# Exploring the Determinants of Air Travelers' Willingness to Pay for Sustainable Aviation Fuel

*THE GREENEST AIRLINE*. (n.d.)

# Exploring the Determinants of Air Travelers' Willingness to Pay for Sustainable Aviation Fuel A Stated Choice Experiment


By

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# Preface

Embarking on my master's thesis journey, my initial certainty centered around a commitment to exploring the realm of sustainability. The recent months have been an enjoyable expedition of delving into this subject, punctuated by exhaustive hours and unwavering dedication to my final thesis report for the master's program in Complex Systems Engineering and Management.

Throughout this undertaking, I have been immensely fortunate to have garnered substantial support, and my gratitude overflows for the remarkable and inspiring individuals who have accompanied me on this journey. I wish to seize this moment to extend my heartfelt appreciation to a select few.

Foremost, I am indebted to my committee, as their collective contributions have rendered this thesis a reality. I sincerely thank the committee chair, Eric Molin, whose unwavering support and accessibility have guided me through my project. His profound insights and mastery of choice modeling have been my guiding light. To Gerdien de Vries, I am immensely grateful for the meticulous review of my report and the consistently constructive feedback provided. Her eye for detail and incisive comments have improved my work's quality. Furthermore, I extend my gratitude to Louis Lammertyn for affording me this opportunity, his encouragement to produce an exemplary report, and his invaluable feedback.

Additionally, my appreciation extends to the individuals who participated in and shared my survey; their engagement was pivotal to the success of this research endeavor. Moreover, I am deeply thankful for the unwavering support and invaluable guidance my family and friends offer throughout the research process.

The journey toward graduation has been a transformative experience, and retrospection yields a sense of contentment regarding its progression. With my time at TU Delft drawing to a close, I deeply appreciate the knowledge I have gained and the enriching experiences I have encountered here.

*Y. Ouaj*
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# Contents

# Abstract

The invention of aircraft has revolutionized global connectivity, trade, and exploration, allowing people to travel long distances quickly and efficiently. However, the aviation industry's environmental impact, particularly concerning CO2 emissions, is a cause for concern. Before the COVID-19 pandemic, commercial aviation accounted for 2-3% of anthropogenic CO2 emissions worldwide. In Europe alone, departing flights in 2016 contributed to roughly one-fifth of global aviation emissions. Aviation emissions, including CO2 and other greenhouse gases, contribute to rising temperatures, leading to environmental consequences such as rising sea levels, more frequent and intense natural disasters, and biodiversity loss.

Using sustainable aviation fuel (SAF) is a critical solution for reducing emissions in the aviation industry. SAF, produced from sustainable sources such as e-fuels and biofuels, can achieve significant greenhouse gas emission reductions compared to conventional jet fuel. The Greenest Airline is an  committed to making air travel more sustainable through the use of SAF. Despite higher costs, they prioritize fuel efficiency and environmentally sustainable operations. The main question for this thesis is defined as What are the underlying factors that influence the willingness of air travelers to pay for sustainable aviation fuel?"

Chapter 2 first explains what SAF is. From this chapter, it becomes clear that there are four different conversion processes to obtain SAF: Fisher Tropsch (FT), Hydro-Processed Esters and Fatty Acids (HEFA) Synthesized IsoParaffins (SIP), and Alcohol-to-Jet (ATJ). The different conversion methods also impact the amount of CO2 that can be saved. FT can save up to 94%, while HEFA, currently the most accessible conversion method, can save an average of 80%. The prices also vary, where HEFA is twice as expensive as current kerosene, while FT, for example, is six times as expensive. This chapter also analyzed factors that can influence the usefulness of choosing flights. These factors include various attributes such as price, time, carrier type, and CO2 reduction, as well as different attitudes such as Flight Shame, carrier type, environmental concern, and perception of SAF. Finally, some personal characteristics, such as sociographic features and fly experience, can also influence the usefulness.

Chapter 3 explains the method used to answer the research questions. The multinomial logit model is employed, a discrete choice model used to analyze individuals' choices when presented with multiple alternatives. In addition to the multinomial logit model, the chapter introduces the latent class choice model (LCCM). The study addresses inherent limitations in the multinomial logit (MNL) model by employing the LCCM. The LCCM allows for a more nuanced analysis by capturing heterogeneity in individuals' preferences and accounting for distinct latent classes within the population.

Chapter 4 explains the survey design used in the study. The survey consists of various components, including 16 choice sets, questions about different attitudes measured using 5-Point Likert scales, personal characteristics, and two control questions to assess the consistency between participants' willingness to pay (WTP) obtained from the experiment and their stated WTP.

In Chapter 5, it is described that a total of 276 respondents completed the survey. The data analysis revealed the presence of seven distinct factors, as determined through factor analysis. These factors are as follows: Flight Shame, the efficacy of SAF, Greenest Airline Neophobia, the importance of SAF, the image of the Brand, Sustainability pressure, and Flight Shame alleviation through SAF.

It is possible to conclude that consumer heterogeneity does exist in flight alternative preferences by contrasting the LCCM estimation with a multinomial logit model that disregards consumer heterogeneity, as demonstrated in Section 6. The best way to account for heterogeneity was to estimate a three-class LCCM. The resulting classes are Price-Sensitive, efficient, and Economic-environmental sensitive travelers, as shown in Section 7.

Within the ambit of these segments, the Economic-Environmental Sensitive Travelers stand out as a group particularly pertinent to adopting Sustainable Aviation Fuel (SAF). This cohort of travelers exhibits a heightened sense

of utility as the magnitude of $CO_2$ reduction surpasses the 50% threshold. The composite portrait of the Economic-Environmental Sensitive Travelers emerges as follows: typically male, possessing a Master's Degree in education, currently employed, residing in Belgium, aged between 25 and 45 years, enjoying a middle-income bracket, primarily traveling for leisure purposes, and undertaking a moderate annual frequency of air travel, ranging between 3 to 5 flights. Based on these findings, the determination of willingness to pay (WTP) per segment was also achievable. For the Economic-Environmental Sensitive Travelers segment, as the $CO_2$ reduction escalates from 0% to 80%, the WTP equates to 38.50 euros. As the $CO_2$ reduction is further elevated from 0% to 100%, the respective WTP values become 58.5 euros.

In Chapter 8, various strategies have been outlined based on the attributes of the different factors. Additionally, these same strategies have been reevaluated using a more representative distribution of classes, as the sample did not adequately mirror the population. Finally, an assessment was conducted to examine the impact on market share and revenue when the same flights are operated by different carriers.

Finally, four recommendations were made to stimulate the use of SAF The first recommendation emphasizes the need for an in-depth investigation into the motivations driving the Economic-Environmental Sensitivity segment. The second recommendation delves into the realm of research methodology, suggesting an exploration utilizing revealed preference data. The third recommendation underscores the aviation industry's responsibility in cultivating awareness about SAF. Lastly, the fourth recommendation delves into the intricate financial dynamics tied to reducing SAF pricing.

# 1 Introduction

The presence of aircraft has become integral to global connectivity, providing a platform for people to collaborate, explore different cultures, and exchange ideas. The invention of the airplane signaled a significant turning point in human civilization. With the creation of aircraft, people could traverse vast distances more quickly than ever before, discover new areas, and connect distant locations. Technology also transformed trade by enabling companies to send goods rapidly and effectively to far-off markets. Despite the numerous benefits of aviation, it is also associated with various adverse outcomes.

The environmental impact of commercial aviation, specifically in terms of CO2 emissions, must be considered despite its benefits. According to multiple studies, worldwide commercial aviation accounted for 2-3% of anthropogenic CO2 emissions before the COVID-19 pandemic (ATAG, 2018; EEA, EASA & EUROCONTROL, 2019; Erbach, 2018; Graver et al., 2019). In Europe, departing flights in 2016 were responsible for 171 million tonnes of CO2, which accounts for roughly one-fifth of global aviation emissions. The emissions from European commercial aviation have nearly doubled between 1990 and 2016 and made up 4.3 to 5.6% of total EU CO2 emissions and 3.6 to 3.9% of total EU greenhouse gas emissions in 2016 (EEA, EASA & EUROCONTROL, 2019; UNFCCC, n.d.; EEA, 2019). In 2019, the most comprehensive computation estimated that commercial aviation worldwide contributed 918 million tonnes of CO2 emissions, with 85% caused by passenger travel and the remaining 15% by freight carriage (Graver et al., 2020). When considering other greenhouse gases and their effects on global warming, the contribution of international aviation is estimated to be two to three times larger than that of CO2 alone (Grewe et al., 2017; Grewe, 2019; Lee, 2018; Lee D. et al., 2020; Lee D. et al., 2009; EASA, 2020).

According to Sher et al. (2021), the effects of emissions and byproducts released into the environment include risks to human health, poor air quality, and global warming. CO2 emissions from aviation contribute to rising temperatures, leading to various environmental consequences such as rising sea levels, more frequent and intense natural disasters, and biodiversity loss. These consequences have severe implications for both human populations and ecosystems, threatening the very foundations of our planet. Rising sea levels pose a significant threat to coastal communities and infrastructure. Glaciers and ice sheets melt as temperatures rise, leading to higher sea levels. The resulting coastal flooding, erosion, and saltwater intrusion into freshwater supplies can significantly impact human populations, ecosystems, and economies.

Rising atmospheric CO2 concentrations trap more heat, raising the earth's temperature and influencing extreme weather. Heat-related diseases and fatalities increase as heatwaves grow more common and severe. As droughts worsen, agriculture, water resources, and ecosystems are all affected. Warmer air can hold more water, increasing the likelihood of flooding and heavier rainstorms. Because of the considerable implications these extreme weather events have on communities and the ecosystem, it is crucial to reduce CO2 emissions to lessen those effects (Khandekar,2013).

Longer forward, if primary emission reduction measures are not implemented for the aviation industry, the warming might continue to rise. According to estimates, CO2 accounts for 36%–51% of all aviation-related climate radiative forcing, including short-term climate forcers. However, aircraft CO2 will significantly contribute to decadal time scales because of its prolonged duration of atmospheric residence (Lee et al.,2009).

In addition to climate change, aviation emissions also contribute to air pollution, negatively affecting human health. Air pollution can lead to respiratory and cardiovascular diseases, including asthma, lung cancer, and heart disease. The World Health Organization (World Health Organization: WHO, 2022) estimates that air pollution is responsible for seven million premature deaths worldwide each year. The aviation industry also plays a significant role in this. Due to its significant contribution to air pollution, aviation also substantially impacts this regard.

## 1.1 Research objective

In light of these consequences, it is essential to explore sustainable methods for the aviation industry and reduce its environmental impact. By addressing the environmental impact of aviation, we can continue to enjoy the benefits of global connectivity and exploration while protecting our planet for future generations. However, avoiding air travel would be the best solution, as it prevents environmental harm. Recently, there has been a notable surge in the " flight shame phenomenon." This concept entails an individual's inner disquiet or unease regarding engagement in energy-intensive and ecologically contentious endeavors, notably air travel, showcasing heightened acknowledgment of aviation's notable role in exacerbating climate change. The phrase "flight shame" swiftly garnered widespread attention, underscoring an escalating consciousness of aviation's environmental implications (Gössling et al., 2020). The emergent trend of flight shaming, characterized by the societal disapproval of air travel due to its adverse carbon emissions impact, could moderate prospective growth within the aviation sector (Topham, 2022).

