)?

_____

What is your nationality country?

▼ Afghanistan ... Zimbabwe

What is your average gross monthly income?

- ○ 0€ to 499€
- ○ 500€ to 999€
- ○ 1000€ to 1499€
- ○ 1500€ to 1999€
- ○ 2000€ to 2499€
- ○ 2500€ to 2999€
- ○ 3000€ to 3499€
- ○ 3500€ to 3999€
- ○ 4000€ to 4499€
- ○ More than €4500

What is the highest level of schooling that you have completed or the highest academic degree you have attained?

- ○ Less than high school degree
- ○ High school graduate
- ○ Bachelor's degree
- ○ Master's degree
- ○ Doctoral degree

End of Block: Demographics

A.2 | Consumer survey results

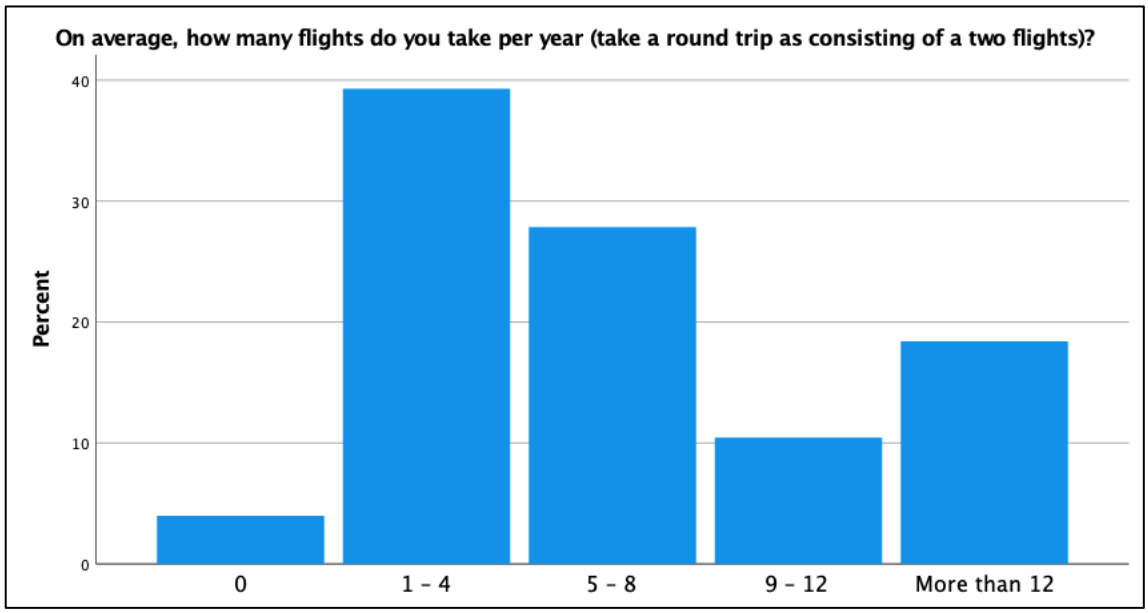


Figure 1. Number of flights taken by respondents (in %)

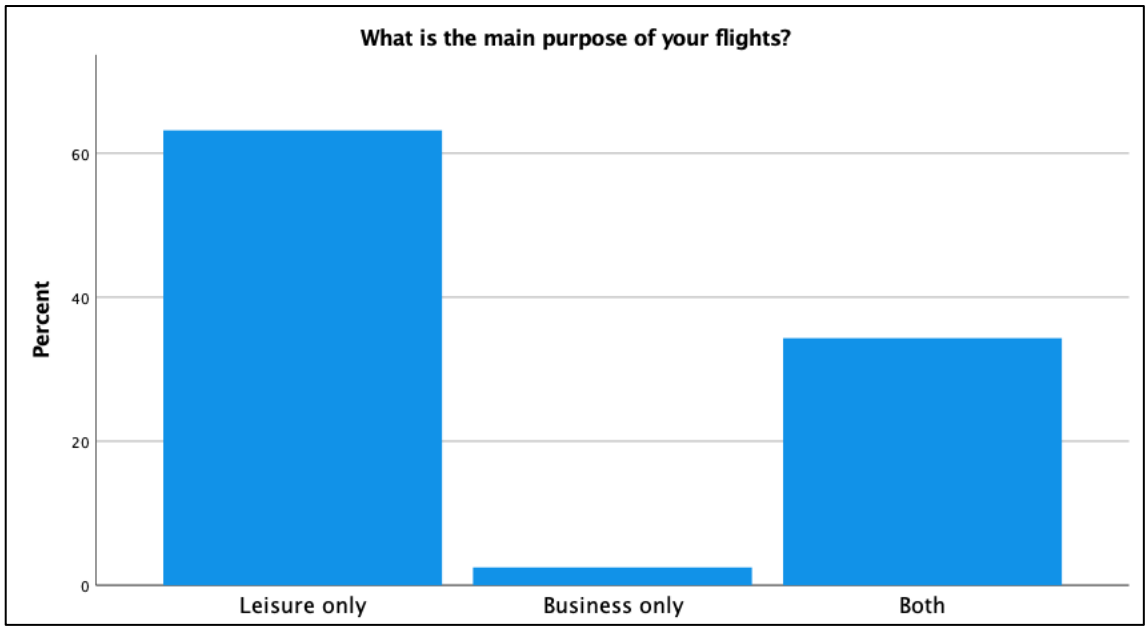


Figure 2. Purpose of flying stated by respondents (in %)

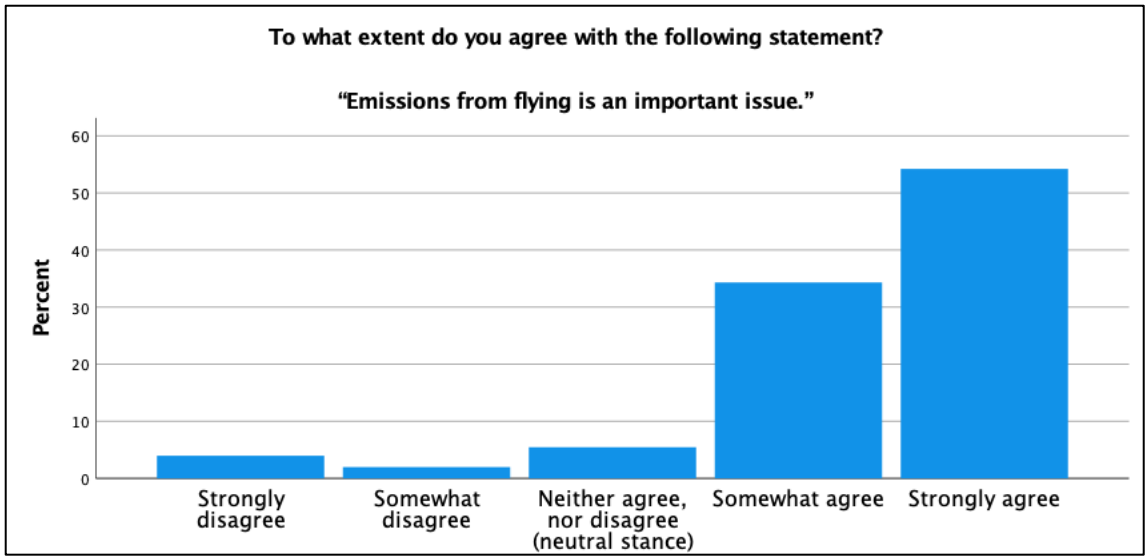


Figure 3. Attitude towards the statement "Emissions from flying is an important issue." (in %)

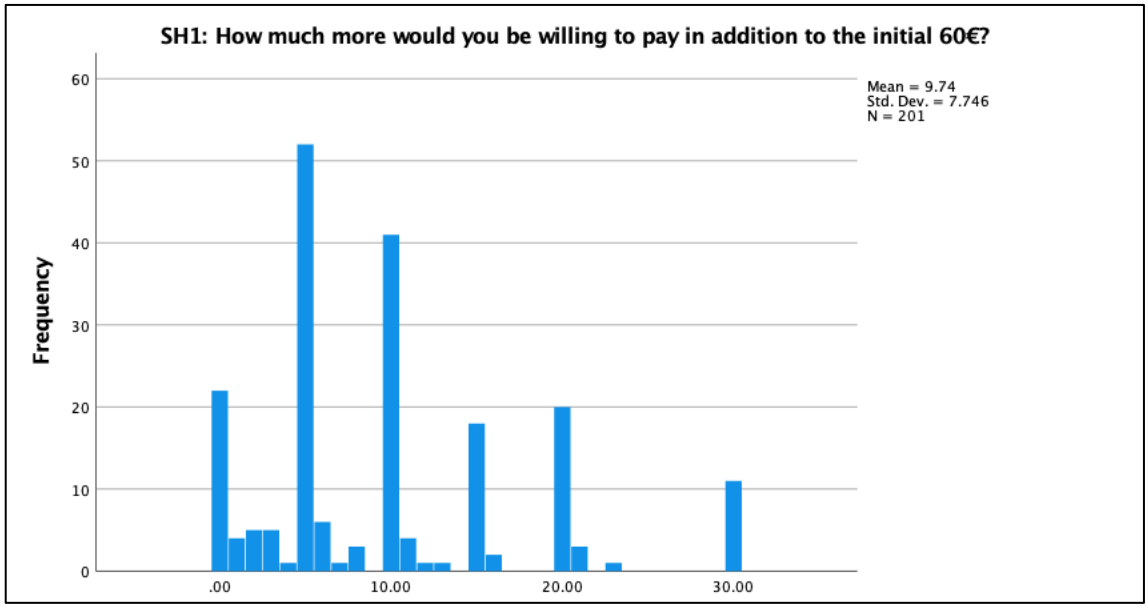


Figure 4. Frequency distribution of additional WTP for short-haul scenario 1

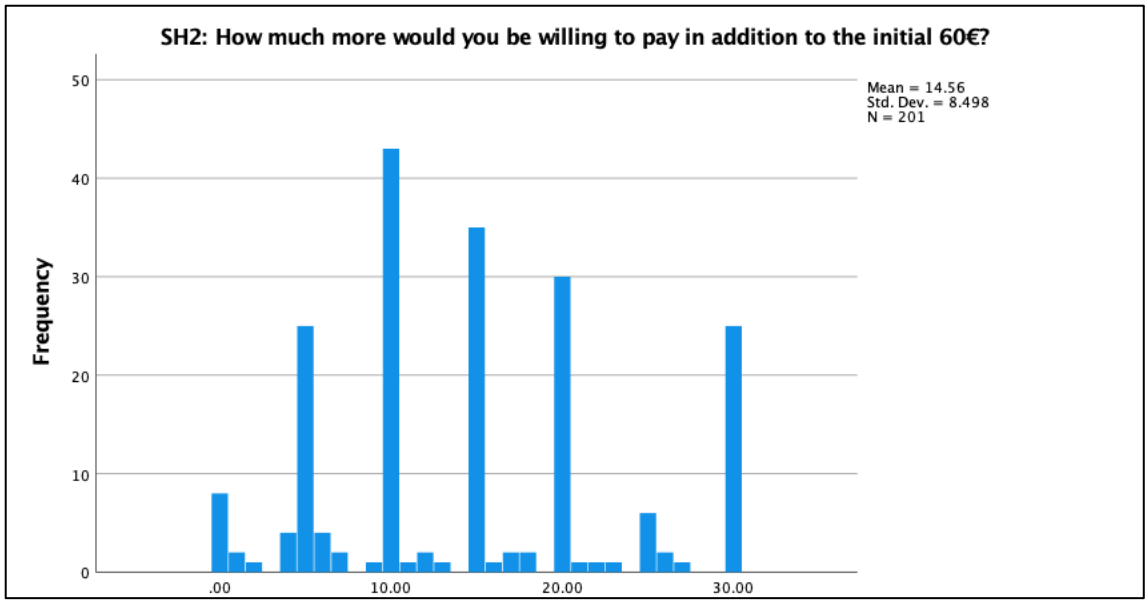


Figure 5. Frequency distribution of additional WTP for short-haul scenario 2

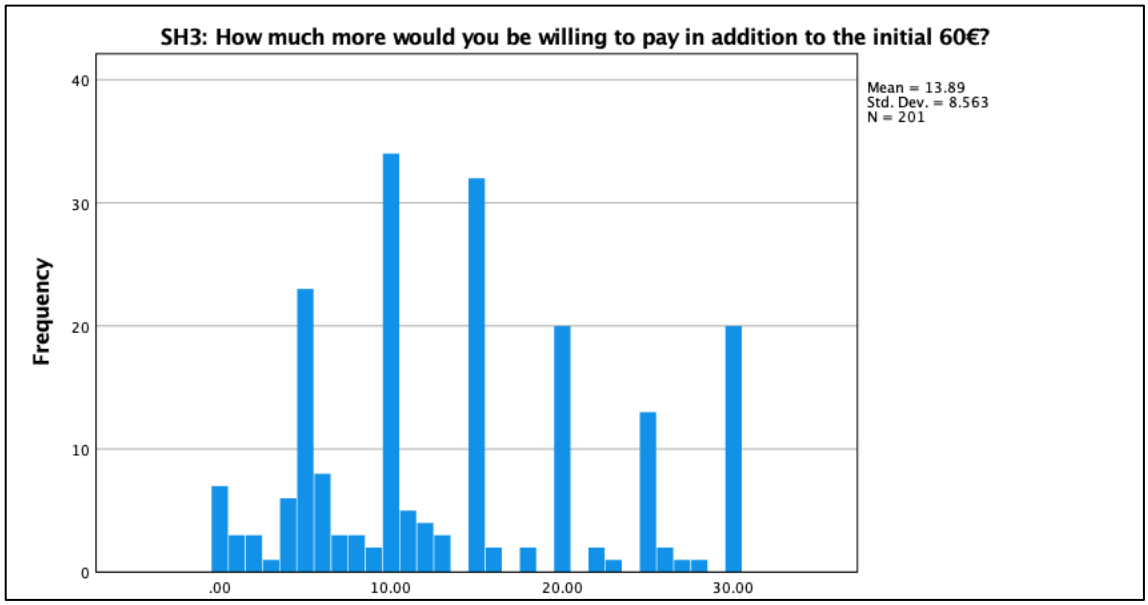


Figure 6. Frequency distribution of additional WTP for short-haul scenario 3

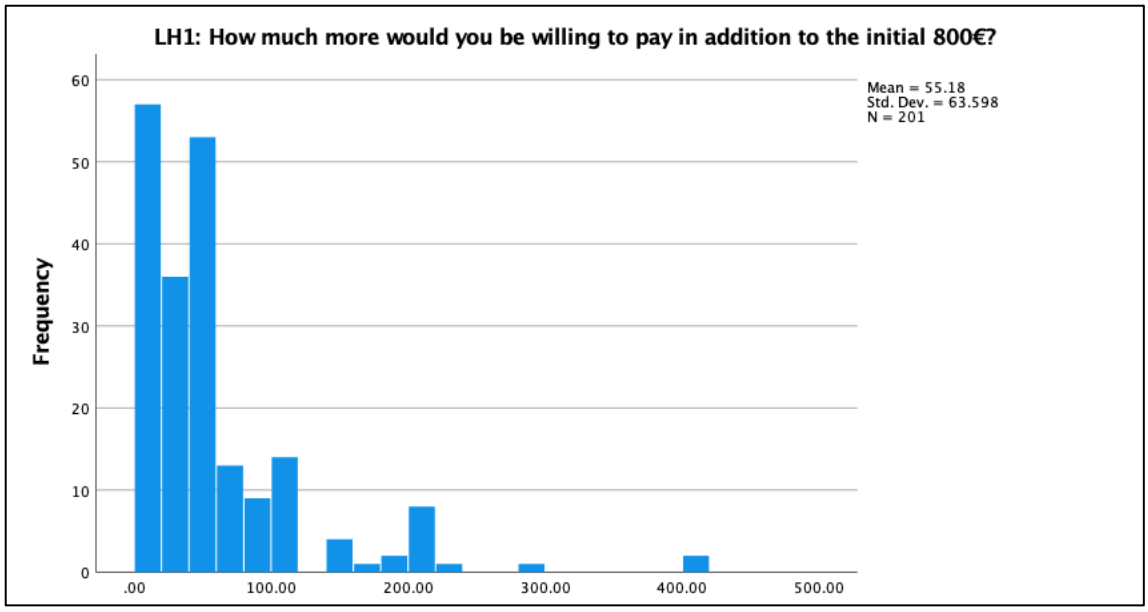


Figure 7. Frequency distribution of additional WTP for long-haul scenario 1

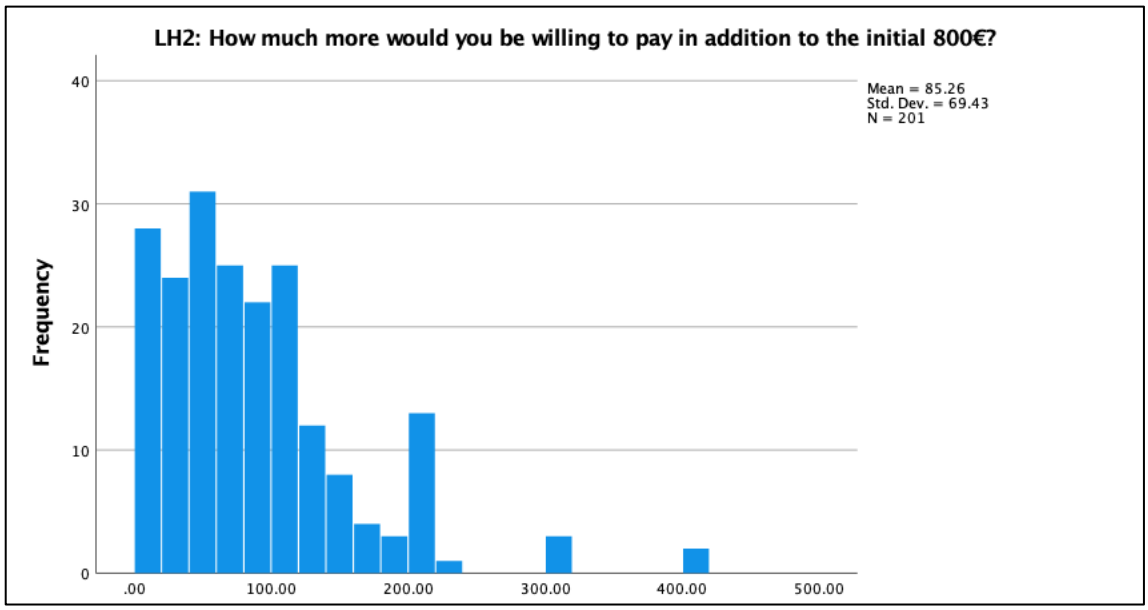


Figure 8. Frequency distribution of additional WTP for long-haul scenario 2

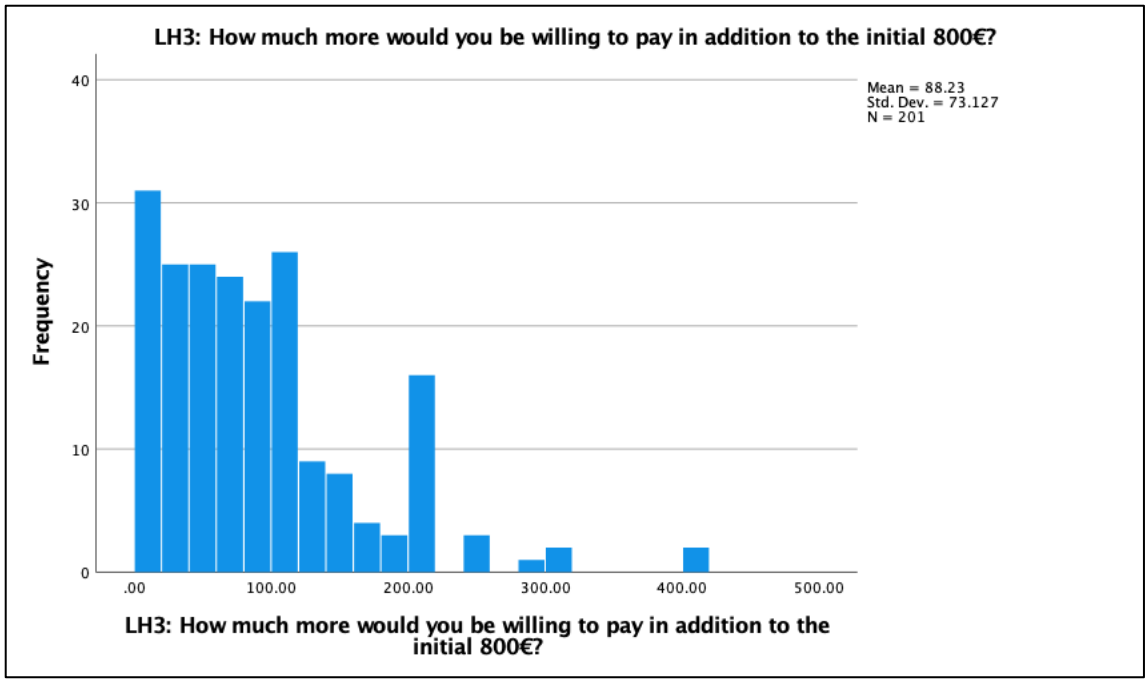


Figure 9. Frequency distribution of additional WTP for long-haul scenario 3

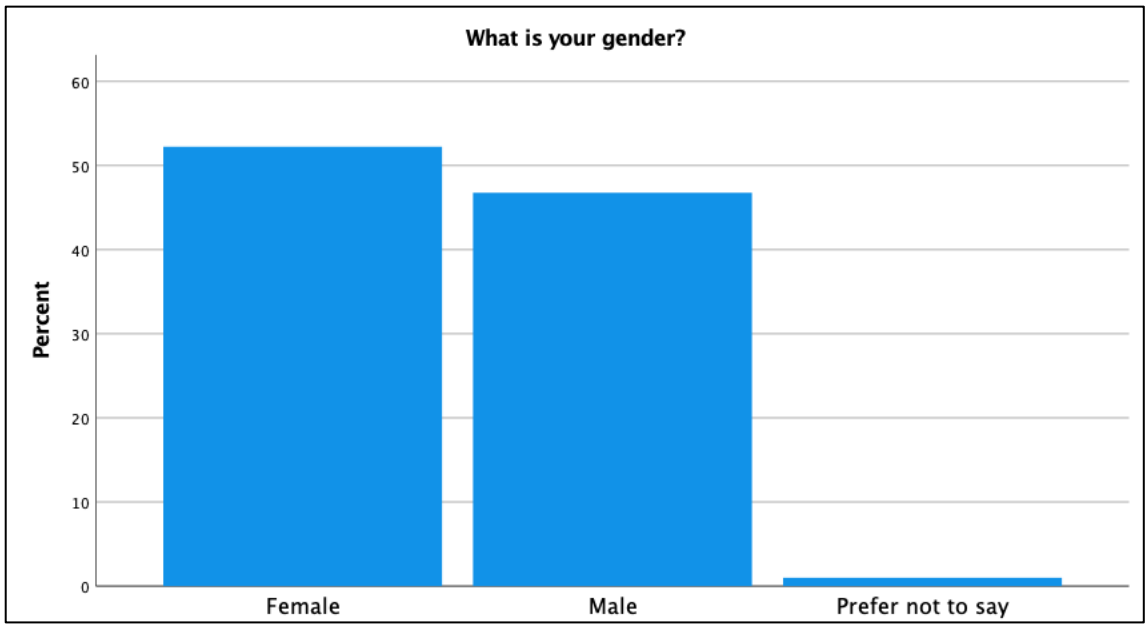


Figure 10. Gender distribution among respondents (in %)