Nonetheless, abstaining from flying is not deemed feasible. As explained, the aviation industry has contributed significantly to economic growth, international trade, and cultural exchange. It has also enabled faster and more efficient transportation of people and goods over long distances. Moreover, many people rely on air travel for personal and professional reasons, such as visiting family or attending business meetings, conferences, or educational programs. For people who live in remote areas, air travel is often the only means of transportation to access essential services and resources. Furthermore, aviation plays a vital role in emergency response and disaster relief efforts, where time is of the essence. It enables rapid deployment of resources, supplies, and personnel to affected areas, saving countless lives and minimizing the impact of disasters.

Given these significant benefits and reliance on air travel, completely refraining from aviation is not feasible. However, it is essential to reduce the number of flights. This could be done by finding destinations closer to home. This would allow for other modes of transportation, such as the train, to be used. In addition, going on vacation less often can also reduce the number of flights. As it is not entirely avoidable to not fly, not only should avoiding flying be encouraged, but sustainable solutions should be promoted to reduce the environmental impact (Baumeister,2019).

The International Civil Aviation Organization (ICAO) estimates that 4.543 billion people will be transported in commercial aviation worldwide in 2023, up from 1.467 billion in 2000. During the same period, the number of revenue passenger kilometers (RPKs) flown climbed from 3.585 trillion to 8.733 trillion (ICAO, 2021). As completely refraining from aviation is currently not considered a feasible solution, it is essential to explore alternatives that address the associated secondary effects of aviation.

The aviation industry has recognized the need to transition towards more sustainable practices, and one of the critical solutions is the use of sustainable aviation fuel (SAF). SAF does not require modifications to current aircraft and is chemically identical to fossil fuel. It is produced from sustainable sources such as e-fuels from solar/wind, hydrogen, and recycled CO2 and biofuels from agricultural or municipal waste products (Barke et al., 2022).

Several scientific studies have attempted to estimate the potential reduction in CO2 emissions from using Sustainable Aviation Fuel (SAF) compared to conventional fossil fuels in aviation. Various factors can influence the environmental performance of fuels throughout their lifecycle. The type of Sustainable Aviation Fuel (SAF) and production process can result in different environmental impacts. Taking a comprehensive approach that accounts for all emissions throughout the fuel's lifetime, the reduction in greenhouse gas emissions achieved through SAF can range from 70% to over 95% compared to fossil jet fuel (*Sustainable Aviation Fuel | EASA*, n.d.). The International Civil Aviation Organization (ICAO) has stated that meeting 100% of aviation fuel demand with Sustainable Aviation Fuel (SAF) by 2050 is physically feasible and could reduce emissions by 63%.

However, achieving this level of fuel production would require significant capital investment in SAF production infrastructure and substantial policy support (ICAO,2019). According to Ng, Farooq, and Yang (2021), it is imperative to expedite the development of Sustainable Aviation Fuel (SAF) to achieve the net zero emission target in the aviation sector. Bioresource-derived aviation fuel has the potential to replace conventional fossil-based aviation fuel, effectively managing the rapid expansion of the aviation market while simultaneously reducing greenhouse gas (GHG) emissions. However, the primary obstacles to the widespread implementation of Sustainable Aviation Fuel (SAF) are the issues of affordability and competitiveness compared to conventional aviation fuel. SAF, for instance, may be up to 2-8 times more expensive than traditional kerosene-based jet fuel. Sustainable Aviation Fuel (SAF) comes at a higher cost than traditional kerosene. This cost differential is expected to be reflected in ticket prices, consequently increasing airfares. This raises the question of whether individuals are willing to bear this additional expense.

The Greenest Airline is an emerging aviation company committed to enhancing the sustainability of air travel by employing Sustainable Aviation Fuel (SAF). The Greenest Airline is a nascent airline operator currently in its preliminary stages of development, with a fleet of four leased aircraft that prioritize fuel efficiency and environmentally sustainable operations. The unwavering commitment to sustainability is evidenced by the utilization of Sustainable Aviation Fuel (SAF), despite the additional costs that may be incurred. Furthermore, aspire to foster a community of environmentally conscious individuals dedicated to promoting positive environmental practices and challenging the aviation industry to reduce its carbon footprint.

The use of Sustainable Aviation Fuel (SAF) incurs higher costs than conventional fossil fuels, raising questions about the willingness of passengers to pay more for tickets powered by Sustainable aviation fuel. Furthermore, whether passengers are inclined to travel with a more expensive yet sustainable airline is still being determined.

The societal objective of this research for the Greenest Airline is to understand how the cost of SAF and commitment to sustainability influence the attitudes and behaviors of potential passengers. The goal is to provide recommendations on how the airliners can address these issues to attract more passengers while maintaining their commitment to sustainability. The research may, for instance, focus on determining the price points at which potential passengers are willing to pay extra for SAF or identifying the factors that influence passengers' decisions to fly with an airline committed to sustainability. The recommendations may relate to finding ways to reduce the costs of SAF or improving communication with passengers about the importance of sustainability and the use of SAF in aviation.

The objective of the Greenest Airline aligns seamlessly with Sustainable Development Goal 13. SDG 13, "Goal for Sustainable Development 13" by the United Nations, is titled "Climate Action." This goal is dedicated to addressing climate change and undertaking measures to mitigate its impact. It encompasses promoting awareness, adapting to climate change's effects, and enhancing community resilience against climate-related disasters. Within the framework of SDG 13, nations strive to curtail greenhouse gas emissions and adapt to the inevitable consequences of climate change. This goal is closely intertwined with the global Paris Agreement, wherein countries have committed to limiting global warming to below 2 degrees Celsius above pre-industrial levels (Goal 13 | Department of Economic and Social Affairs, n.d.).

In conclusion, scant scientific literature exists about the willingness to pay and the extent of demand for flying with Sustainable Aviation Fuel (SAF). From a scientific perspective, this study would significantly contribute by delving into individuals' willingness to use SAF for air travel. Furthermore, an examination is undertaken regarding the willingness to pay (WTP) for flying with Sustainable Aviation Fuel (SAF). A study conducted by McKinsey & Company has shed light on the attitudes and behaviors of travelers toward climate change and carbon emissions concerning air travel. However, this study has not clearly understood the specific monetary extent individuals are willing to pay. Additionally, there has been less emphasis on investigating factors contributing to people's inclination toward using SAF. The research can provide valuable insights and expand the existing knowledge base in the field by investigating the underlying factors that influence travelers' choices, such as product-related and person-related characteristics. This new understanding can help shape future research directions and inform policy decisions regarding sustainable aviation practices and also includes determining the willingness to pay (WTP) and the number of people willing to pay.

## 1.2 Research questions

As mentioned, using Sustainable Aviation Fuel (SAF) entails higher costs than conventional fossil fuels, raising inquiries concerning the passengers' willingness to pay a premium for airline tickets that prioritize sustainability. This necessitates investigating the factors influencing air travelers' decision-making when booking tickets. By conducting such research, valuable insights can be gained to inform airlines, policymakers, and industry stakeholders about the determinants that impact passengers' preferences and motivations, aiding in developing effective strategies and policies to promote sustainable aviation practices and mitigate the environmental impact of air travel.

Undoubtedly, the determinants of air travelers' willingness to pay for sustainable aviation fuel (SAF) encompass various factors, among which product-related characteristics assume a substantial role in shaping consumer behavior. Notably, the price, time, and performance attributes associated with SAF vis-à-vis conventional jet fuel emerge as influential considerations in consumer decision-making processes within this domain. Specifically, the relative pricing of SAF compared to traditional alternatives is recognized as a pivotal factor that can significantly sway consumer choices. When SAF commands a considerably higher price, price-sensitive travelers may exhibit a reduced inclination toward embracing sustainable options. Therefore, a thorough examination of these attributes is crucial. They are significant in comprehending and delineating the determinants underpinning consumers' willingness to pay for sustainable aviation fuel (Xu et al., 2022).

Furthermore, person-related characteristics significantly influence consumers' willingness to pay for sustainable aviation fuel. Demographics, environmental attitudes, awareness of climate change, and personal values play a significant role in shaping consumer preferences (Li & Kallas, 2021). The study has found that individuals with a strong ecological consciousness and genuine concern for climate change are more inclined to pay a premium for sustainable products or services. Younger generations who prioritize sustainability and environmental issues are also more likely to be more willing to pay for SAF. Understanding these person-related characteristics can help airlines and policymakers tailor their marketing campaigns and communication strategies to effectively target and engage specific consumer segments (Li & Kallas, 2021).

In addition to investigating the factors that influence air travelers' willingness to pay for flights operated with sustainable aviation fuel (SAF), it is crucial to quantify the monetary value individuals assign to this alternative. Quantifying the willingness to pay for sustainable aviation fuel holds significant importance in assessing market demand and evaluating the economic viability of SAF. By obtaining precise measurements of the price premium passengers are willing to pay for flights using SAF, policymakers, industry stakeholders, and researchers can gain insights into the market dynamics, potential profitability, and feasibility of transitioning to sustainable aviation practices. This quantitative assessment aids in formulating informed decisions regarding pricing structures, investment strategies, and market positioning to effectively promote and meet the growing demand for sustainable aviation fuel (Xu et al., 2022).

When researching consumers' willingness to pay for sustainable products or services, it is imperative to address potential data collection biases to ensure the findings' accuracy and representativeness. Biases can arise from various sources, including self-reporting bias, social desirability bias, or sampling bias. This overestimation was also evident in the study conducted by Molin & Kroesen (in press). The findings indicated that these results suggest that air passengers are considerably more willing to pay for the compensation of airplane greenhouse gas emissions than the actual costs. Respondents exhibited a willingness equivalent to a cost reduction of 241 euros. In contrast, even if nitrogen and methane exhaust from the flight were additionally offset, the expense would only amount to 6 euros. This suggests that respondents' actual behavior may differ from their actions in a hypothetical scenario, highlighting the importance of investigating the underlying reasons for this disparity.

In the context of sustainable aviation fuel, understanding the concept of warm glow is crucial for comprehending individuals' motivations behind choosing sustainable options. Rooted in behavioral economics and psychology, warm glow refers to the intrinsic satisfaction or sense of fulfillment individuals experience when engaging in actions that align with their values or benefit others. Research has indicated that intrinsic rewards, such as a warm glow, can be powerful motivators for sustainable behavior (Hartmann et al., 2017).

Within sustainable aviation fuel, individuals who possess a strong sense of environmental responsibility and value sustainable practices may experience a warm glow when choosing to pay for SAF. By supporting a greener alternative and actively contributing to reducing carbon emissions, these individuals derive a positive emotional response and a sense of personal fulfillment. This moving reward mechanism reinforces their commitment to sustainable actions and fosters a continued preference for sustainable aviation fuel.

The presence of a warm glow may lead individuals to overestimate their willingness to pay (WTP) for sustainable products or services. In a survey setting, this can occur when respondents state their desire to pay more than they would be willing to pay. The overestimation of WTP can be attributed to the passion for self-enhancement and the psychological satisfaction derived from aligning one's values with sustainable choices. (Iweala et al., 2022).