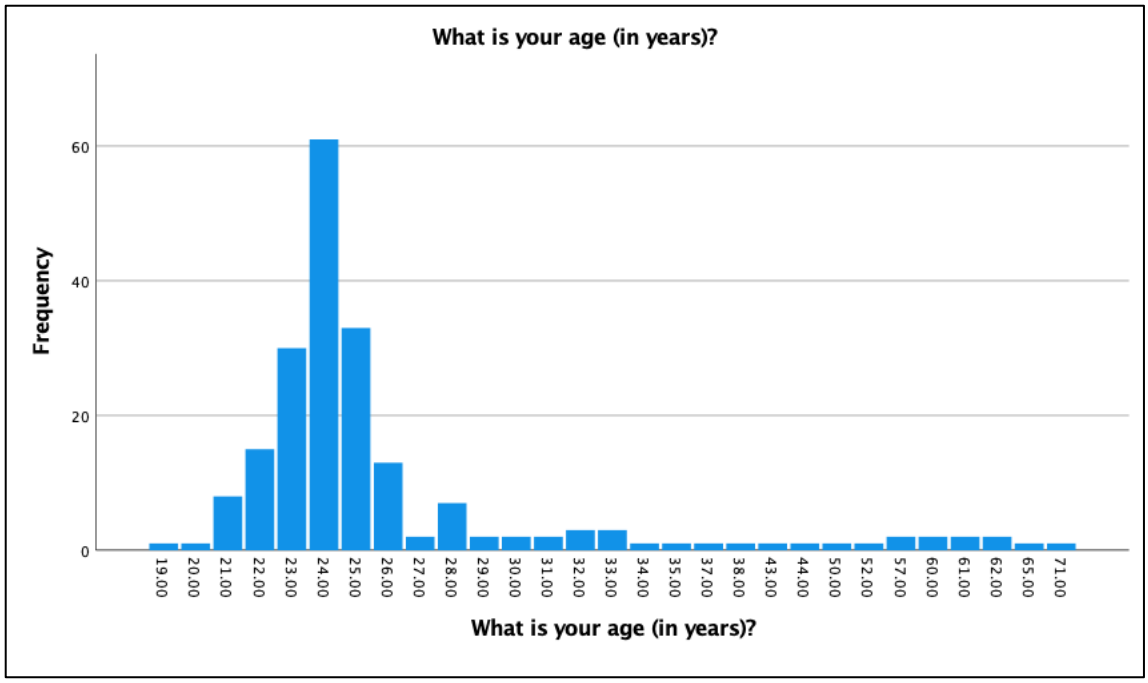


Figure 11. Frequency distribution of participants' age

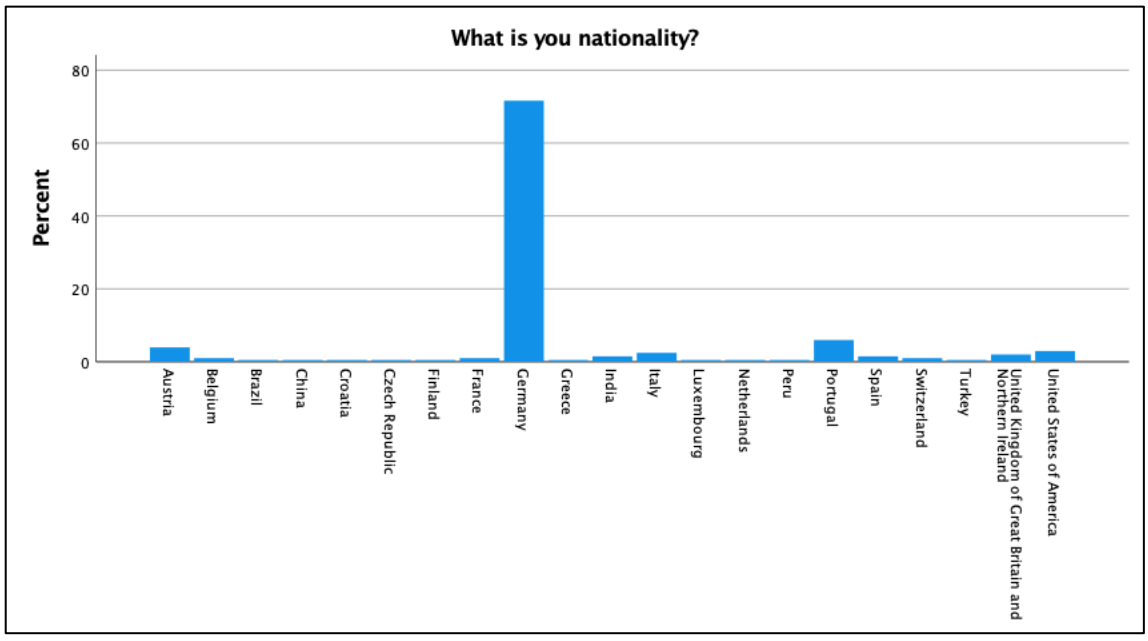


Figure 12. Nationality distribution among respondents (in %)

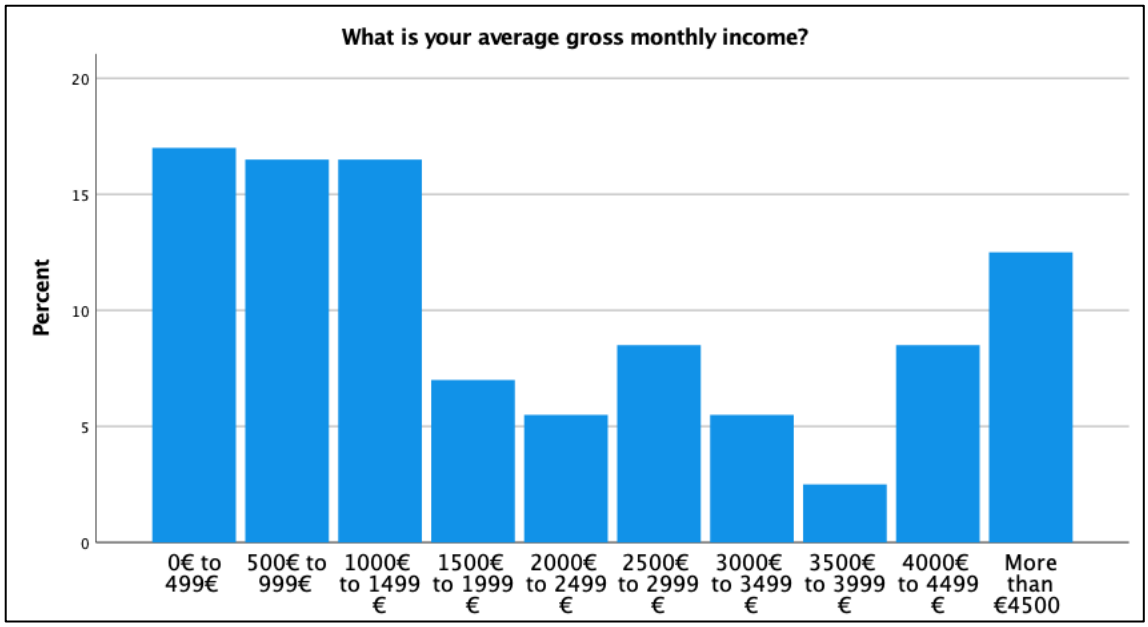


Figure 13. Average gross monthly income distribution among respondents (in %)

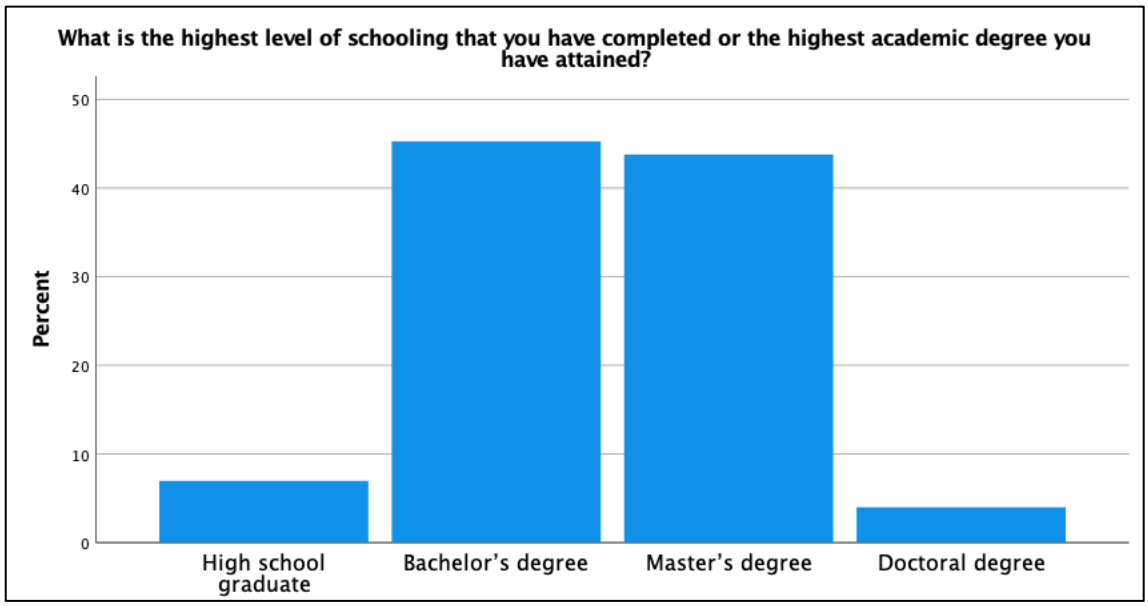


Figure 14. Distribution of education level among respondents (in %)

Why do you <u>strongly disagree</u> with the sentence "Emissions from flying is an important issue"?

- Because it makes up a large part of the human ecological footprint
- Even on high time of flying it was only 3% of global CO2 emissions, methane not considered at all. There are lower hanging fruits to fix with much less impact on global society
- Emissions multiple times higher than other transport modes
- Flying emissions aren't much of an issue. Countries like China produce much more emissions

Why do you <u>somewhat disagree</u> with the sentence "Emissions from flying is an important issue"?

- Emissions from other industries (e.g. textile industry, carbon production in agriculture) much worse and should be focused
- It's necessary to fly, but not too much
- I believe that emissions from aviation only make up a fraction of the general footprint and thus there are bigger emitters
- There are other sectors that emit so much more CO2

Why do you <u>neither agree, now disagree (neutral stance)</u> with the sentence "Emissions from flying is an important issue"?

- For me low price is a more important component
- It's not the biggest issue I see in the world today
- There are industries which by far emit more CO_2 than aviation where it is technologically easier and economically cheaper to reduce emissions effectively
- More important issues exist (emissions from cattle, industry, etc...)
- I believe that the emissions from flying are only a tiny fraction of more severe problems that need to be tackled first (such as thousands of coal fired power stations opening in China). The moment that we are able to travel long distances in an equally efficient way but with less emissions, everyone will switch, I'm sure of that
- Mostly because it is a general statement that can be applied to any activity we carry out nowadays
- I use airplanes to visit family, so I wouldn't give it up

- Of course, flying produces emissions that lead to climate change but not as much as the automobile industry
- Airplanes certainly are strong polluters, but I have to travel a lot for work and the plane is simply the most convenient way to get to my destination

Why do you <u>somewhat agree</u> with the sentence "Emissions from flying is an important issue"?