Finally, individuals will likely be willing to pay more for flights using SAF. However, how many people fall into this category remains unclear, mainly who they are. Hence, it is crucial to investigate the segmentation of this group. Finding segments is helpful because it helps understand the market's diversity better and develop targeted strategies. Companies can optimize their marketing efforts by dividing the market into segments based on common characteristics, needs, and behaviors. Segmentation allows businesses to identify target audiences likely interested in their products or services and provide them with tailored marketing messages. This increases the chances of successful marketing campaigns and better customer engagement. Additionally, segmentation enables companies to allocate resources more efficiently by focusing on the most profitable customer segments. Understanding the varying needs and preferences of customers within each segment allows businesses to align their products, pricing, and promotions more effectively with the specific requirements of each target group.

This research will answer the following main and sub-questions:

*"What are the underlying factors that influence the willingness of air travelers to pay for sustainable aviation fuel?"*

- To what extent do product-related characteristics influence the willingness to pay air travelers?
- What person-related characteristics affect air travelers' willingness to pay for sustainable aviation fuel?
- What is the willingness to pay for Sustainable Aviation Fuel, and how many individuals are willing to pay extra for it?
- How can biases in data collection be minimized to ensure the accuracy and representativeness of research findings on consumers' willingness to pay for sustainable products or services?
- What traveler sub-segments may be recognized within the possible SAF alternative adopter segment based on attribute preferences, and what do those segments' profiles look like?

## 1.3 Method

This study will utilize quantitative research methods to investigate the research question. A survey will be made to answer this central question, as it gives an idea of developing a complex problem. The survey will partially answer all sub-questions. Cresswell and Zhang (2009) state that quantitative research is a systematic and empirical approach that tests objective theories by analyzing the relationship between variables using numerical data. Data collection for this type of research is typically achieved through various measurement instruments.

Rose (2009) states that in transportation studies, stated choice (SC) experiments are frequently used to estimate and forecast traveler, road authority, and other behavior. Stated choice experiments (SCEs) are a survey-based research method that aims to understand how individuals make choices when presented with hypothetical scenarios. In a stated choice experiment, respondents are presented with a series of hypothetical scenarios where they are asked to choose among alternatives, each characterized by specific attributes. Researchers can discern the relative importance of various attributes in influencing decision-making by analyzing respondents' choices across different scenarios.

To answer subquestions 1, 3, and 5, the results of the stated choice experiment are crucial. By analyzing the data from the stated choice experiment, researchers can determine the extent to which product-related characteristics influence air travelers' willingness to pay for sustainable aviation fuel. The outcomes of such experiments can be employed in discrete choice models, serving as a basis for quantifying the utility individuals derive from specific attributes. These models determine how much value respondents place on each attribute. Furthermore, utilizing the findings derived from discrete choice models, the Willingness to Pay (WTP) calculation and finding segments becomes feasible.

For subquestion 2, a survey will be conducted to gather data on various aspects such as demographics, environmental attitudes, climate change awareness, and the respondents' values. This comprehensive approach ensures a thorough understanding of factors influencing willingness to pay for Sustainable Aviation Fuel (SAF). These survey questions will provide insights into the person-related characteristics influencing air travelers' willingness to pay for sustainable aviation fuel. Additionally, the survey will include questions to assess the importance of sustainability, environmental concerns, climate change awareness, and the role of sustainability initiatives in the respondents' decision-making process. Analyzing this data will help quantify the significance of sustainability as a criterion in air travelers' travel choices.

Subquestion 4 will require a combination of questions in the survey and the stated choice experiment. The survey will include specific questions aimed at minimizing biases in data collection. These control questions will help researchers identify and mitigate potential biases that may affect the accuracy and representativeness of the findings. Using the survey and the stated choice experiment, researchers can gather comprehensive data on consumers' willingness to pay for sustainable aviation fuel while minimizing biases in data collection. Lastly, the Willingness to Pay (WTP) derived from the experiment is juxtaposed with the actual price of a flight using Sustainable Aviation Fuel (SAF). This comparative analysis enables the assessment of potential overestimation, thereby facilitating a determination of whether such discrepancies exist.

## 1.4 Report Structure

The format of this report will be as follows. The literature currently available on sustainable flying is described in Chapter 2. The conceptual model that defines the relations comes at the end of this chapter. Chapter 3 goes into further detail on the methods after that. It discusses how the experiment and survey were built and the data analysis models. The Survey design is covered in Chapter 4. In Chapter 5, the data analysis of the survey will be explained. Chapter 6 explains the estimation process, whereas Chapter 7 goes further into the results of the estimation process. Chapter 8 provides the application. Lastly, Chapter 9 offers conclusions by addressing the research issues and providing advice on science and public policy.

# 2 Theory

To answer the main research question, several aspects need to be explained. This chapter will begin by providing a more detailed explanation of Sustainable Aviation Fuel (SAF). To fully comprehend the implications of sustainable aviation, it is essential first to establish a thorough understanding of the underlying technology, such as SAF. Furthermore, travelers' motivations to fly play a critical role in determining the success of sustainable aviation initiatives. Therefore, an examination of these motivations is necessary to provide context for the research question at hand. Previous research on this topic has been conducted, and it is essential to consider these studies to avoid duplication and build on existing knowledge. Reviewing the literature makes it possible to identify gaps in the research and develop a more comprehensive understanding of the subject. Finally, with the knowledge gathered from this review, a conceptual model will be designed to guide future research in sustainable aviation. The model will be based on the identified gaps in the literature and provide a framework for addressing the research question in a structured and systematic manner.

## 2.1 Sustainable Aviation Fuel

Understanding the definition and significance of SAF establishes a foundation for examining the factors that can influence its utilization. Analyzing these factors allows us to gain insights into the opportunities and challenges associated with the broader implementation of SAF in the aviation industry and identify potential measures to promote its adoption. Furthermore, SAF is still in development, and by understanding the various types that exist, it becomes possible to assess which ones are feasible for aviation applications. If multiple types could be suitable, this would allow exploring different scenarios in Chapter 8. The article of Ng et al. (2021) pertains to the discourse on four verified methodologies for producing sustainable aviation fuel, namely, Fischer-Tropsch (FT) synthesis, hydro-processed esters and fatty acids (HEFA), alcohol-to-jet (ATJ), and hydroprocessing of fermented sugars (HFS).

### 2.1.1 Fischer-Tropsch

The FT procedure primarily employs lignocellulosic biomass derived from municipal solid waste as a feedstock to produce a blend of aviation and road fuels. The feedstock is transformed into fuel through gasification, where it is converted into synthesis gas, which comprises a combination of hydrogen and carbon monoxide (Pavlenko et al., 2019).

The Fischer-Tropsch (FT) process is a versatile technology that can be integrated with various biomass conversions methods, such as gasification, pyrolysis, and liquefaction, to produce synthetic fuels. This review will focus on the gasification-FT route, the certified and commercialized process for jet fuel production. A more comprehensive review of biomass-to-FT liquid fuel production technologies can be found in Ail and Dasappa (Dasappa, 2016). Gasification is a high-temperature process that converts carbonaceous materials, such as biomass, into syngas primarily composed of CO and H2, essential building blocks for synthesizing FT liquid. Integrating biomass gasification with FT synthesis and refining (as shown in Fig. 1) allows for producing cleaner and high-quality jet fuel. Typically, 5-6 tons of biomass are needed to make 1 ton of FT liquid fuel (IATA Sustainable Aviation Fuel Roadmap, 2015).

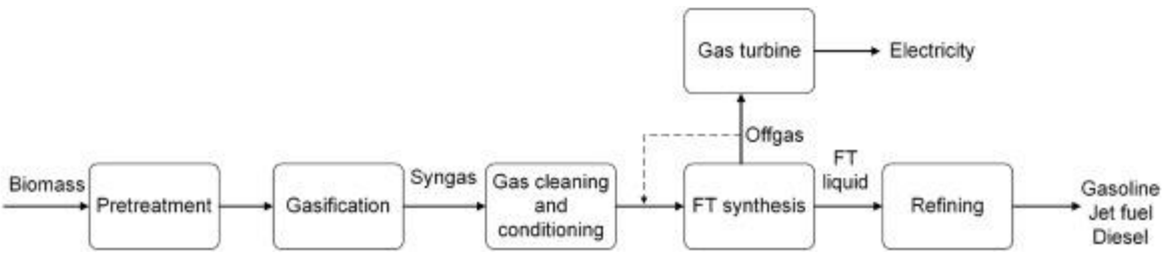



Figure 1: An integrated process combining biomass gasification, Fischer-Tropsch synthesis, and refining techniques is employed to produce gasoline, jet fuel, diesel, and electricity (Ng et al., 2021)

FT synthesis produces hydrocarbons with various carbon chain lengths, including light hydrocarbons (C1-C4), naphtha (C5-C10), kerosene (C10-C16), distillate (C14-C20), and waxes (C20+), which can be refined into diesel fuel. One of the significant advantages of FT liquid is its lack of sulfur and a minimal amount of aromatics compared to gasoline and diesel, leading to less environmental pollution (Tijmensen et al., 2002). However, to avoid catalyst poisoning, the feed for FT synthesis must meet stringent requirements, necessitating syngas cleaning to remove solid, tar, nitrogen, and sulfur-containing compounds and other contaminants that may cause equipment fouling. Syngas cleaning remains a significant challenge in the integrated system of biomass gasification with FT synthesis, and further development is needed to ensure satisfactory cleaning standards of the FT feed while achieving significant cost reduction (Santos & Alencar, 2020).

### 2.1.2 Hydro-processed esters and fatty acids

The HEFA process is the most well-developed Sustainable Aviation Fuel (SAF) pathway with a technology readiness level between 8 and 9, as de Jong et al. (2017) noted. It shares a remarkable similarity with the Hydrotreated Vegetable Oil (HVO) technique utilized for the production of road transport fuels, with the addition of further hydrocracking. The primary feedstock sources for HEFA are waste and vegetable oils, while alternative feedstocks such as oil-bearing algae are currently under investigation. The feedstocks undergo a deoxygenation reaction, followed by adding hydrogen to break down the compounds into hydrocarbons (Pavlenko et al., 2019). Refining procedures are then implemented to yield a fuel mixture that includes kerosene.

The Hydroprocessed Esters and Fatty Acids (HEFA) process produces jet fuel from biomass, including vegetable oils, animal fats, waste cooking oil, pyrolysis oil, and algal oil. Typically, 1.2 tonnes of vegetable oil is required to produce 1 tonne of HEFA fuel (IATA Sustainable Aviation Fuel Roadmap, 2015). The process involves a series of reactions, as shown in Figure 2, that extract free fatty acids (FFA) from the biomass, isomerize (rearrange), and hydrocrack (reduce carbon chain length) the molecules to obtain jet fuel that meets the specification.

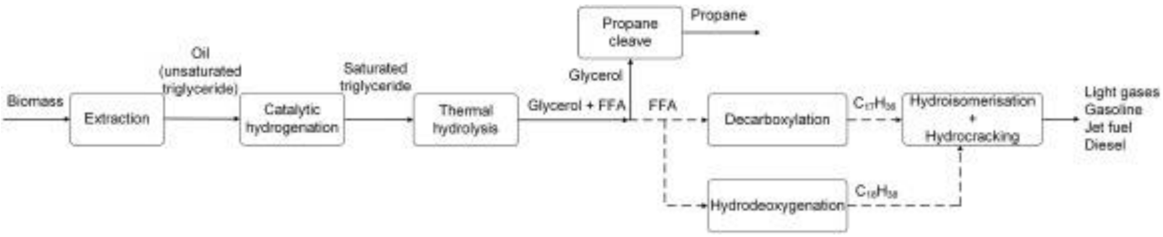



Figure 2: The HEFA process produces jet fuel from oily biomass (Ng et al., 2021).

The process starts with extracting oil from oil-bearing biomass containing unsaturated fatty acids/glycerides with double bonds. These bonds are removed via a catalytic hydrogenation reaction to produce saturated triglycerides. Hydrogenation is carried out at pressures of 0.7–4 bar with nickel catalysts at 150–220°C, while lower temperatures at 80–120°C are also possible if palladium and platinum catalysts are used (Alenezi et al., 2010). Triglycerides can be broken down into one molecule of glycerol and three molecules of FFA through thermal hydrolysis reactions, and glycerol is further converted into propane by adding hydrogen.

The oxygen content in the FFA is removed via hydrodeoxygenation (HDO) or decarboxylation (DCO) reaction, producing octadecane (C18H38) and heptadecane (C17H36), respectively. HDO requires 9 moles of hydrogen and generates water as a by-product, while DCO creates carbon dioxide. HDO is typically carried out at temperatures of 300–600°C, accompanied by a heterogeneous catalyst such as sulphided NiMo and CoMo supported on alumina (Huber et al., 2006). DCO occurs favorably under lower pressure and hydrogen consumption (Marker, 2005). Straight chain paraffin (C18H38 from HDO or C17H36 from DCO) is produced, but they do not meet the specifications for jet fuel applications such as flash point, freeze point, and cloud point. Therefore, they are further processed in a hydroisomerization reaction to form branched chain paraffin, which lowers the freezing point to meet the jet fuel standard (Marker, 2005). Hydrocracking reaction, which occurs sequentially or concurrently with hydroisomerization, is also involved in cracking and saturating the hydrocarbons to form synthetic paraffinic kerosene (SPK), consisting of a carbon chain length from C9 to C15 (Marker, 2005).

## 2.1.3 Alcohol-to-jet

As the name implies, the alcohol-to-jet (ATJ) process involves the conversion of alcohol into jet fuel. This method utilizes fermentation, whereby sugars, starches, or hydrolyzed cellulose are transformed into alcohol, specifically isobutanol or ethanol. The resultant alcohol is processed and upgraded to yield fuel (Pavlenko et al., 2019).

The Alcohol-to-Jet (ATJ) process is promising for producing jet fuel from biomass-derived alcohols. Two major processing routes have been identified: (1) methanol-to-olefins (MTO) followed by Mobil's olefin-to gasoline/distillate (MOGD) and (2) dehydration, oligomerization, and hydrogenation of ethanol/isobutanol/butanol/other alcohols (Ng & Sadhukhan, 2011a). Alcohols can be produced from biomass via thermochemical and biochemical routes, including gasification, pyrolysis, and fermentation (Martinez-Hernandez & Ng, 2018). Emerging technologies such as microbial synthesis are also becoming attractive (Lan & Liao, 2013; Soleimani et al., 2017).

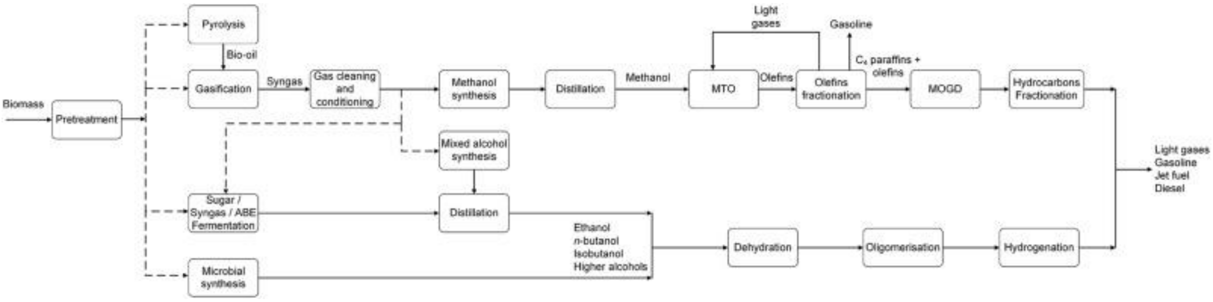


Figure 3: Alcohols can be produced from biomass through various routes, including alcohol-to-jet (ATJ) processes. Additionally, other ways such as methanol-to-olefins (MTO), Mobil's olefins-to-gasoline/distillate (MOGD), and acetone-butanol-ethanol (ABE) are employed in the production of alcohols from biomass (Ng et al., 2021).

The MTO-MOGD route involves the conversion of methanol to jet fuel via a fluidized bed reactor operated at 482 °C and 1 bar using a ZSM-5 catalyst. The product slate from the MTO unit includes methane, C2–C4 paraffin, C2–C4 olefins, and C5–C11 gasoline. The olefin fractionation unit separates these products into light gases, gasoline, and olefins, which are further processed in the MOGD unit, a fixed bed reactor operating at 400 °C and 1 bar with a ZSM-5 catalyst. The MOGD unit produces light gases, gasoline, and distillate. The final products, including light gases (C1–C4), gasoline (C5–C11), jet fuel/kerosene (C11–C13), and diesel (C14+), are obtained from the MOGD fractionation unit (Baliban et al., 2013). In the dehydration-oligomerization-hydrogenation route, alcohols are dehydrated to form alkenes using acidic catalysts such as alumina-based catalysts, ZSM-5 zeolites, γ-type zeolites, and Amberlyst acidic resins. The oligomerization process combines alkene molecules to create longer-chain hydrocarbons such as dimers, trimers, and tetramers using Amberlyst-35 or Nafion catalysts. Dimers are recycled to obtain a higher yield of trimers and tetramers, which give C12–C16 olefins for jet fuel. The last step, hydrogenation, involves saturating olefins to produce paraffinic kerosene using an external supply of hydrogen and PtO2 catalyst (Harvey & Quintana,2010).

## 2.1.4 Hydroprocessing of fermented sugars

The hydroprocessing of fermented sugars (HFS) pathway involves the use of genetically modified microorganisms, such as bacteria or yeasts, to transform sugar into lipids or hydrocarbons (E4tech (UK) Ltd & Studio Gear Up, 2019). One of the noteworthy examples of this method is Synthesized Isoparaffins (SIP), which converts sugary feedstocks, currently sugar cane, through fermentation and subsequent upgrading into farnesane.

Figure 4 depicts the biological conversion pathway of biomass to synthetic iso-paraffins (SIP) jet fuel, also known as "direct sugars-to-hydrocarbon" (DSHC) bio-jet fuel. The process involves four steps: (1) pretreatment to separate sugars from lignin, (2) enzymatic hydrolysis and fermentation of sugars into farnesene (C15H24), (3) solid-liquid separation and recovery of farnesene, and (4) hydroprocessing of farnesene into farnesane (C15H32), which is the final bio-jet fuel product. This technology is commercialized by Amyris and Total, which utilize an S. cerevisiae strain (PE-2) in the fermentation process to produce farnesene via the mevalonate pathway (Jiménez-Díaz et al., A, 2017).

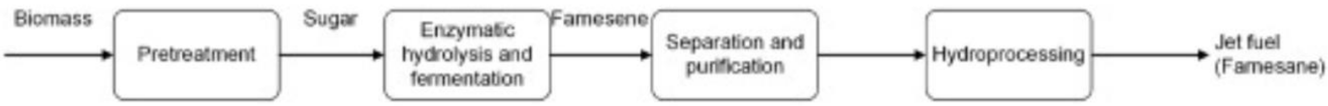



Figure 4: Fermented sugars can undergo hydroprocessing to produce jet fuel (Ng et al., 2021).

### 2.1.5 Characteristics of SAF

The various types of Sustainable Aviation Fuels (SAFs) have been examined, and their values have been compared to a fossil fuel baseline to determine the reduction percentage. These values are presented in Table 1. For each method, the available feedstock is assessed, followed by an evaluation of the potential CO2 emissions reduction compared to the current kerosene associated with that specific feedstock. The third column is irrelevant to this study, but the fourth column demonstrates the percentage of emissions reduction achieved by utilizing a particular process to produce SAFs. On average, the FT process can result in the highest emissions savings compared to other processes. In fact, up to 94% of emissions could be saved if Municipal Solid Waste (MSW) is used as the feedstock.

Table 1: Emission savings per method (A Route To Net Zero European Aviation, 2021).

| Conversion process | Feedstock | LCA $gCO_2e/MJ$ | % emissions savings compared to fossil-kerosene baseline of 89 g $CO_2eq/MJ$ |
|---|---|---|---|
| Fischer-Tropsch (FT) | Agricultural residues | 7.7 | 91% |
| | Forestry residues | 8.3 | 91% |
| | Municipal Solid Waste (MSW), 0% NBC | 5.2 | 94% |
| | MSW, NBC as % of total C | NBC × 170.5 + 5.2 | |
| | Short-rotation woody crops | 12.2 | 86% |
| | Herbaceous energy crops | 10.4 | 88% |
| Hydro-processed esters and fatty acids (HEFA) | Tallow | 22.5 | 75% |
| | Used cooking oil | 13.9 | 84% |
| | Palm fatty acid distillate | 20.7 | 77% |
| | Corn oil | 17.2 | 81% |
| | Soybean oil | 40.4 | 55% |
| | Rapeseed oil | 47.4 | 47% |
| | Camelina | 42 | 53% |
| | Palm oil - closed pond | 37.4 | 58% |
| | Palm oil - open pond | 60 | 33% |
| | Brassica carinata | 34.4 | 61% |
| Synthesized IsoParaffins (SIP) | Sugarcane | 32.8 | 63% |
| | Sugarbeet | 32.4 | 64% |
| Iso-butanol Alcohol-to-jet (ATJ) | Sugarcane | 24 | 73% |
| | Agricultural residues | 29.3 | 67% |
| | Forestry residues | 23.8 | 73% |
| | Corn grain | 55.8 | 37% |
| | Herbaceous energy crops | 43.4 | 51% |
| | Molasses | 27 | 70% |
| Ethanol Alcohol-to-jet (ATJ) | Sugarcane | 24.1 | 73% |
| | Corn grain | 65.7 | 26% |

The most comprehensively understood production process for sustainable aviation fuel (SAF) is the hydro-processed esters and fatty acids (HEFA) pathway, currently the sole commercially available process (A Route To Net Zero European Aviation, 2021). Consequently, the costs associated with this route can be estimated with the highest degree of certainty. According to Table 2, the minimum economically feasible price for HEFA-based SAF in the European Union (EU) is estimated to be 1.9 to 2.8 times the cost of fossil jet fuel (considering a Jet-A1 price of €0.39 per liter). These costs predominantly rely on feedstock costs, such as used cooking oil, which is unlikely to decline due to heightened competition from other sectors (A Route To Net Zero European Aviation, 2021). Thus, the cost of HEFA-based jet fuel is projected to remain relatively stable over time.