- Because the marginal emissions globally caused by the airline industry are low compared to e.g. the energy from fossil fuels sector. However, the absolute amount of emissions from the aviation industry is still a problem
- Emissions from flying is a strong source for global warming and climate change
- Only small part of overall emissions
- It has a great impact
- Too many plane flying without a needed reason, burning kerosene uselessly
- I believe that all kinds of unnaturally formed emissions are important issues that need to be solved. However, aviation only composes to around 1-3% of all global emissions
- All emissions are an important issue - the priority for short-term actions needs to be on the discussion on what is easy to abate AND represents a large share of emissions, then on what is hard to abate AND represents a large share of emissions. From one (or even both of these two), solutions for the then remaining emissions can and will arise
- It is definitely a relevant issue but it is not something that I often think about
- Emissions from flying are an issue, but there are way bigger issues such as pollution from industrial production, meat production, rainforest destruction etc.
- It is a major contributor to climate change. On the other hand, even bigger contributors (like cement and steel) are often overlooked
- It is very important for the climate
- Flying is an essential part of leisure and business these days. Reducing emissions is important to be able to continue flying while not polluting the air
- Because the environmental consequences of flying contribute to climate change. Climate change is an important issue and should be addressed in any industry
- For me time is the most important aspect, but sustainability is getting more focus now
- Because planes produce nearly 350g of CO_2 per km

- Because it is one of the emissions which really results in more pollution than other means of transportation.
- It is an important issue but on the other hand flying is essential way of long distance transportation
- Flying definitely contributes to the emissions, but I believe that there are other sources of emissions that have a bigger impact
- There is a lot more CO_2 in the air than when riding a train
- Because it is important and a great problem without any real solutions (cars have electricity as kind of a solution but planes don't)
- I work in aviation and see the effects of emissions
- Because of the impact it could have on the planet
- It is definitely important and avoidable. Emissions should be reduced/more sustainable as much as possible
- Fight against climate change is an important issue; air-travel is responsible for part of the emissions that cause climate change; other industries already have alternatives to fossil fuels, so can make easier reductions, but share of aviation-industry is also relatively low overall
- Planes and road traffic are some of the most polluting means of transportation, contributing to a combined of around 12% of the global CO2 emissions. So, it is clear that, to preserve our planet, we should try to innovate and bring new fuel solutions, not only for planes but also for road and marine traffic
- Because they produce 2% of all human induced CO_2
- We need to protect the environment while maintaining mobility
- Because I care about our planet
- We are in a worldwide climate crisis and emissions are playing a huge role in this. Hence, it is an important issue for me as I am sadly having a negative impact on the climate through my frequent flights
- e.g. 2-3% of global CO2 emissions by flight traffic
- Because most emissions derive from industrial companies and only a fraction are from private aviation. Therefore, it is important, but not the solution to solving the climate crisis
- The emissions destruct the environment and thus are an important issue

- Needs to be improved regarding the increasing frequency of people flying (aside from Covid) as it eventually has an impact on the environment and ultimately climate change. However it is not the only issue that needs to be addressed when we talk about climate change etc.
- It is a big driver of GHG emissions, but not the biggest one
- Emissions from flying are not the most important reason of ecological problems but somehow have to be considered
- Because it's an emission that should be considered and moreover a luxury emission
- A lot of CO_2 emission compared to the short time you fly.
- The lack of (affordable) alternatives as well as the prices of flights make frequent flying an important issue in the climate debate
- Large impact on global warming but on the other hand can hardly be avoided for personal or business travel
- It's part of globalization, emissions should be reduced as much as possible – 0 CO_2 flying should be pushed it is already possible
- Because it is true that emissions from flying are polluting, but it is not a reason that keeps me from flying
- It causes huge emissions but is often something that could be avoided. However there are also other bigger levers causing emissions
- Emissions from flying are important but aren't the most important emissions out of all the industries
- I perceive it to be one of the major contributors, but not by far the most damaging or avoidable
- Important, but there are other issue related to carbon footprint that have a greater impact and should be tackled first
- From what I know, short distance flights' CO_2 emissions are only responsible for a low percentage of the total emission. However, reducing CO_2 emissions is an important goal to decrease human influence on nature. The biggest impact might be if long-distance and cargo flights will be operated using alternatives to traditional fuels
- It plays an undeniable role in global emissions
- Because global aviation (including domestic and international; passenger and freight) accounts for only 1.9% of greenhouse gas emissions (which includes all greenhouse

gases, not only CO_2). I think there are more serious issues to tackle (cruise ships, meat production, street transportation, energy production

- Because it has a great impact on our environment but for some destinations it cannot be avoided
- Because there is indeed a large potential on improving the aviation industry under sustainability aspects, although aircrafts are in comparison not as big of a polluter as often claimed
- Flying produces a lot of emissions
- Emissions released from flying and the aviation industry as a whole are large contributors to global warming and a cause for climate change which could ultimately hurt humanity
- Because flights release harmful GHG
- Because it is true, it is an important issue. At the same time I believe there are more important issues in the world
- Because emissions is generally an important issue, which definitely needs to be reduced. However, aviation is not the only industry that needs to reduce emissions
- Due to climate change and global warming
- To my knowledge makes up great share of total emissions
- It's of course important, but not the first thing I think of when I'm flying
- Because it is damaging our environment and this sector is increasing
- Emissions from flying are considerably higher than for other transportation modes, however, global air traffic only contributes about 2% to global emissions
- Need to reduce CO_2but flying is not the worst
- Makes up over 2% of worlds total emissions
- Because we have to protect the earth and further our life on the planet
- As always, reduction of emissions is great - however in priority of main emission sources and feasibility of emission reduction (which is relatively low for most flight use cases today)
- Emissions from flying pose a substantial environmental impact, however, due to a lack of alternative transportation modes, flying is currently the only option for me

Why do you <u>strongly agree</u> with the sentence "Emissions from flying is an important issue"?

- The reason I hesitate to fly to places is because of the amount of pollution caused by it
- Climate change is one of the biggest crisis that humans have ever face and emissions from flying are part of it. Change and innovation in regard to more environmental friendly alternatives have to happen in every domain
- Aviation is a major driver of CO_2 emissions worldwide
- The emissions from flying are highly destructive for the environment
- international air traffic is one of the main emitters of CO_2
- Flying is a convenient way of travelling but harms the natural environment still to a larger extent then buses or public transportation for example
- Because of the impact it has on the climate
- Emissions from airplanes are much higher than from any other transportation mode
- Because there are still too many people not thinking about that or not caring about it. Also, still too many companies flying their employees from one place to the next without considering alternatives
- Global warming
- Because of the big amount of emissions from flying and their impact on the environment and the climate change. There should be efforts to reduce these emissions.
- High amount of emissions, often possible to choose alternatives like trains
- It's a huge ecological issue and needs to be tackled
- It's the least sustainable yet sometimes only way to travel (e.g. to certain holiday destinations) and as many people will continue to travel for business and leisure and there isn't an alternative, it's important to find ways to cut these emissions
- Because it is a high amount of CO_2 that we create willingly. It adds up to a lot and in contrast to other things it is easily allocated to one specific individual
- Huge flight traffic causing a lot of emission, perceived as very unsustainable
- Aviation accounts for 2.5% of global CO_2 emissions
- I should be reduced
- Climate change
- Because I care about the environment and the emissions aren't good for it
- Increasing trend for mobility, high emissions per flight

- Aircraft should be improved. Especially for short-haul flights, there should be better alternatives. I see the pollution caused by aircraft as very problematic
- I prefer to take carbon neutral flights to reduce my carbon footprint
- Since they're emissions that could be reduced through several ways but not enough effort seems to have been put on that
- I think emissions from flights represent a large share of global CO_2 emissions
- Climate crisis
- Because of the future of our children
- Global warming is the single most important challenge the world faces as of today
- I think that the aviation industry needs to find ways to make flying environmentally friendly to stay relevant as THE choice for long distance travelling
- High CO_2 emissions
- The fuel is an important driver in CO_2 emissions
- It's the worst means of transportation in terms of emissions
- Greenhouse gases are obviously not good for the environment
- Because of climate change
- All emissions are important and if there are measures that from a cost-benefit perspective make sense, then it should be tried to reduce these emissions
- Climate change due to carbon dioxide emissions
- Too much pollution, there are better means of transportation
- Strong effect on climate change
- Because we need to be as carbon neutral as possible when we fly
- Emissions in general is an important issue and emissions from flying are quite high (at least what I know)
- It is a part of solving the environmental crisis
- Strong impact on environment with even one flight
- Often business flights are unnecessary, but done anyways despite suitable virtual setups (damage to environment should be more considered when deciding whether or not to fly)
- The emissions from flying accelerate the climate crisis
- Climate goals/change
- Aviation industry is producing significant emissions especially when compared to other means of transportation e.g. railway

- Because the environmental impact is large while the incentive to switch to an alternative is low
- 3% of global CO2 emissions as far as I know
- Compared to other ways of travel, flying produces a larger amount of CO_2
- Flying has an environmental cost and negatively impacts climate change
- Since flying allows people to travel more quickly compared to other vehicles but is connected to a considerable amount of emissions. Making flying more sustainable instead of introducing restrictions banning short flights for example is for me the best solution as to keep the advantages of planes as a quick vehicle while becoming more sustainable overall
- Impact on global warming
- Carbon emissions at a certain level of height have a stronger impact on the accumulation/greenhouse effect
- Environmental pollution
- Bad for environment, high CO_2 output
- Because flying is the mode of travel with the highest emissions
- I generally believe that reducing emissions from aviation is an important step toward achieving climate neutrality by 2050 as set out in the Paris Agreement. Short-haul flights in particular emit a lot of emissions that could be reduced by using more sustainable modes of transport
- It is harmful for the environment
- Because environmental issues should be addressed in every sector
- Climate change and lack of more sustainable alternatives
- Significant influence on climate change
- It is clearly bad for the environment. We should try to minimize emissions from flying as they are one of the biggest sources of emissions
- Sustainability and global warming are an issue that has gained a huge importance, so it is important that people are aware of some of the factors that contribute to it, which is the case for emissions from flying
- In a world where flying is being continued at the extend it is today, new solutions are needed regarding the CO_2 emissions
- Because emissions from flying add ~3.5% of the total emissions related to human made climate change

- It’s emitting huge amounts of CO_2
- Especially national flights are not necessary and should be forbidden
- Because climate change in general is a big issue, both currently and in the future, and emissions from flying clearly contribute in a negative way
- Planes emit an important part of total CO_2 emissions
- Because reducing emissions as a whole is critical in mitigating climate catastrophes and because airlines specifically emit more than other modes of transport
- Because to protect the environment
- They are one of the biggest contributors to pollution and global warming. I consider it to be highly important to minimize these emissions from planes
- This type of pollution is significant but can be prevented individually
- Climate change needs to be addressed and emissions from aircrafts are very high
- Climate change is the biggest threat to society and emissions should be cut as much as possible
- Personal CO_2 footprint & environmental protection
- Because 2.4% of global CO_2 emissions come from aviation
- Because we are in the middle of a climate crisis and it’s just becoming an addition to the problem
- Because flights increase my CO_2 footprint by a lot. I am not able to offset the emissions I cause by flying with my day to day environmentally friendly actions
- Because climate change is real
- Amount of CO_2 per flight is considerably large. Also, reasonable alternatives exist, but are not attractive enough in my opinion (e.g. convenience, price, …)
- Emissions from flight are very bad for the climate. Most flights are unnecessary. You should choose other ways to travel
- Because it contributes immensely to the CO_2 emission problem
- Because emissions from flying is one of the most current and biggest CO_2 emissions. There are many people every day flying
- Because flying is one of the main carbon emitter activities and its impact is highly neglected
- Despite accounting for only a small part of global emissions, flying is still the most polluting form of travel and I think it's on a path of becoming more accessible, therefore there will be more flights in the future