Table 2: Minimum Viable Price Estimates for HEFA in the EU per Litre and Tonne with a Kerosene Density of 0.8 kg/L (A Route To Net Zero European Aviation, 2021).

| Pathways | Feedstocks | €/litre | €/tonne | Compared with fossil at 0.39 €/litre[124] |
|---|---|---|---|---|
| HEFA | Soy oil, palm oil, Palm fatty acid distillate and used cooking oil | 0.88-1.09 | 1100-1363 | 2.3-2.8 |
| HEFA | Used cooking oil | 0.76-0.84 | 950-1015 | 1.9-2.2 |
| HEFA | Used cooking oil | ± 1 | ± 1,300 | 2.6 |

The International Council on Clean Transportation (ICCT) conducted a comprehensive analysis of the costs associated with various sustainable aviation fuel (SAF) production pathways in the European Union (EU), including CO2-equivalent abatement costs, as presented in Table 4. Following the hydro-processed esters and fatty acids (HEFA) pathway, the Fischer-Tropsch (FT) pathway yields the lowest CO2-equivalent abatement costs, ranging from €400 to €800 per tonne, depending on the feedstock utilized. Meanwhile, depending on the feedstock employed, the alcohol-to-jet (AtJ) pathway can also produce relatively low CO2-equivalent abatement costs (€800 per tonne in the most cost-effective scenario). It is important to note that the assumed greenhouse gas (GHG) reductions differ across the various pathways and feedstock types. These methods are still undergoing significant development, and the Greenest Airline anticipates that prices will continue to decrease. In comparison to HEFA, the prices are thus not very stable.

Table 3: Minimum Viable Price Estimates of SAF Pathways in the EU with Carbon Abatement Cost, Based on ICCT and a Kerosene Density of 0.8 kg/L (A Route To Net Zero European Aviation, 2021).

| Pathway | Feedstocks | €/tonne | €/litre | Compared with fossil at 0.39 €/litre[127] |
|---|---|---|---|---|
| FT gasification | MSW | 1675-2338 | 1.34-1.87 | 3.4-4.8 |
| AtJ | Corn, sugarcane, agricultural residues and energy crops | 2000-3125 | 1.60-2.50 | 4.1-6.4 |
| SIP | Sugar cane molasses | 5000 | 4.00 | 10.3 |
| FT power to liquid | Renewable electricity and $CO_2$ point sources | 3125 | 2.50 | 6.4 |

## 2.2 Motivations to fly

Now that we have established how SAF is produced and the associated costs, we must examine why travelers choose to fly. By understanding these motivations, we can then explore how SAF can become appealing to passengers.

### 2.2.1 Travel purpose

According to the European Parliament, in 2019, more than 1.1 billion passengers were flying within the European Union (Europees Parlement,2019). People choose to fly for various reasons that reflect life's diversity and adventure. This study solely examines the motivations of travelers who engage in aviation. Naturally, numerous other motivations exist for flying, such as cargo transportation, but these aspects are not addressed within the scope of this research.

One of the most common reasons is for business travel. Professionals worldwide regularly board airplanes to attend important meetings, close deals, and collaborate with international colleagues. The ability to travel quickly and efficiently is crucial in the modern business world, with the airplane providing the ideal solution for long-distance travel (Ritchie, 2020).

In addition to business travel, flying is a popular vacation choice. Whether it is a relaxing beach getaway, an adventurous trek in the mountains, or exploring historical cities, the airplane enables rapid travel to exotic destinations worldwide. The prospect of discovering new cultures, exploring breathtaking landscapes, and gaining unforgettable experiences attract travelers to the skies (Pereira et al., 2019).

Family visits are another significant motivation for people to fly. Family members who reside in different countries can regularly reunite through air travel. The accessibility of the airplane allows for sharing special moments, celebrating holidays together, and strengthening family bonds (Gössling et al., 2019).

Furthermore, flying can be a necessity for individuals traveling for health-related reasons. It may involve visiting specialized medical centers for treatments, undergoing medical procedures in other countries, or consulting renowned experts in their fields. In such cases, the airplane can offer life-saving opportunities (Pereira et al., 2019).
Education is another vital driver for air travel. Students and professionals in training often travel to international conferences, seminars, or universities to enhance their knowledge, gain new insights, and collaborate with experts in their fields. The airplane provides quick access to educational opportunities worldwide (Wynes et al., 2019).

Beyond these common reasons, there are countless other motivations for flying. Participating in sports events, engaging in cultural exchanges, embarking on spiritual retreats, and exploring personal interests and hobbies are just a few examples. The airplane opens up a world of possibilities and adventure, granting people the freedom to explore new horizons and connect with others across the globe.

### 2.2.2 Accessibility, Price, and Time

Now that the purpose of travel has been explained, it does not necessarily imply that it is the sole reason for choosing to fly. There are various reasons why people opt for air travel. The first reason is accessibility. Air travel offers accessibility that is unmatched by other modes of transportation. Airports are strategically located in major cities and regions, allowing people to easily reach distant destinations that may not be easily accessible by road or rail. This convenience and efficiency in getting to far-flung locations make flying a preferred choice for many travelers. Additionally, airlines operate on regular schedules, providing frequent and reliable transportation options for both domestic and international travel. The extensive network of flights and routes further enhances the accessibility factor, enabling individuals to reach their desired destinations quickly and conveniently (IATA,2022). The greenest airline focuses on flights to destinations that cannot be reached by train.

Air travel has become an increasingly popular mode of transportation due to its benefits in terms of price and time savings (Gössling et al., 2019). The affordability of air travel has made it accessible to a wide range of travelers, including budget-conscious individuals, backpackers, students, and families on a tight budget. Seat sales and special promotions are effective marketing strategies for airlines to attract these groups of travelers (Bieger & Wittmer, 2019; Ryanair, 2018). By offering seat sales and special promotions, airlines can successfully capture the attention of these targeted traveler groups. These strategies capitalize on the appeal of discounted fares and exclusive offers, stimulating demand and creating a sense of urgency and value.

In addition to the affordability factor, time savings are another significant advantage of air travel. Research has shown that travelers highly value the efficiency of air travel, as it enables them to reach their destination quickly and easily (Gössling & Scott, 2020). This is particularly crucial for business travelers who must attend meetings and conferences and for travelers attending time-sensitive events such as sports games or music festivals. Air travel offers the added benefit of reducing travel time, allowing travelers to spend more time at their destination engaging in various activities (Gössling & Scott, 2020). Air travel is often preferred over other modes of transportation due to its ability to cover long distances quickly. Research has shown that time savings are a significant factor in the decision-making process when selecting a mode of transportation (Wensveen, 2015; Oxford Economics, 2018). Cost is also an important consideration when choosing a mode of transportation (Abkowitz, 2018; Zhong et al., 2018).

Furthermore, airlines and travel companies have capitalized on the price and time savings offered by air travel by using them as key marketing strategies to promote their services. For example, Lufthansa marketed its shopping weekend packages by emphasizing the convenience of air travel for shoppers and highlighting the time-saving benefits of flying (Lufthansa, 2019). Similarly, CNN reported the appeal of mileage runs to frequent flyers, highlighting the time-saving benefits of earning points through air travel (CNN, 2018). Overall, the price and time savings offered by air travel have become critical factors for travelers considering their transportation options. The industry's marketing strategies continue to reflect this, as airlines and travel companies promote their services based on convenience, affordability, and time efficiency.

### 2.2.3 Type carrier

Price, availability, and time are significant factors in the type of carrier travelers choose. Generally, there are two main types of carriers: full-service/main carriers and budget carriers. Main carriers typically offer a wide range of services and amenities to passengers. These airlines often have a comprehensive network of routes, providing extensive flight options to various destinations. They typically offer higher comfort levels, in-flight entertainment, complimentary meals, and additional services such as lounge access and priority boarding (Fageda et al., 2015).

Comfort is another motivation for air travel, especially for those who prioritize convenience and luxury during their trips. A study by Gössling and Scott (2020) found that the quality of the travel experience is a significant factor in travelers' decision-making process. Comfortable seats, ample legroom, and other amenities such as in-flight entertainment and meals can significantly enhance the travel experience and make it more enjoyable for passengers. Moreover, air travel offers more comfort and convenience than other forms of transport for long distances. Modern airplanes are equipped with comfortable seating and entertainment options. Online check-in and baggage handling add to the comfort of air travel (APEX, 2019; IATA, 2020). However, these services are often reflected in higher ticket prices than budget carriers.

On the other hand, budget carriers focus on providing no-frills, cost-effective air travel options. They operate on a point-to-point model, serving popular routes at lower prices. Budget carriers often adopt a simplified service model, where passengers can pay for additional services, such as checked baggage or in-flight meals, per their requirements. This cost-conscious approach allows budget carriers to offer competitive fares, appealing to travelers seeking affordable travel options (Fageda et al., 2015).

The choice between a main carrier and a budget carrier depends on individual preferences such as destination, the choice between direct or indirect flights, brand image and other related elements, budget constraints, and the specific needs of the journey. Travelers prioritizing comfort, additional services, and a more comprehensive range of destination options may opt for a main carrier despite higher costs. On the other hand, those seeking to minimize expenses and prioritize affordability may choose a budget carrier for their travel needs. Availability of flights and the desired departure and arrival times also play a crucial role in the decision-making process. Travelers consider their priorities and evaluate the offerings of different carriers to make an informed choice that aligns with their preferences and requirements.

## 2.3 Motivations not to fly

In the first chapter, the negative consequences have been extensively explained, and it is indeed a significant reason why people choose not to fly. The environment is essential to many individuals, influencing their decision to avoid air travel. Price, availability of alternative modes of transportation, and fear of flying can also be reasons for not flying. Investigating these factors in this research is relevant because it assumes that travelers have chosen to fly but have not yet booked the ticket. However, another motivation for not passing is further zoomed in, namely flight shame. Studying flight shame is interesting because it can provide insights into the psychological and social factors that influence the decision-making process regarding air travel and the change in behavior in response to environmental awareness.

### 2.3.1 Flight shame

As described in the introduction, one of the main reasons why people are reconsidering air travel is due to the significant CO2 emissions from aircraft. Scientists have extensively studied and established that airplanes emit substantial amounts of carbon dioxide (CO2) and other greenhouse gases, which are known to contribute to climate change. Concerns over the effects of air travel on the environment have grown in recent years. People around the world are becoming increasingly aware of the negative consequences that the aviation industry can have on our environment and climate. This concern is supported by scientific sources that demonstrate the impact of flying on the environment.

In recent years, there has been a rise in the phenomenon known as flight shame. 'Flight shame' refers to an individual's discomfort or uneasiness with participating in energy-intensive and environmentally problematic activities such as air travel, reflecting recognition of aviation's significant contribution to climate change. The term 'flight shame' quickly gained global traction, indicating an increasing awareness of the impact of aviation on the environment (Gössling et al.,2020). The trend of flight shaming, which involves making air travel socially unacceptable due to its environmental impact on carbon emissions, may potentially contribute to a slowdown in future growth within the aviation industry (Topham, 2022).

One aspect, among others that influences individuals' perceptions of the necessity of travel is the purpose of the trip. For example, leisure-related trips are often less important than business or family trips (Gössling et al., 2019). While not all respondents expressed feelings of shame or embarrassment related to flying, these emotions were most commonly reported during holiday travel. This finding suggests that holiday trips may be seen as relatively less significant, leading to a greater sense of personal responsibility and potentially stronger emotional reactions when considering the climate impacts associated with such trips (Doran et al., 2021).

The personal moral obligation to act is the strongest predictor for individuals feeling flight shame and deciding to avoid flying for climate reasons. It is important to note that while personal norms accounted for a significant portion of the reported flight shame, injunctive norms consistently contributed to it across different travel situations. This suggests that in addition to moral beliefs regarding taking a personal stance against climate change, the subjective experience of flight shame may also be influenced by the perceived social acceptance of carbon-intensive activities like flying (Doran et al., 2021).

In conclusion, the concern over the environmental impact of air travel, particularly the significant carbon dioxide ($CO_2$) emissions from aircraft, has led to a rise in flight shame. This phenomenon reflects individuals' discomfort and uneasiness with participating in energy-intensive and environmentally problematic activities like flying, highlighting the recognition of aviation's contribution to climate change. Flight shame has gained global traction, indicating an increasing awareness of the aviation industry’s environmental impact.

## 2.4 Willingness to Pay for Sustainable Aviation Fuels

Research on the willingness to pay for sustainable aviation fuels (SAF) has yielded various studies, but these studies are also limited in their conclusions due to certain constraints. Below is an overview of some of these studies and the limitations they encountered.

### 2.4.1 Population

Several studies have been conducted on the willingness to pay for more sustainable flights. However, drawing sound conclusions from these studies has been challenging. One of the significant limitations was the low number of respondents and the use of data from different platforms, which resulted in a non-representative sample of the population. This issue affected the validity and generalizability of the results, making it difficult to draw firm conclusions from these studies. For this research, ensuring an adequate number of respondents are enlisted and that the data is collected directly. This approach facilitates the derivation of more robust conclusions compared to the studies cited below, which suffer from limited respondent pools or rely on indiscriminate data extraction from databases.

Shaari et al. (2022) concluded that to ensure the generalizability of the results, future studies should aim to replicate the findings using a more prominent and representative sample of the general population. Furthermore, Ragbir et al. (2021) argue that the study should include a broader population to ensure that the results are more generalizable and to acknowledge that attitudes may change over time, especially in response to significant events in the field. By considering these factors and conducting further research in this area, we can better understand how customers decide when booking flights and develop more effective strategies to meet their needs. In addition to ensuring the generalizability of the findings, future studies should also consider potential generational differences in attitudes toward climate change (Winter et al., 2021). Given the increasing awareness of the impact of air travel on the environment, it is essential to understand how these attitudes may influence customers' decision-making processes.

It is important to note that obtaining a diverse sample can be challenging and depends on individuals' availability and willingness to participate in the survey. However, it is crucial to ensure that the sample is representative of the population to obtain reliable results. This is because a non-representative sample can lead to biased and inaccurate conclusions.

### 2.4.2 Variables Affecting Willingness to Pay for Sustainable Aviation Fuels

Sustainable aviation fuels (SAFs) can potentially reduce carbon emissions in the aviation industry. However, their adoption relies heavily on consumer willingness to pay for them. According to Xu et al. (2022), age, income, environmental sentiments, and risk perception are potential variables affecting customers' willingness to pay for SAF. These variables will also be incorporated into this study, as they constitute pertinent information necessary for addressing research sub-question 1. Rotaris et al. (2020) argue that while calculating customers' willingness to pay for SAF, it is essential to consider other factors such as travel frequency, gender, educational attainment, and employment position. This will result in more accurate demand estimations for SAFs and enable policymakers to develop effective policies to promote their use. Furthermore, these variables are included in the research to enhance the understanding of which personal characteristics impact the inclination to adopt Sustainable Aviation Fuels (subquestion 1).

The paper by van Birgelen et al. (2011) aims to explain pro-environmental consumer behavior in air travel. The authors surveyed 1000 Dutch air travelers to explore the factors influencing pro-environmental behavior in air travel. They found that attitudes towards the environment, subjective norms, and perceived behavioral control significantly predict pro-environmental behavior in air travel. Moreover, the authors found that frequent flyers have more positive attitudes toward the environment and higher perceived behavioral control, positively affecting pro-environmental behavior. The study also found that age and education level significantly predict pro-environmental behavior in air travel. Younger and more educated respondents were found to have more positive attitudes towards the environment, stronger subjective norms, and higher perceived behavioral control, which led to more pro-environmental behavior in air travel. In contrast, income did not significantly affect pro-environmental behavior in air travel.

This study has prompted the exploration of personal characteristics as an intriguing avenue of investigation. These encompass socio-demographic attributes, such as age, gender, income, etc., and travel experience factors, including flight frequency. Hence, this will also be incorporated into this research. The study had intriguing findings that can be cross-referenced with the outcomes of this study. However, it is important to note that the research setup will differ, yet the comparative analysis remains valuable for insights.

### 2.4.3 Business models

Hinnen, Hille, and Wittmer (2015) suggest that future studies could examine different business models, such as low-cost airlines and high-value clients, and how they contribute to sustainable aviation. This could assist in creating strategies for various customer groups and company models. This can help better understand which travelers are more inclined to fly sustainably. Moreover, understanding the influence of different business models on sustainable aviation can provide valuable insights into which travelers are more likely to choose sustainable flight options. Researchers can identify specific factors influencing their inclination towards sustainable air travel by examining the preferences and behaviors of different customer segments, such as budget-conscious travelers or luxury-seeking clients. This information can then be used to develop targeted initiatives and communication strategies to encourage and promote sustainable choices among these specific traveler groups. These findings from the study warrant further investigation, as they provide deeper insights into the preferences of traveler types inclined to opt for SAF-enabled flights. This aspect will undoubtedly be explored in this research. Utilizing a Latent Class Choice model, distinct segments can be identified to ascertain which types of travelers are more likely to prioritize flying with SAF.

The choice of an airline can significantly influence individuals' decisions when it comes to flying. This has already been mentioned earlier in this chapter. Some travelers have preferences for specific carriers, which can be based on factors such as reputation, service quality, loyalty programs, or personal experiences (Fageda et al., 2015). Understanding the influence of different carriers on flight choices is crucial for airlines, as it can help them tailor their services and marketing strategies to meet the needs and preferences of their target customers. Moreover, studying the influence of carriers on flight choices can provide valuable information on consumer behavior and priorities within the aviation industry. This knowledge can assist airlines in developing more sustainable practices, fostering competition, and encourage adopting environmentally friendly measures across the industry. Hence, the respondents will be tasked with choosing between various types of carriers.

### 2.4.4 True price of SAF

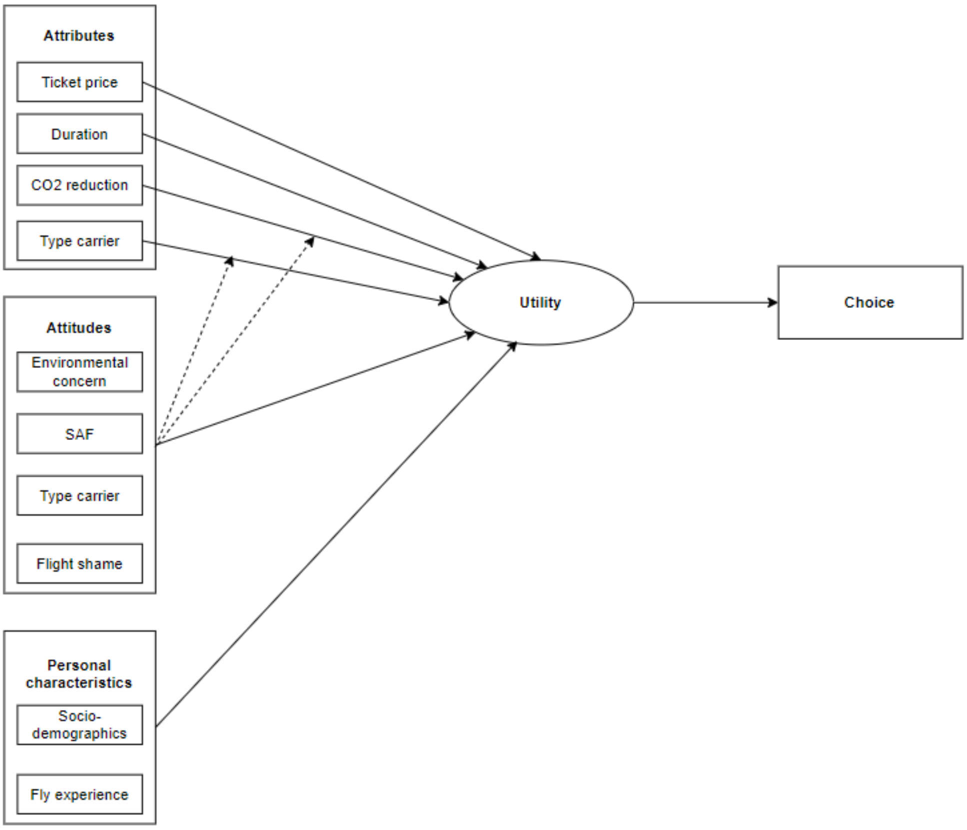
McKinsey & Company's research on the willingness to pay for more sustainable flights has provided insight into the attitudes and behaviors of travelers toward climate change and carbon emissions. However, further research is needed to determine how much consumers will pay for sustainable flights. Addressing this knowledge gap will require rigorous methodologies and a representative sample of consumers, which can help airlines and policymakers develop more effective strategies for promoting sustainable air travel (McKinsey & Company, 2022). They investigated the factors and had a good sample population of more than 5500 respondents, but their study lacked a definitive conclusion. They do not know what travelers are willing to pay. While they have provided an overview of factors influencing sustainable flights, they have not determined an exact price.

In conclusion, comprehending the variables affecting consumers' willingness to pay for SAFs is crucial to promoting their adoption. Further research in this area, including the presentation of the attributes, the effects of different business models, and accurate demand estimations for SAFs, can assist industry stakeholders and policymakers in creating successful adoption promotion plans.

## 2.5 Conceptual model

The conceptual model incorporates various variables discussed in the preceding paragraphs. Figure 1 provides a visual representation of this model, which will serve as the basis for constructing the Discrete Choice Model. The input for the conceptual model has been derived from this chapter and the first chapter. The oval symbolizes the utility, encapsulating preferences and satisfaction associated with choices, while the square represents the observable choice made from those alternatives in choice modeling. Following Figure 1, there will be a further elaboration on the conceptual model.

Figure 5: Conceptual model




The attributes are varied in the choice experiment. Flights can have different prices, durations, carrier types, and CO2 reduction. CO2 reduction plays a significant role when an aircraft utilizes Sustainable Aviation Fuel. Based on these attributes, travelers will choose a ticket. The introduction mentioned that The Greenest Airline is a nascent airline operator currently in its preliminary stages of development, with a fleet of four leased aircraft that prioritize fuel efficiency and environmentally sustainable operations. In addition to the two carriers we already know, the main and budget carriers, there is now a third type of carrier, The Greenest Airline. With this information, research sub-questions one and three can be addressed.