- flying = luxury but seeing the world is essential for a global cohesion and general understanding on a world working as a whole, which is essential for reaching sustainability goals
- Emissions from flying covers a high percentage of the total CO_2 emissions which has to be reduced in order to reach the 1.5 degree goal
- Because transportation emissions are generally an important issue when talking about sustainability and climate change
- They are a big contribution to climate change
- Accounts for significant portion of global (carbon) emissions
- Flight emissions are having a big impact on our climate
- Because the aerospace industry is significantly impacting global greenhouse gas emissions & there is significant room for improvement
- Because of air pollution
- I believe that the fuel component of the airlines industry is a huge issue not only for the environment but also for the entire industry as a whole. The carbon footprint and volatility of fuel prices, if eliminated, can definitely make the industry way more sustainable and efficient
- Because aircraft produce significant amounts of CO_2
- Minimum of 5% of global warming is caused by flying
- Because climate change is an issue and needs to be combatted, but not at the cost of peoples' freedom
- Because of climate change
- We need to reduce CO2 emissions, no matter what
- Especially short-haul flights are extremely harmful for the environment
- If I remember correctly, it takes only one long-haul flight to use up all your personal CO_2 budget for one year, which is really bad
- Tackling climate change is essential
- Flight emissions are highly polluting
- I try to reduce flying as much as possible. Compared to trains, airplanes have a much worse environmental impact
- Aviation is only responsible for 2% of global emissions, but every sector must reduce its carbon footprint

Descriptive statistics	SH-1	SH-2	SH-3	LH-1	LH-2	LH-3
Obs.	201	201	201	201	201	201
Min	0	0	0	0	0	0
Max	30	30	30	400	400	400
Mean	9,74	14,56	13,89	55,18	85,26	88,23
% of org. price	16,2%	24,3%	23,2%	6,9%	10,7%	11,0%
Median	10	15	12	48	71	74
Std. Dev.	7,75	8,50	8,56	63,60	69,43	73,13
Variance	60,00	72,22	73,32	4044,69	4820,55	5347,51

Table 1. Descriptive statistics of the sample

Frequency	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
0	15,75	15,75	14,13	110,25	121,63	142,25
1 – 4	9,95	14,95	14,23	52,89	86,06	85,41
5 – 8	10,25	14,88	14,00	55,95	85,09	89,80
9 – 12	7,76	13,33	12,10	46,62	67,38	67,29
> 12	8,32	13,68	13,95	51,89	86,11	92,08

Table 2. Average WTP (in EUR) per scenario by frequency

Purpose	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
Leisure only	10,19	15,35	14,20	55,57	87,71	88,98
Business only	15,00	15,80	15,20	104,80	129,00	113,20
Both	8,52	13,01	13,20	50,88	77,59	85,03

Table 3. Average WTP (in EUR) per scenario by purpose

Attitude	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
Strongly disagree	8,50	12,88	7,88	48,88	100,13	74,25
Somewhat disagree	9,25	18,75	8,00	27,50	83,25	41,25
Neutral stance	7,27	12,18	13,00	31,82	55,18	61,27
Somewhat agree	8,87	14,41	14,97	50,23	85,46	97,75
Strongly agree	10,64	14,86	13,94	62,16	87,16	87,67

Table 4. Average WTP (in EUR) per scenario by attitude

Gender	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
Male	10,64	15,58	15,02	62,40	91,12	96,65
Female	8,88	13,40	12,28	48,19	78,37	77,52
Prefer not to say	2,50	15,00	30,00	5,00	101,50	149,50

Table 5. Average WTP (in EUR) per scenario by gender

Age	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
< 20	2,00	6,00	6,00	43,00	62,00	98,00
20 – 29	8,98	13,98	13,31	47,94	78,85	81,56
30 – 39	11,07	18,29	17,21	79,07	121,21	111,07
40 – 49	8,50	8,50	8,50	21,00	21,50	20,50
50 – 60	15,83	13,67	19,33	103,00	107,50	164,83
> 60	23,83	26,67	20,17	172,83	188,17	170,33

Tables 6. Average WTP (in EUR) per scenario by age

Nationality	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
German	10,64	15,58	15,02	62,40	91,12	96,65
Other	8,88	13,40	12,28	48,19	78,37	77,52

Table 7. Average WTP (in EUR) per scenario by nationality

Income	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
0€ to 499€	7,53	13,50	12,29	39,97	68,47	68,00
500€ to 999€	10,67	15,48	15,15	53,45	89,82	98,09
1000€ to 1499€	8,85	14,27	12,85	47,39	76,73	74,76
1500€ to 1999€	11,33	12,67	11,47	55,87	73,00	64,40
2000€ to 2499€	11,64	12,73	12,45	59,00	70,00	73,73
2500€ to 2999€	10,18	15,29	15,00	67,00	90,76	86,06
3000€ to 3499€	13,09	12,64	10,64	58,82	82,18	88,64
3500€ to 3999€	11,00	18,00	16,00	42,80	95,40	105,40
4000€ to 4499€	9,94	17,06	16,18	80,71	117,88	124,65
> €4500	8,72	15,04	16,52	61,84	100,84	114,28

Table 8. Average WTP (in EUR) per scenario by income

Education	Average of SH-1	Average of SH-2	Average of SH-3	Average of LH-1	Average of LH-2	Average of LH-3
Highschool	8,50	17,00	14,21	46,07	104,21	83,71
Bachelor	9,76	13,42	13,65	51,58	74,63	84,34
Master	9,18	14,51	13,19	53,48	86,73	87,06
Doctor	17,75	23,75	23,63	130,88	157,00	153,25

Table 9. Average WTP (in EUR) per scenario by education

A.3 | Interview questionnaire template

FACTSHEET

Interviewee	…
Company	…
Position	…
Other relevant positions	…
Date	…
Time	…
Duration	…
Setting	…
Permission to record & use real name?	…

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- …

Could you please elaborate on other relevant positions you held in the industry?

- …

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- …

How strong is the consumer's concern for flight emissions?

- …

Which regulatory requirements with regard to sustainability have affected your airline in the past, present, and the future?

- …

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- …

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- …

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- …

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- …

What is Airbus doing in this direction?

- …

And Boeing?

- …

In which of these areas is <u>your</u> airline currently active or planning to be active?

- …

Should politics support the industry in any way through financial support?

- …

What are the <u>main reasons</u> that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- …

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- …

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- …

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?

A.4 | Interview analysis

Cluster	Luis Rodrigues	Nico Buchholz	Valter Fernandes	Florentina Buchholz	MD and Partner at a consultancy
Industry's sustainability concerns	• Sustainability was an emerging topic before the pandemic, but currently, the COVID-19 impact is more prevalent	• The aviation industry has certainly seen a growing concern for sustainability related issues in the past	• Concerns for sustainability will definitely change the industry, but big changes cannot be seen at the moment	• Sustainability concerns have been an issue for many years	• Sustainability concerns have not really impacted the industry in the past, but it will in the future
Customers' sustainability concerns	• More people tend to speak up about environmental issues, but people do not question the necessity to fly • Business travels will decrease due to alternatives of meeting online	• Offerings barely noticed by passengers • More of a way to clear one's conscience	• Growing concern can be seen, but nobody wants to pay extra for flying green	• Especially younger people show high concerns for sustainability, but WTP extra to fly green remains low • Corporate clients understood their environmental impact and will fly less	• Concern for sustainability has definitely increased for business travelers as they are already traveling less • Leisure travelers will switch to other modes especially for shorter routes
Past, present and future regulatory requirements	• Obligation to report pollution in all forms (paper, water, fuel, etc.) • CORSIA, imposed by the EU, greatly impacts airlines' path towards	• Local noise regulations as main tool to penalize old and noisy aircraft • More regulatory requirements expected due to	• Most regulations target noise control • High differences between countries • CO_2 taxation will dominate the	• Current requirement of reporting the airline's use of water, plastic, fuel and emissions • Differences in the American and	• CO_2 certificates and carbon taxes are most important regulations of the past and today • EU's "Fit for 55" will entail more

	sustainability today	EU's "Green Deal", with a greater focus on CO_2 taxation	regulatory landscape • Especially the European market will see more bans on domestic flights	European market; Europe introduced CO_2 certificates and carbon taxes, while USA follows an incentivization approach (tax advantages for sustainable airlines)	regulations in the future • Mandates for the use of SAF • End to free carbon allowances • Tariffs to make competition fair
Other sustainable business practices except organizational initiatives, sustainable aviation fuels and technological innovation	• All three categories cover the most important areas through which airlines can become more sustainable	• All three categories cover the most important areas through which airlines can become more sustainable	• All three categories mostly cover the most important areas through which airlines can become more sustainable • Operational enhancements such as optimizing flight plans, climbing speed, routes and weight are done by all airlines	• All three categories mostly cover the most important areas through which airlines can become more sustainable • Great focus on reducing environmental impact by reducing and recycling use of plastic • Transformation of ground fleet to electric vehicles • Boost of inter-modality ("train-to-flight" tickets)	• Operational aspects such as weight reduction, flight plan optimization and noise reduction • Stronger focus on recycling and reducing single waste plastic

				to reduce need for domestic flights	
Impact of organizational initiatives on revenues and cost	• Least costly area	• This is an unknown variable as it can change quite rapidly and is dependent on local governments	• It is something that is offered to passengers, but does not represent a critical revenue stream	• This is something we invest in, as a service to our clients, but there are no immediate revenues connected to it	• Least costly as it can be split between the airline and passengers
Impact of sustainable aviation fuel on revenues and cost	• SAFs as the second highest investment category at the moment as prices are just too high • Will eventually become cheaper and less of an investment	• SAFs will pose the highest operating cost as fuel represents between 30-50% of an airlines operating costs • At the moment, SAFs are too expensive for commercial uses	• SAFs are the highest investment area as the price are 4-5 times higher than for conventional kerosene	• SAFs are the second largest area of investment, however not at the moment as the delivered quantity is insufficient to sustain our operations and prices are too high to be economically reasonable	• Does not entail big CAPEX but will eventually increase operating costs as long as prices do not decrease to a more competitive level
Impact of technological innovation on revenues and costs	• Most costly category as it includes substantial amounts of physical asset	• Poses the highest upfront investment	• Technological innovation is the second largest area	• Largest investment is certainly the fleet renewal	• Poses high CAPEX, but will reduce costs due to fuel efficiency of the aircraft
Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or	• Organizational initiatives is probably easiest to sell to customers	• Organizational initiatives and SAFs only represent expenditures	• SAFs could be highly attractive to passengers as they will know that specifically their	• N.a.	• Technological innovation poses best opportunity to save money at a later stage

more revenue enhancing) for your airline	• Technological innovation is difficult to sell to passengers. Although they enjoy flying on modern aircraft, passengers barely base their decision of which airline to choose on the aircraft type	• Technological innovation in the form of new aircraft will reduce operating costs and thus save cash from the second it is deployed • Technological innovation represents the most measurable economic impact as every Euro saved in fuel costs goes directly into the bottom line of the airline's financial statements	flight was operated using highly environmentally friendly fuels		• Organizational initiatives and SAF are rather a cost
Most relevant sustainable business practice in the future from an airline perspective	• Too early to say which of the three areas will dominate the future • Most likely, it will be a mix of all of them in the long-run	• SAFs will be the future of aviation in the mid-term as no major changes to existing infrastructure will be required • There has been no major technological breakthrough and current alternatives	• SAFs will become the near-term future as soon as prices drop to economically reasonable levels • SAF has the advantage that it can build on existing infrastructure,	• Deployment of SAFs in the mid-term, as soon as economies of scale are achieved • Until then, constant fleet renewal will help airlines to reduce emissions • We still lack a major	• Technological innovation (i.e. more fuel efficient airplanes) will be the short-term solution • SAF is the focus area for the mid-term • Other, more advanced technological

		such as electric or hydrogen propulsion systems are not ready for the mass market yet	which limits the upfront investment	breakthrough when it comes to new propulsion systems, which postpones hydrogen and battery-electric flying to the long-term future	innovations such as hydrogen or electric flying will be the long-term solution
Airbus' initiatives	• Strong commitment to increase aircraft efficiency • Airbus is betting on hydrogen technology, but long lead times and complicated certification processes slow down development and will make this technology ready for the mass market only in the long term	• Airbus is committed to hydrogen, but hydrogen is not as environmentally friendly as it appears • Large hydrogen tanks reduce the space for passengers and payload and thus decrease the economic potential • Hydrogen also requires completely different engines which has a substantial impact on the whole value chain	• Hydrogen will be the future but it is not as well developed as SAFs • Hydrogen will be the long-term solution	• Airbus' planes have risen tremendously in their efficiency over the last years • Plans to introduce hydrogen planes to the mass market will take 2-3 decades, which does not make it a short- to mid-term strategy	• Hydrogen and electric flying is the focus area of Airbus in the future

		• Airbus' initiatives will rather play a role in 30 years			
Boeing's initiatives	• Boeing currently fights its own problems with the 737 MAX crisis and delays in the 777X program • No specific course of action planned but optimistic that Boeing will catch up quickly	• Boeing currently fights its own problems with the 737 MAX crisis and delays in the 777X program • Shows some intentions to invest in SAFs • Greater priority is to make aviation greener now and not in 10 years	• Boeing currently fights its own problems with the 737 MAX crisis and delays in the 777X program • Americans do not feel the same pressure to become sustainable, but Boeing must innovate quickly in order not to lose the battle	• N.a.	• N.a.
Airlines' planned sustainability initiatives	• Reduction of resources is currently the primary concern • Keeping the fleet young and modern is a constant effort we are making • A newly appointed "Sustainability Director" will guide future initiatives	• N.a.	• Saving fuel through flight plan optimization • Keeping the fleet age as low as possible • SAFs as mid-term solution • Director for sustainability affairs at TAP Group will steer activities to become greener	• Operating on multiple tracks • Constant fleet renewal as key activity • Reduction of resources used (e.g. water, paper, plastic, fuel) • SAFs as mid-term solution • Further development of CO_2 calculators	• N.a.

Attitude towards political interference	• Politics should stay out • Airlines know exactly what they are doing and will become sustainable eventually • Political interference through financial support is always connected with certain constraints • Penalization of the industry through taxes will not help the transformation process	• Every airline should make its own decisions • Politics should only guarantee stable long-term conditions that ease predictability in which airlines can operate • Airlines' intrinsic motivation to burn less fuel to save costs will make them sustainable eventually	• It depends on the point of view • Politicians often lack the deep technological insights to make decisions about an industry's future • On the other side, airlines cannot carry the financial burden of the transformation process on their own and will need support	• It depends on the country • Politics should incentivize through tax advantages and funds rather than penalizing through bans and taxes	• Yes, the transformation process should be supported • Aviation is a public good and a critical enabler of the service economy • Governments helped airlines during the pandemic, therefore, they should also help them in this phase
Airline's main drivers to become sustainable	• Doing good for the planet as personal main motivator	• Economic drivers are most relevant • Marketing effectiveness will become a big driver in the future, but does not play a decisive role yet	• Regulations as strongest driver • Economic interests due to highly competitive industry as second most critical motive	• Doing good for the planet and society as main driver • Regulatory and economic drivers second most important motives • Drive to innovate and use latest technologies also highly relevant	• All drivers are relevant • Economic motivators critical due to competitive pressure to save costs • Marketing effectiveness important due to rising concerns of customers

					• Regulatory adherence key for airlines in order not to fall behind
Assessment of relevance of sustainable initiatives to different traveler groups	• Most relevant for business travelers as a way to clear their conscience • Frequent leisure travelers should be more concerned • Less relevant for non-frequent travelers	• Low willingness to voluntarily offset carbon footprint across all traveler groups makes it hard to pinpoint most relevant group	• Business travelers as most important group as they care less about price • Leisure travelers are more price sensitive and will be less interested in/willing to pay for airlines' sustainable initiatives	• Most relevant for business travelers as they travel the most and corporate clients recognized their environmental footprint • Due to higher expected levels of leisure travelers, this group will show an increased interest in sustainable initiatives	• Business travelers are more likely to pay an extra for a sustainable ticket as price is not the main driver behind their purchasing decision
Evaluation of possibility to extend continuum between low-cost carriers and premium by an additional dimension with respect to sustainable	• No, all airlines will eventually become sustainable • Current announcements (e.g. EasyJet) are more of a marketing gag • Industry is still driven by price and destination	• No, we will rather see an upscaling of the current product rather than a standalone sustainable airline	• Yes, there are actually some initiatives to standardize airlines' degree of sustainability through a labelling system	• No, this is not a development that can be seen at the moment • Flag carriers tend to be the first movers when it comes to becoming sustainable • Sustainability could possibly	• Current market leaders have the resources to become green • Market leaders are also pressured to become sustainable by competitors • Given the broad range of demands that passengers

	• Sustainability will become an entry barrier to be a legitimate player			become an entry barrier at some point	have, an airline that is only sustainable is not very likely

Legend	Agreement	Partial agreement	Disagreement

A.5 | Expert interviews

FACTSHEET

Interviewee	Luís Rodrigues
Company	SATA Group
Position	CEO
Other relevant positions	Board member of TAP Air Portugal
Date	1st October 2021
Time	11:00 a.m. WET
Duration	45 minutes
Setting	Microsoft Teams
Permission to record & use real name?	yes/yes

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- I am the CEO of SATA Group where I started in January 2020
- My main tasks during the pandemic where to maintain good customer relationships, while stabilizing the airline financially

Could you please elaborate on other relevant positions you held in the industry?

- I worked as an executive board member at TAP Portugal

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- I would answer differently if we did not have COVID-19
- Sustainability was definitely an emerging topic before the pandemic

- The pandemic turned the industry upside down and brought a lot of movement to the sector
- Currently, aviation is in survival mode, which takes out the focus of what has to be done in the long term
- The industry will definitely regain focus on sustainability after COVID-19
- Now that the pandemic is already fading out, there are first events that are devoted to sustainability in aviation → IATA summit in Boston
- Changing aviation to make it more sustainable is challenging as a large number of stakeholders is involved, but we see a growing number of players publicly committing to the new course of action → Rolls Royce announced to be 100% electric
- But for now: 1st priority is COVID-19 recovery and then focus shifts to sustainability

How strong is the consumer's concern for flight emissions?

- Personally, I do not have that many insights
- From my personal point of view, people do not necessarily question the need to fly because of environmental issues
- However, I observe that more passengers are speaking up
- Especially business travelers learning to operate without traveling by replacing physical meetings with video calls
- Interestingly, we know from multiple studies that passengers are willing to pay more for flying sustainably

Which regulatory requirements with regard to sustainability have affected your airline in the past, present, and future?

- To some extent, we are already obliged to measure pollution in any form (paper, water, fuel etc.)
- CORSIA is another example of restrictive guidelines that have been imposed on the industry
- However, I do not think that the industry requires further regulations. We first need to recover from the severe impact of the pandemic. Then, we will become sustainable on our own
- There is no need to force additional taxes, as the industry is relatively sensitive to such policies
- The industry shows willingness to become sustainable, therefore, there is no need to impose regulations
- Other sectors, such as the automotive are already in the transformation phase to become more sustainable → aviation does not want to be left behind
- Difficult to reach a consensus on EU level, as there are many countries involved in the policy making process
- I do not expect any major regulations coming up in the future

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- No, your list is already exhaustive
- All the measures you listed are not exclusive, airlines can engage in all three of them
- It is in the nature of the industry that firms in aviation should assume a bigger role in terms of societal impact
- Airlines are so influential in terms of the economy and the people they impact that they should be role model and support activities (regardless of the business of flying)

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- We should look at sustainable business practices as an investment
- Initially, it will force us into a higher cost structure
- We do not know precisely about passengers' exact WTP in medium term, but over the long term, it is the right thing to do
- Let me give you an example: Today, all airlines are safe. It does not matter which airline you fly on, all are equally safe. Safety has been a regulatory requirement that was established in the industry. In the future, all airlines will be sustainable. I will be a requirement to play in the industry
- Technological innovation appears to me as the most costly category as it involves too much physical asset
- In terms of upfront investment, sustainable aviation fuels and organizational initiatives are the least costly categories
- At the moment, sustainable aviation fuels are still relatively expensive. It is a question of scale to bring prices down to a more competitive level

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- Organizational initiatives is probably easiest to sell to customers
- Technological innovation is difficult to sell to passengers. Although they enjoy flying on modern aircraft, passengers barely base their decision of which airline to choose on the aircraft type

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- This is too early to say
- It will probably be a mixture of all three of them

What is Airbus doing in this direction?

- Airbus is very committed to develop more modern aircraft
- Airbus bundles its efforts on researching hydrogen as a new propulsion system

- However, lead times will be long due to certification requirements
- Safety regulations always slow down the development
- Developing a new aircraft is not like a vaccine that can be developed in record time since there are no direct human lives at stake

And Boeing?

- Boeing is a little bit behind Airbus in this affair
- They are still dealing with their own problems such as the effects of the Boeing 737 Max crisis and the delays in the Boeing 777X program
- However, I am sure that Boeing will catch up quickly

In which of these areas is <u>your</u> airline currently active or planning to be active?

- At the moment, we are focusing on calling everybody's attention to use less water, paper, etc.
- However, in the past, sustainability did not play a central role
- In fact, tomorrow, a new director for sustainability will be appointed who will be in charge of developing an agenda to bring our firm on a sustainable path
- We actually have one of the most modern fleets in the industry (4-5 years) → this was not on purpose for sustainability reasons, but it is a nice thing to have because it brings economic advantages due to a lower fuel consumption
- In the future, we will certainly focus on accelerating our efforts to become more sustainable

Should politics support the industry in any way through financial support?

- No, politics should stay out → we know exactly know what to do and we do not need another party being involved in this process
- If politics gets involved through funding certain activities, it always comes at the cost of additional regulations and demands
- The industry does not want to be penalized any further → we can take care of our own

What are the <u>main reasons</u> that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- This is hard to answer, you will probably get a different answer from different players
- From my personal perspective, the main driver is doing good for the planet (and it should also be for others…)

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- Frequent leisure travelers should be more concerned
- Non-frequent travelers will probably think about it, but will most likely not be the primary group to pay too much in addition to the basic airfare

- Business travelers certainly have to pay and might actually do that to clear their conscience

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- No, eventually, all airlines will become sustainable
- Looking at EasyJet's announcement to become the first sustainable airline, I believe that at the moment, it is more of a marketing gag
- Currently, the industry is heavily driven by price and destination, not really by how sustainable an airline is

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?

FACTSHEET

Interviewee	Nico Buchholz
Company	Flightlevel500
Position	Founding Partner
Other relevant positions	Airbus, Lufthansa, Bombardier, Delta
Date	11th October 2021
Time	10:00 p.m. WET
Duration	60min
Setting	Microsoft Teams
Permission to record & use real name?	yes/yes

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- Together with the former CEO of Brussels Airlines, I founded FL500, a management consultancy focused on aviation
- Next to that, I am a mentor at the Sustainable Aero Lab in Hamburg

Could you please elaborate on other relevant positions you held in the industry?

- I have an engineering background and studied at TU Berlin, Cranfield University, London Business School and Columbia University
- I started my career at Airbus in the field of sales, before switching to BMW-Rolls Royce
- From 2001 to 2015, I was Executive VP of Lufthansa Group Fleet management where I purchased 600 airplanes worth approximately EUR 100bn
- At the same time, I held a supervisory board membership position at the German aircraft leasing company GOAL
- After my time at Lufthansa, I worked in Bombardier's procurement department for a few years and switched to Delta's fleet management team afterwards

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- There certainly has been a growing concern in aviation for sustainability, however, two main drivers slow down the transformation process
- First, in the aviation sector, long development cycles prevent the quick introduction of brand new, cutting-edge technologies
- Second, especially in Germany, politics does not provide favorable conditions to innovative start-ups that develop great ideas to increase sustainability in aviation → compared to countries such as the UK, high administrative hurdles reduce the entrepreneurial potential that exists

How strong is the consumer's concern for flight emissions?