The attitudes and personal characteristics are measured in the survey. An attitude is a person's general outlook or disposition toward something, reflecting their feelings, beliefs, and opinions. It influences their thoughts, emotions, and behaviors related to that particular subject. Under the attitudes section, the type of carrier is mentioned again, not as an attribute but as an attitude. In this context, the question revolves around one's opinion of this type of carrier and the feelings associated with it.

Attitudes can influence attributes and ultimately lead to a different choice. Attitudes can exceptionally affect the attributes of CO2 reduction and the type of carrier. For example, if someone is environmentally concerned but still needs to fly, they might be more inclined to choose a flight with higher CO2 reduction. An exciting relationship that will be investigated in the survey is how flight shame changes when travelers fly with Sustainable Aviation Fuel (SAF). Does it ultimately have an impact on their choice? By assessing the attitudes, it is possible to infer to some extent why a respondent opts for a specific choice. This facilitates the partial addressing of research sub-question two and partially contributes to answering the main research question.

Finally, personal characteristics can indeed influence the choice of a flight. This insight is drawn from the studies referenced in section 2.4.2. One's financial situation can affect one's flight selection. They may prioritize cheaper flights, even if they have lower CO2 emissions. Additionally, the frequency of air travel can influence their choice. It is possible that someone who only flies once a year may not feel the need to choose a more sustainable flight because they may perceive that one flight has a minimal impact on the environment. Consequently, this information can partially elucidate why a respondent makes a particular choice, thereby partially answering the main research question.

In conclusion, the input from this and the preceding chapter has culminated in developing the conceptual model. This model constitutes the crux of the research, as it serves as the foundation for crafting the survey, including the stated choice experiment. After this, the obtained results can be analyzed, wherein the methodologies employed for comprehending, interpreting, and addressing the research inquiries will be expounded upon in the ensuing chapter.

# 3 Methodology

This chapter presents the methodology that will be used to address the research questions. Section 3.1 explains discrete choice modeling. Section 3.2 introduces the stated choice experiment, which is the specific method employed in this study. Finally, Section 3.3 describes the discrete choice models used in the analysis.

## 3.1 Discrete choice modeling

Before delving into a comprehensive explanation of the methodology, a reiterated clarification is provided regarding the rationale for employing discrete choice modeling in this study and the elucidation of its essence. Discrete Choice Modelling (DCM) is a statistical technique that analyses decision-making behavior in the context of multiple alternatives within a choice set (Bernasco & Block, 2013). DCM facilitates the estimation of choice models that reveal individuals' trade-offs when faced with different options and the factors influencing their choices (McFadden, 1972; Train, 2003). Discrete choice models analyze decision makers' selections when presented with other options. These decision-makers can be individuals, households, companies, or any entity responsible for making decisions. The considered alternatives could include competing products, potential actions to take, or any other choices requiring a decision (Train,2003).

A discrete choice model is suitable for answering the question, "What are the underlying factors that influence the willingness of air travelers to pay for sustainable aviation fuel?" because it allows for the analysis and prediction of individual choices. It enables researchers to identify the factors that influence the decision-making of air travelers and obtain quantitative insights into their willingness to pay for sustainable aviation fuel. Using a discrete choice model, researchers can collect data on the choices made by air travelers when presented with different alternatives. The attributes of these alternatives can vary, such as price, CO2 reduction, duration, and carrier type (see also Figure 5: conceptual model). By analyzing this data, a discrete choice model can quantify the relative influence of these attributes on travelers' choices. By incorporating these attributes into a discrete choice model and analyzing the choice patterns of air travelers, researchers can identify the factors that play a role in their willingness to pay for sustainable aviation fuel.

## 3.2 Stated choice experiment

Stated choice experiments employ experimental designs to create hypothetical alternatives that participants consider when making choices. These experiments typically present participants with a series of choice sets, usually around 10, and ask them to select within each set. In essence, participants expressed their preferences by stating what they would choose if the presented options were the only ones available. It is widely recognized that the more closely the constructed hypothetical situations resemble real-world opportunities, the more valid the observed choices become. Stated choice experiments have become a preferred data collection method in marketing and transportation due to their convenience and cost-effectiveness (Molin, 2014).

In summary, collecting SP data through a stated choice experiment in a digital survey is a convenient and efficient way to gather information about individuals' preferences and choices. The digital format allows a larger sample size to be reached quickly and easily compared to traditional face-to-face interviews or paper surveys. Additionally, using a stated choice experiment allows for a controlled setting where respondents can make choices based on different combinations of attributes (Cost, duration, CO2 reduction, and type-carrier) related to sustainable aviation fuel, providing valuable insights into their preferences and trade-offs.

The SP data for this study will be collected through a stated choice experiment conducted in the form of a digital survey among individuals aged 18 years and older who reside in the Netherlands and Belgium and have experience with flying. The sample will include consumers of all age groups, including younger individuals who have flown before, to ensure diversity among the research's target group. Respondents who had never passed were excluded from the sample, as their responses would not provide relevant information for the study. However, suppose individuals opt not to fly due to environmental concerns. In that case, these respondents are still included, as it becomes compelling to investigate whether the presence of Sustainable Aviation Fuel (SAF) would influence their decision to fly. This inquiry is examined by analyzing the outcomes stemming from the diverse attitudes exhibited by such a category of travelers.

Additionally, travelers under 18 were not included in the sample. This population has firsthand experience with the aviation industry and can provide valuable insights into the attitudes and choices regarding sustainable aviation fuel (SAF). As the use of SAF is gaining momentum in the aviation industry, understanding the preferences and choices of individuals with experience with flying is crucial in shaping policies and strategies related to SAF adoption.

## 3.3 Discrete choice models

The framework for a discrete choice model, as described by Ben-Akiva and Bierlaire (1999), is based on four general assumptions: Discrete choice models focus on individual decision-makers. This can refer to individuals, households, organizations, or any other relevant entity. The model may incorporate characteristics of the decision-makers, such as age, gender, education, and income, to account for the heterogeneity of preferences.

A choice set is the set of alternatives that the decision-maker considers during the choice process. These alternatives are explicitly listed and can be chosen from a finite set. The choice set generation process determines the available alternatives based on deterministic criteria. The decision-maker's awareness of alternatives may also influence the choice set, and probabilistic choice set generation models can be used to capture this uncertainty.

A set of attributes characterizes each alternative in the choice set. Attributes can be generic to all alternatives or specific to individual alternatives. The unlabeled form utilizes the same attributes for all alternatives, while the labeled form provides alternative-specific descriptions. Each form has its advantages, with the labeled form facilitating contextual decision-making by respondents and the unlabeled form providing more precise information about attribute trade-offs.

Finally, The decision rule describes how the decision-maker evaluates the attributes of the alternatives in the choice set and selects the alternative with the highest utility. Utility theory, based on utility as a measure of preference, is commonly used to model decision-makers' choices. The decision-maker's preference for an alternative is represented by its utility, and the alternative with the highest utility is chosen.

### 3.3.1 Random Utility Theory

This subsection introduces various types of Discrete Choice Models that can be estimated. According to Random Utility Maximization (RUM) theory, individuals assign utilities to each alternative in a choice set and select the alternative that maximizes their utility (Dillingham, 2016; Fujiwara et al., 2003).

Train (2003) explains that Random Utility Models (RUMs) are derived as follows: A decision maker, referred to as n, is faced with a choice among J alternatives. Each alternative provides a certain level of utility, denote $U_{nj}$, where j ranges from 1 to J. Although the decision maker knows their utility, it is unknown to the researcher. The decision maker selects the alternative with the highest utility, leading to the behavioral model of choosing alternative I if and only if:

$$U_{ni} > U_{nj} \, for \, all \, j \neq i.$$

On the other hand, the researcher does not observe the decision maker's utility directly but only observes attributes of the alternatives ($x_{nj}$) and attributes of the decision maker ($s_n$). The researcher specifies a function, $V_{nj}$ = V($x_{nj}$, $s_n$), known as systematic utility, which relates the observed factors to the decision maker's utility. Typically, V depends on unknown parameters that are estimated statistically. Since the researcher cannot keep all aspects of utility,

$$V_{nj} \neq U_{nj}.$$

The utility is decomposed as:

$$U_{nj} = V_{nj} + \varepsilon_{nj}$$

Where $\varepsilon_{nj}$ captures factors that influence utility but are not included in Vnj. The total utility derived from choosing an alternative comprises systematic utility and an error term (ϵ) (Chorus, 2022). Systematic utility arises from factors included in the experiment, while the error term (ϵ) encompasses all other influences on the individual's choice (Chorus, 2022).

The decision-maker assesses the attributes of the alternatives in the choice set and assigns a weight to each attribute based on their preferences. In cases where all parameters are assumed to be linear, the deterministic component of the utility function can be expressed as follows:

$$U_{nj} = \sum \mathrm{m}\beta_m * \mathrm{x}_{jm} + \varepsilon_{nj}$$

β is the taste or weights for attributes that need to be estimated, and m is the attribute-subscripts (Chorus, 2022).

### 3.3.2 Multinomial logit model

The multinomial logit model is a discrete choice model used to model individuals' choices when faced with multiple alternatives. The model is based on the Random Utility Theory (RUM) assumptions and utilizes the multinomial logit function to calculate choice probabilities.

The Multinomial Logit (MNL) model is a commonly used choice model due to its simplicity. It estimates the probability of an individual selecting a specific alternative from a set of alternatives based on the utility of each alternative. The probability of choosing alternative $i$ from a choice set $C$ is calculated using the exponential function, where the systematic utility of alternative $i$ is divided by the sum of the systematic utilities of all alternatives in the choice set. The systematic utility of alternative $i$, denoted as $Vi$, is divided by the sum of the systematic utilities of all alternatives $j$ in the choice set $C$. This can be expressed as:

$$\frac{P(i) = \exp(V_i)}{\exp \sum(V_j)}$$

where exp($V_i$) represents the exponential function raised to the power of the systematic utility $V_i$ of alternative $i$, and ∑exp($V_j$) represents the sum of the exponential functions raised to the power of the systematic utilities $Vj$ of all alternatives $j$ in the choice set $C$.

Three areas highlight the effectiveness of logit models in representing choice behavior while also outlining their limitations. These areas encompass taste variation, substitution patterns, and the dynamics of repeated choices over time (Train,2003)

The Logit model is valuable for capturing systematic variations in taste, which account for preferences related to observed characteristics of decision-makers. However, it is limited in its ability to capture random variations in taste, representing differences in preferences that observed characteristics cannot explain.

Furthermore, the Logit model assumes proportional substitution between alternatives based on the researcher's specification of systematic utility. This assumption implies that the degree of substitution remains constant regardless of the specific attributes or characteristics of the alternatives. To accommodate more flexible forms of substitution, alternative models are necessary.

Moreover, the Logit model can capture the dynamics of repeated choice situations, including state dependence, when unobserved factors influencing choice are independent over time. State dependence refers to the influence of previous choices on current choices. Nevertheless, the Logit model is inappropriate for situations where unobserved factors are correlated over time, as it cannot accurately account for the impact of past choices.