- People barely respond to programs offered by airlines
- Some airlines offer it to passengers, but only few of them actually make use of it
- Compensation programs are rather a way for passengers to clear their conscience

Which regulatory requirements with regard to sustainability have affected airlines in the past, present, and future?

- In the past, regulatory requirements have varied greatly between different countries
- CO_2 taxation did not affect airlines as much in the past, however, it is becoming increasingly important
- Most regulations were directed towards noise reduction and bans on night flights
- In the future, carbon taxes will dominate the regulatory landscape
- Bans on domestic flights could also become a more popular measure, however, this depends on each country's respective infrastructure → while France has a very well-developed high-speed rail network which poses a viable alternative to domestic flights, the German railway system lacks a high-speed rail network which makes the country more dependent on domestic flights

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- No, all areas cover the most important activities that airlines can pursue to become more sustainable
- Organizational initiatives is a different term for carbon taxation which will inevitably come in the form of regulations
- Sustainable aviation fuels are already available and can already be used with existing infrastructure, but prices are still too high and production is still too low → Lufthansa committed to purchase 25,000l of SAF per year, however, this is not enough to make a real impact (an Airbus A350 has a fuel capacity of approximately 150,000l)

- Technological innovation is a measure to reduce the carbon footprint, but it is not the long-term solution → all technologies that are to be developed will not enter service in the next decade

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- Technological innovation will certainly pose the highest upfront investment, but it will reduce operating costs as soon as it is deployed → a brand new Airbus A350 will burn less fuel from the first second onwards
- Sustainable aviation fuels will pose the highest operating costs → fuel represents approximately 30-55% of an airline's operating costs
- SAFs are too expensive at the moment and do not yield any economic advantages (4x the price of conventional kerosene)
- Organizational initiatives represent an unknown variable as carbon prices/taxes differ by country and can change rapidly

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- Technological innovation (i.e. brand new aircraft) yield the most measurable cost advantages, as the costs of every liter of fuel saved are transferred directly into the bottom line of an airlines' financial statements

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- There has been no major technological breakthrough and current alternatives such as electric or hydrogen propulsion systems are not ready for the mass market yet
- SAFs will be the future of aviation in the mid-term → We should be burning less of the right fuel
- 80% of the global fuel consumption is burned on long-haul flights, which means that if we can replace conventional kerosene by SAFs especially on longer flights, we can make a great impact
- SAFs do not require any major adjustments to existing infrastructure (i.e. airplane engines, airport fueling system, etc.)
- While SAFs are still too expensive, it is a question of time and scalability until prices will come down to a more competitive level

What is Airbus doing in this direction?

- Airbus is committed to hydrogen-based propulsion systems
- Hydrogen is not entirely eco-friendly due to NOx emissions
- Hydrogen is problematic in a sense that it requires substantial storage space → one concept plane is a modified Airbus A321 with a capacity of 230-240 seats, however, the hydrogen tanks reduce the available space to approximately 140-150 seats

- Furthermore, hydrogen powered airplanes require entirely different engines → this has implications on the manufacturers' suppliers e.g. engine manufacturers
- Hydrogen will be the future, but it will still take several decades until this technology achieves market readiness

And Boeing?

- Boeing has some intentions to focus on SAF, but this is not a priority at the moment
- The 737MAX crisis and delays in the 777X program present far greater problems to Boeing
- Boeing's general course of action is to make aviation greener now and not in 10 years, through airplanes that emit substantially less emissions

Is there any airline that is highly active in sustainable aviation or can be even seen as a role model?

- There is no role model in the market, as there are no uniform and coherent standards or criteria to benchmark players in terms of their degree of sustainability
- UNITED has published a few ads/promotional videos to make large investments into new, zero-emission aircrafts (e.g. Boom project)
- Generally, airlines are reluctant to make big announcements or to publicly commit to large scale sustainability projects as these usually cost a lot of money
- Furthermore, the industry dynamics make it fairly difficult to plan ahead in the long term → quickly changing regulations further reduce predictability

Should politics support the industry in any way through financial support?

- Every airline should decide on its own what to do
- Politics should refrain from interfering too much
- The job of politics is to create long-term framing conditions that ease airlines' predictability
- Airlines have an intrinsic motivation to burn less fuel as it simply saves costs

What are the <u>main reasons</u> that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- We see that passengers start to consider the degree of sustainability of an airline, therefore, marketing seems to play a more important role
- However, the main drivers behind a passenger's purchasing decision are still price and schedule
- I agree with the statement that all airlines will have to become sustainable in the future to become a legitimate player in the industry

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- In my opinion the currently low interest in voluntary CO_2 offsetting programs makes it hard to tell for which passenger group sustainable initiatives are most relevant

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- I do not believe that we will see an additional dimension coming up
- What we will rather see is an upscaling of current product → all airlines will invest in new aircraft to reduce fuel burn and all airlines will offset emissions or use SAFs if they have to comply with regulations

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?

FACTSHEET

Interviewee	Valter Fernandes
Company	TAP Portugal Express
Position	CEO
Other relevant positions	TAP Portugal
Date	12th October 2021
Time	10:00 a.m. WET
Duration	33min
Setting	Microsoft Teams
Permission to record & use real name?	yes/yes

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- I am the CEO of Portugália Airlines (TAP Express)
- Additionally, I hold board positions at Groundforce Portugal and the European Regions Airline Association

Could you please elaborate on other relevant positions you held in the industry?

- I have an engineering background and worked as an aircraft maintenance manager at TAP in Portugal and Brazil

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- Concerns for sustainability will change the aviation industry for sure, but not at the moment

- Frankly speaking, the industry has been doing the same thing for the last 20 years by relying on old or updated technology
- There has not been a real major technological breakthrough or game changer
- If there was no pressure, we would even continue like this for the next years

How strong is the consumer's concern for flight emissions?

- The consumers' concerns have definitely increased. Especially in Scandinavia the phenomenon of flight shaming has increased
- However, not flying is not the answer (we don't stop using electricity only because it was generated in coal plants)
- At the moment, the biggest mission is to identify ways to fly with less emissions
- The biggest problem with passengers is that everyone wants to fly green, but no one wants to pay the bill

Which regulatory requirements with regard to sustainability have affected your airline in the past, present, and future?

- The EU's Green Deal that aims to achieve net zero by 2050 and substantial reductions by 2030 is probably the most important regulatory issue
- Currently, airlines are most affected by local noise regulations that heavily penalize airlines with old and noisy aircraft
- Taxing airlines in the future will not be the answer to make aviation greener, as it will make flying only more expensive → it will be more of a cash cow to governments
- Forcing airlines to be climate neutral by 2050 could be a way to set a long-term framework that indirectly pressures airlines to become greener

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- These areas mostly cover what airlines are currently doing
- Operational enhancements, such as optimizing weight, climbing rate, speed, routes, etc. are standard procedures that all airlines follow to reduce costs
- As far as technological innovation is concerned, airlines do not really invest into brand new, cutting edge technology, but rather focus on buying new aircraft that burn less fuel and are thus cheaper (e.g. the A320neo burn up to 20% less than its predecessor A320)
- Other technological innovations such as battery-electric flying will only be relevant for very short domestic flights; hydrogen will not be ready for the mass market within the next 20 years
- Developing airplanes follows extremely long cycles → technologies, such as new engines, that are currently being developed will only enter service by 2030 → we need the right technology right now
- Airlines frame such activities as green but they are just a way of reducing costs

- As for SAFs, we will see which airline is actually committed → SAFs do not reduce an airlines cash outflow, but only its emissions
- While SAFs reduce emissions by up to 80%, they currently cost approximately 4 times the price of conventional kerosene → thus, airlines can do good for the planet, but it will not help them to make their income statement look better

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- SAFs represent the highest investment at the moment, as the price is just too high
- Technological innovation is the second highest category
- Compensation programs exclusive to EU; other states such as Brazil, India or China did no join the program

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- SAFs could be highly attractive to passengers as they will know that specifically their flight was operated using highly environmentally friendly fuels

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- SAFs are the future but we still need economies of scale to lower prices to a more competitive level
- The major advantage is that we can build on existing infrastructure, which lowers the upfront investment

What is Airbus doing in this direction?

- Hydrogen will be the future, but the technology is not as well developed as SAFs
- Hydrogen is more of a long-term solution

And Boeing?

- The Americans never felt the pressure to be as green as the Europeans
- Currently, Boeing has bigger fish to fry (737 MAX and 777X)
- Boeing must take action now, otherwise it will not see the benefits in time

In which of these areas is <u>your</u> airline currently active or planning to be active?

- TAP Express aligns all actions with TAP Group
- The usage of SAFs is certainly going to be our focus area for the future
- We are continuously renewing our fleet to keep it as modern as possible
- A strong focus is also put on saving fuel through optimized flight planning
- In fact, TAP Group has a sustainability officer whose sole task is to steer the firm's sustainability activities

Should politics support the industry in any way through financial support?

- This a very delicate and hot topic
- Politicians often lack the complete understanding of the industry to make accurate judgements about the sector's future → politicians think that, like in the automobile industry, battery-electric propulsion systems are the future, however, that is far from realistic in aviation
- On the other hand, in the whole value chain, airlines make the least money, therefore, they should not carry the whole burden to make heavy investments → airlines need more financial support

What are the main reasons that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- Regulations are the strongest driver that forces airlines to become more sustainable as it defines the rules of the game
- Economic interests are the second most important driver as the industry is incredibly cash strapped → saving money is oftentimes the first priority

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- Leisure travelers are more sensitive to costs which will make them rather unlikely to pay more to compensate their carbon footprint
- Business travelers' purchase decision is less price related and rather focused on schedule convenience, thus, they are more willing to pay an additional fee

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- I fully agree, as there are already plans to standardize airlines' environmental footprint
- For example, there are talks in Europe to introduce labels (A,B,C,D,E,F) that display and airline's eco-friendliness
- Whether a flight receives a good or a bad label depends on whether it is a direct or connecting flight, the aircraft type, the airlines' eco-friendliness as a whole, etc.
- The aviation industry is moving at different speeds in the world. While Europe is relatively advanced, other regions, especially in Asia have less of an emphasis on sustainable flying
- A major concern of this development is that it might distort competition. For example, if European airlines have to follow strict guidelines or have to pay high carbon taxes, while foreign airlines do not have to follow the same regulations, European airlines will be put at a competitive disadvantage

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?

FACTSHEET

Interviewee	Florentina Buchholz
Company	Lufthansa Group
Position	Director Sales Northwest USA
Other relevant positions	Marketing, Ops., Business Dev. LH
Date	15th October 2021
Time	00:00 a.m. WET
Duration	55min
Setting	Microsoft Teams
Permission to record & use real name?	yes/yes

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- I am currently the Director of Sales Northwest USA at Lufthansa Group
- I am responsible for all geographic areas from California to Alaska
- My main tasks include contract management, agency management in the field of B2B
- Brand positioning, especially for corporate clients is one of my main activities
- Recently, I overtook the task to steer sustainability activities in the field of sales

Could you please elaborate on other relevant positions you held in the industry?

- In the past, I was mainly busy with process architecture and sales process design activities at Lufthansa Group

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- Sustainability has been on our radar for quite some time

- For 20 years already, we release an annual sustainability report
- This document includes all activities undertaken that contribute to the reduction of our environmental impact
- Our mantra is "avoid, reduce, compensate"
- Increasing our plane efficiency, reducing CO_2 emissions, reducing plastic waste, using electric vehicles on the ground are some of the main activities we perform to become more sustainable
- But then again, global aviation traffic only accounts for 2-3% of global emissions → this is not much, but has to be reduced anyway

How strong is the consumer's concern for flight emissions?

- It depends as it is more of a question of generation
- We see that especially younger customers display a higher environmental awareness
- This development is probably mainly driven by the "Fridays for Future" movement initiated by Greta Thunberg
- While younger passengers have a higher awareness, only a fraction of them chooses to offset via Lufthansa's booking page
- Corporate clients on the other hand understood that they have the technological means to reduce corporate travelling → however, the pandemic gave them time to think more about their environmental impact and they show a higher willingness to reduce it in the future
- In terms of geography, the European market is the most important one for sustainability
- The USA is split between the densely populated areas at the east and west coast on the one hand and the middle west on the other hand → the highly populated areas show a higher concern for sustainability
- In general, Americans show a greater sense of urgency when climate catastrophes happen in their own "backyard" → feel greater pressure to act upon it

Which regulatory requirements with regard to sustainability have affected your airline in the past, present, and the future?

- CO_2 taxes have already been introduced in the past
- In the USA, there are no specific laws planned to be introduced soon, but this is mainly due to the different approach that the US government follows
- In general, the USA tends to focus less on regulations and bans, but rather on incentives and funds
- A popular approach that has been seen in the industry are tax advantages for sustainable airlines

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- We care a lot about reducing plastic that we use on board → everything is recycled
- On the other hand, Lufthansa places great care on inter-modality → instead of flying from and to smaller airports in Germany, (e.g. Hannover, Nuremberg or Stuttgart), we offer complementary "train-to-flight" tickets to our customers
- Lastly, almost all our ground fleet vehicles, e.g. crew buses, are operated electrically

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- Largest investment is certainly the fleet renewal, which is probably Lufthansa's biggest project at the moment → newer airplanes reduce emissions substantially and also reduce the amount of emissions that we have to compensate
- SAFs are the second largest area of investment, however not at the moment as the delivered quantity is insufficient to sustain our operations
- At the moment, the lack of breakthrough developments leaves us with no other technology than kerosene

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- N.a.

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- I believe that the industry will see the deployment of SAFs in the mid-term, as soon as we achieve economies of scale, so that the prices fall to an economically reasonable level
- Until then, constant fleet renewal will help airlines to reduce emissions
- We still lack a major breakthrough when it comes to new propulsion systems, that is why I see hydrogen and battery-electric flying as something that will be ready in 20 to 30 years

What is Airbus doing in this direction?

- We see that the efficiency of Airbus' planes has risen immensely, that is why we have been purchasing more and more of its most modern aircraft, such as the A350 and A320neo
- With respect to their hydrogen concept planes, market readiness will most likely not be achieved in the next years

And Boeing?

- N.a.

In which of these areas is <u>your</u> airline currently active or planning to be active?

- Regardless of the area, we will always follow our guideline to "avoid, reduce and compensate"
- SAFs will be the mid-term future, as soon as we achieve economies of scale
- Fleet renewal is a constant process that we are committed to already today
- We are highly engaged in the development of CO_2 calculators together with our partners to offer our clients better ways to compensate their environmental footprint
- We at Lufthansa operate on multiple tracks as far as sustainable business practices are concerned → we do not bet on a single area but try to improve wherever we can

Should politics support the industry in any way through financial support?

- It depends on the country where you are in
- In the USA, Tesla has been greatly supported by the US government. With Tesla's market entry in Germany, German car makers were forced to innovate as well which led to a domino effect → now, everyone is building electric cars
- On the other hand, in Europe, governments tend to prefer restrictions and punishments → to me, this does not really seem like an efficient approach

What are the <u>main reasons</u> that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- From Lufthansa's point of view, since we have been concerned about this topic for over 20 years, we believe that doing good for the planet and society is the main driver
- Still, regulatory requirements and the market sentiment pose further external pressure to become more sustainable
- Moreover, since we operate in a business that is strongly influenced by technology, our love for technology is another major intrinsic motivator → we have a high interest in the latest technologies and our urge to always deploy the most modern aircraft further drive our ambitions

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- Corporate clients represent a large lever with which air travel can be made more sustainable → if business travelers start to care more about sustainability, a great impact can be made
- In the future, airlines expect to focus more on leisure travelers → since we see especially younger people being highly concerned about sustainability, we can expect that this traveler group will also be interested in more sustainable initiatives from our side

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- I do not see this development taking place in the near future
- In my opinion, the traditional flag carriers are more in the role of becoming sustainable → in the USA, Delta, American and UNITED already show some engagement in sustainable business practices
- With regards to EasyJet purchasing CO_2 certificates, I am not really convinced that this is the way to become the first climate neutral airline as it is just a way of being green on paper
- Being sustainable as an entry barrier could become reality if it is economically viable → I am confident that the political pressure and the inner pursuit to achieve sustainability will eventually lead us there

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?

FACTSHEET

Interviewee	MD and Partner of a large consultancy
Date	26th October 2021
Time	09:30 a.m. WET
Duration	35min
Setting	Microsoft Teams
Permission to record & use real name?	yes/no (anonymize)

INTRODUCTION

Thank you for participating in this interview. Your insights will be highly valuable to my research. My name is Alexander Gerich and I am a Masters student in International Management at Nova School of Business and Economics in Lisbon. I am currently writing my thesis about sustainable aviation trends by investigating passenger perspectives on airlines' sustainable business practices and comparing them to airlines' current initiatives. This interview will last approximately 45min. We will start with a brief introduction to your background before we move to the discussion of the topic of sustainability in aviation. In case of any questions, do not hesitate to raise them throughout the session. Would you mind if I record this interview and if I use your real name in my thesis?

BACKGROUND

Could you please introduce yourself by describing your current position and responsibilities?

- I am the Managing Director and Partner at a large consultancy in the Lisbon office
- My focus, especially in recent years, has been on the aviation industry
- In the past, I mostly conducted efficiency and transformation projects, with further experience in commercials (i.e. revenue distribution management) and MRO (maintenance, repair and overhaul)
- The main focus of my past projects was on European full-service carriers
- Furthermore, I am working with the leading industrial companies in Portugal to push the topic of sustainability

Could you please elaborate on other relevant positions you held in the industry?

- N.a.

SUSTAINABILITY

To what extent do you believe that the concern for sustainability has changed civil aviation in recent years?

- I would be cautious to talk about "change" with respect to sustainability in the aviation industry, as the industry is still at the beginning of a transformation phase
- Some markets are in fact a little bit more advanced (e.g. Scandinavia)
- Countries with a well-developed alternative transport infrastructure (i.e. trains) to short-haul commercial flying are also more advanced
- We also see more partnerships evolving between airlines and producers/suppliers of SAF
- Still, aviation only makes up for 3% of global carbon emissions
- This topic will become more important eventually, as the industry and regulators have set ambitious targets to become net zero by 2040/2050
- Especially at my consultancy, we will be pushing this topic together with our clients in the next years

How strong is the consumer's concern for flight emissions?

- We can already see that corporate travel has decreased significantly due to the pandemic
- Companies are aiming to reduce costs as well as their carbon footprint, therefore, we will see a lower level of business travel in the next years
- Leisure travelers are also somewhat concerned about flight emissions and we will see a change in the behavior on short- to medium-haul routes if there are equally convenient alternatives, however, we are still far away from completely replacing commercial air traffic

Which regulatory requirements with regard to sustainability have affected your airline in the past, present, and the future?

- There are two main regulatory initiatives that affected and will affect airlines
- In the past, CO_2 certificates have increased airlines' costs
- For example, in 2021, Portugal introduced a carbon tax on airlines
- The second major wave of regulations affecting airlines in the future is the "Fit for 55" initiative, which was announced by the EU in July and aims to reduce carbon emissions to net zero by 2050 with a 55% reduction in emissions by 2030 → this initiative is connected to several smaller regulations that are more targeted to specific sectors (i.e. the aviation industry)
- Further regulation include a mandate for SAFs that dictate the percentage of SAF an airplane must use for a flight
- Ending free carbon allowances will also increase airlines' cost structure in the future
- Lastly, border tariffs to make competition more fair could also affect the industry

I am concentrating on three main areas in which airlines can achieve more sustainable operations: (i) organizational initiatives, (ii) sustainable aviation fuels, and (iii) technological innovation. Do you see any other major area beside these three which airlines might be active in to increase sustainability?

- The measures mentioned above are fairly reasonable
- Other measure include operational aspects such as weight reduction, flight plan optimization and noise reduction
- Furthermore, airlines have shown an increased awareness for recycling and reducing single waste plastic

What is the impact on revenues and costs of these three categories? (If you don't have exact figures, please give your answer in approximate terms).

- The most common form of increasing an airline's sustainability is certainly technological innovation through fleet modernization → it also represents the largest CAPEX but yields significant fuel savings
- SAF is still in its pilot phase and costs are still carried by the suppliers and less by the airlines → for airlines, SAF does not have any CAPEX, but higher prices will lead to higher operating costs
- Organizational initiatives can be done incrementally → costs scan be split between airline and passengers, thus representing the lowest expenditure

Of the three (or more) areas, which yields the highest economic advantage (i.e. is least costly, or more revenue enhancing) for your airline?

- Technological innovation yields the highest economic advantage as more modern airplanes save substantial amounts of fuel

Which of these areas do you believe will be the most relevant in the future from an airline perspective?

- At the moment, the only option that airlines have is deploying more efficient airplanes and reducing fuel consumption through more efficient operations
- One large European airline conglomerate of flag ship carriers announced that the modernization of its fleet will the most important project for the upcoming years
- Another airline group is planning on investing EUR 400bn in the next 20 years in more efficient airplanes
- In the next phase, SAF will be the main focus
- At last, as soon as the technology matures, hydrogen and electric propulsion systems will be at the center of attention

What is Airbus doing in this direction?

- The manufactures are in fact a critical enabler of sustainability in aviation
- Airbus bets on electric and hydrogen airplanes
- However, we are dealing with a complex web of many stakeholders → engine producers (e.g. P&W and Rolls Royce) are also involved

And Boeing?

- N.a.

In which of these areas is <u>your</u> airline currently active or planning to be active?

- N.a.

Should politics support the industry in any way through financial support?

- Yes, politics should support the industry in its transformation process
- Aviation must be seen as a public good → it is an enabler of the service economy by providing mobility to the people and a dysfunction of the industry has several socio-cultural and economic implications
- Governments around the world supported airlines during the pandemic, therefore, they should also help them in this process

What are the <u>main reasons</u> that lead your airline to be active in any of these areas (if any). For example, economic drivers, doing good for the planet, marketing effectiveness, adherence to regulatory requirements, others reasons (please describe)?

- All of the above mentioned drivers are relevant
- From an economic perspective, fuel efficiency is indispensable, otherwise, expensive CAPEX could not be justified
- Passengers are also becoming more aware of environmental issues, therefore, marketing effectiveness will play a more important role in the future
- As mentioned earlier, there are several regulations coming up in the next years that airlines need to be prepared for

In your opinion, for which traveler group (business vs. leisure and frequent vs. non-frequent travelers) are these sustainable initiatives most relevant?

- As price is not the major driver behind the purchasing decision, business travelers are most likely to pay more for a sustainable ticket

Do you believe that the continuum between low-cost carriers and premium carriers can be extended by an additional dimension with respect to sustainable airlines? If yes, when do you believe will we see the first major sustainable airline arise?

- Current market leaders will adopt the position of sustainable airlines first, in order not to be caught off guard by competitors → as they are the biggest players, they have the resources to make big investments
- On short-haul routes, we will maybe see sustainable providers
- However, an airline that only focuses on being green will not work as today's customers demand several aspects from an airline e.g. punctuality, best digital experience, most routes, lowest prices → it is difficult for a new player to just focus on one area
- Sustainability will become a market barrier at some point as soon as the technologies are available and the competitive pressure to become sustainable increases

WRAP-UP

We have now reached the end of the interview. I would like to thank you again for your participation. Do you have any other questions or comments that you would like to share?