In conclusion, the MNL model is pertinent for addressing subquestion 1. Utilizing the MNL model makes it feasible to infer that the attributes yield greater utility in-flight selection. Furthermore, the determination of willingness to pay can be derived from the outcomes of the MNL model, thereby facilitating an elucidation of subquestion three as well.

### 3.3.2 Latent Class Choice Model

The latent class choice model (LCM) is a statistical modeling approach commonly employed in market research and econometrics to investigate the discrete choice behavior of individuals. It posits that the population comprises multiple unobservable segments, or latent classes, each characterized by a distinct preference structure, and that individuals belong to one of these latent classes. The LCM addresses limitations inherent in the multinomial logit (MNL) model (Cranenburgh, 2018).

The LCCM allows for a discrete mixing distribution of the parameter β, where β can take M distinct values. Each value of β, labeled b1,..., $b_M$, has a probability $s_m$ of being selected. This can be expressed as:

$$P_{ni} = \sum_{m=1}^{M} s_m \left( \frac{e^{b_m' x_{ni}}}{\sum_j e^{b_m' x_{nj}}} \right)$$

This formulation resembles the latent class model commonly used in psychology and marketing research, where different population segments exhibit distinct choice behaviors or preferences. The choice probability for an individual is calculated as the sum of probabilities across all segments, with each segment's probability weighted by its corresponding $s_m$ value. This model enables the estimation of segment shares ($s_m$) and the parameter values (b) associated with each segment, providing insights into the heterogeneity of preferences within the population (Train, 2003).

By employing a Latent Class Choice Model, you can uncover distinct groups of air travelers with varying preferences and willingness to pay for sustainable aviation fuel. These segments may represent different customer profiles or market segments, each characterized by unique underlying factors that drive their choices.

The LCCM procedure will be thoroughly discussed. The first step was to find the number of classes that allow the LCCM to suit the data best. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) are typically used to support this choice (Hernandez,2022). When deciding the number of classes, the AIC and BIC values should be as low as possible (Molin & Maat, 2015). The attribute weights of such classes could be examined after deciding how many classes should be included in the model. The significance of an attribute is expressed by its attribute weight. About the other attributes and random errors, this weight is assessed. (2022, Molin).

Once the number of classes has been determined, the coefficient beta (β), or attribute weight, is employed. The attribute weight should be understood as the increase or decrease in utils caused by an attribute increasing by one unit, where util is a utility unit. The sign of the attribute weight determines whether the utility goes down or up. If an attribute weighs 0, it does not affect the respondents' decision-making. When an attribute has a high value, respondents will need it to make their decision. Due to the multiple unit systems, those attribute weights can be compared by calculating the WtP.

To determine this, divide the weight of the characteristic being considered by the weight of the price attribute. The WtP value demonstrates the amount a respondent is ready to spend for a one-unit increase in the relevant attribute. The classes could be given a descriptive name based on the weights and signs of the attribute values. It was possible to identify what proportion of responses belonged to each class, making it evident which class was the largest and which was the smallest. More intriguingly, it was possible to identify which respondents belonged to which class based on their demographic, socioeconomic, and psychographic traits. It is necessary to have significant responder attributes as predictor variables to accomplish this. This demonstrates the significance of careful and deliberate characteristic selection(Hernandez,2022).

Finally, the Latent Class Choice Model (LCCM) can identify distinct segments, addressing subquestion 5. Additionally, within each segment, the determination of willingness to pay can be computed, effectively providing insights to address subquestion 3. These outcomes constitute crucial findings essential for comprehensively resolving the overarching research question.

# 4 Survey design

A carefully designed survey is crucial for investigating the underlying factors that influence the willingness of air travelers to pay for sustainable aviation fuel. This chapter describes how the survey was designed and conducted to collect and analyze the desired data. In section 4.1, the survey will be introduced, outlining its distribution method and scope. Section 4.2 will explain the stated choice experiment, while section 4.3 will outline the attitudes that will be assessed. Finally, section 4.4 will address personal characteristics.

## 4.1 Survey

The survey will be developed using Qualtrics software. Respondents are guaranteed complete anonymity, and no potentially personally identifiable information will be collected. The survey consists of three components derived from the conceptual model. Firstly, the attributes are necessary for the stated choice experiment. The second part of the survey includes questions about various attitudes, and the final part comprises questions about the respondent's characteristics.

Before explaining the three components, it is essential to understand the nature of the flights. The Greenest Airline focuses on offering point-to-point connections from Belgium to selected destinations. Their operational strategy emphasizes serving regional airports while catering to leisure and corporate travelers. They exclusively operate flights to destinations that are not accessible via train travel.

The stated choice experiment will present a flight from Brussels to Lisbon. The choice of Lisbon is due to its suitability as a destination for almost every travel purpose. Lisbon can be visited for both business and leisure purposes. It is a versatile destination that caters to a wide range of travel objectives, making it a suitable choice for various types of travelers.

As previously mentioned, the objective of this study is to ensure that the survey closely represents the population of consumers who will use sustainable aviation fuel (SAF). To achieve this goal, the survey will be distributed randomly among personal and professional contacts of the researcher through channels such as LinkedIn, Instagram, Facebook, and WhatsApp groups. LinkedIn will be utilized as a more professional platform to expand the survey's reach beyond personal circles. Meanwhile, Instagram, Facebook, and WhatsApp groups will be employed to reach personal contacts, who will be asked to disseminate the survey among their networks.

To ensure the survey reaches a diverse range of respondents, efforts will be made to target students and working individuals of various genders and education levels. Furthermore, respondents will be asked if they will share the survey with their professional and personal contacts. In addition, the survey will include filter questions at the beginning to exclude individuals who do not fit the target group. The ultimate goal is to obtain as many survey respondents as possible. Still, the target is to achieve a minimum of 200 respondents because this quantity directly represents the population and aligns realistically with the available time and resources.

As mentioned in Chapter 3, individuals aged 18 years and older who reside in the Netherlands and Belgium and have experience with flying are the respondents who are aiming for. The sample will include consumers of all age groups, including younger individuals who have flown before, to ensure diversity among the research's target group. Respondents who had never passed were excluded from the sample, as their responses would not provide relevant information for the study. However, suppose individuals opt not to fly due to environmental concerns. In that case, these respondents are still included, as it becomes compelling to investigate whether the presence of Sustainable Aviation Fuel (SAF) would influence their decision to fly

## 4.2 Choice set

To create a choice set, attributes are required. These attributes were determined in the conceptual model and include ticket price, duration, CO2 reduction, and type of carrier. The ticket price of a flight can vary due to various factors, such as the type of carrier booked, the booking period, and the travel period. Accounting for all these factors can be challenging, so average ticket prices have been chosen.

### 4.2.1 Attributes

According to Struck, L., & Struck, L. (2020), fuel constitutes approximately 35% of the ticket price. This means that for a ticket priced at 100 euros, 35 euros is allocated to fuel costs. HEFA (Hydroprocessed Esters and Fatty Acids) fuel is twice as expensive as the current fuel, resulting in a ticket cost of 135 euros instead of 100 euros. The ticket price for FT (Fischer-Tropsch) power to liquid fuel will be even higher. According to Table 3, it is currently 6.4 times higher, but the Greenest Airline anticipates a decrease to approximately three times higher than the current fuel due to its rapid development. Therefore, a ticket priced at 100 euros will cost around 170 euros.

Since the flights are relatively short and direct, selecting attribute levels that are as realistic as possible is essential. The price levels in the stated choice experiment will be as follows: 50 euros, 225 euros, and 400 euros. The flight duration from Brussels to Lisbon is typically around 2 hours (Hoe lang vliegen naar. . .? 2020). However, please note that flight times may vary depending on weather conditions, air traffic, and specific flight routes. It is always a good idea to check with the airline for the most accurate and up-to-date information regarding flight durations.

The CO2 reduction attribute has three levels: 0%, 50%, and 100%. In the short term, HEFA (Hydroprocessed Esters and Fatty Acids) fuel is expected to be the most popular choice because it is the cheapest option (Table 2). Depending on the chosen feedstock, HEFA fuel can achieve CO2 savings of up to 84%. On the other hand, FT (Fischer-Tropsch) power to liquid fuel can save up to 91% of CO2 emissions. The ultimate goal is to achieve a 100% reduction in CO2 emissions.

The type carrier attribute also consists of three levels. Main carriers are traditional airlines typically more prominent in scale and offer extensive global connectivity. They have a vast network of destinations and provide passengers with a comprehensive range of services. Examples of main carriers include KLM, Lufthansa, and British Airways. Budget carriers, also known as low-cost airlines, prioritize offering affordable flights with essential services at lower costs. They aim to provide cost-effective travel options for passengers. Examples of budget carriers include Ryanair, Easyjet, and Transavia. The "Greenest Airline" refers to an airline dedicated to environmentally friendly practices and sustainability. These airlines prioritize reducing their environmental impact by investing in fuel-efficient aircraft, implementing strategies to lower CO2 emissions, and promoting sustainable initiatives. They reduce CO2 emissions using Sustainable Aviation Fuel (SAF).

Table 4: Overview attributes

| **Attributes** | **Attribute levels** |
|---|---|
| Ticket Price | 50 euros, 225 euros, and 400 euros |
| Duration | 2 hours, 4 hours, and 6 hours |
| CO2 Reduction | 0%, 50%, and 100% |
| Type Carrier | Main Carrier, Budget Carrier, and The Greenest Airline |

### 4.2.2 Alternatives

Now that the attributes have been defined, it is time to determine the form of the alternatives in the choice sets. In determining the form of the alternatives, two options were considered: unlabeled and labeled. The decision has been made to utilize unlabelled alternatives.

By using unlabelled alternatives, biases arising from preconceived notions or brand perceptions can be minimized. Respondents are likelier to base their choices on their attributes rather than being influenced by brand names or other subjective factors, thus promoting a more objective decision-making process. The label has no meaning other than the distinction.

Unlabelled alternatives allow respondents to consider the trade-offs among different attributes objectively. They can compare the levels of each attribute across alternatives and make decisions based on their preferences for those attributes. This approach provides better information about the relative importance of each attribute and facilitates a deeper understanding of the trade-offs involved (Molin, 2023). Employing unlabelled alternatives ensures that respondents make choices based on the inherent attributes, avoiding introducing biases and promoting a more rigorous evaluation of attribute trade-offs.

### 4.2.3 Creating choice sets

The choice sets have been defined using Ngene software, and the syntax for defining the choice sets is provided in Appendix A. Sequential construction has been employed since two unlabeled alternatives must be constructed for each respondent, where alternatives are randomly placed into choice sets. This ensures that the correlations considered are solely between alternatives, while the correlations within alternatives are assumed to be zero. As a result, estimating parameters is feasible, and this assumption does not present significant challenges. This is also evident in Appendix A.

By implementing an orthogonal fractional factorial design, a set of 9 flight alternatives is generated. The choice of using nine sets is based on basic plan 2. A fold-over design is incorporated to ensure the independence of main effects and two-way interaction effects among the attributes. This additional design step expands the total number of flight alternatives to 18, including a fold-over design that guarantees that the influence of each attribute on the alternatives is unaffected by any potential interaction effects with other attributes. This approach allows for a comprehensive analysis of the main effects. It facilitates a more accurate understanding of the individual contributions of each attribute to the overall choice process (Molin, 2023b).

Table 5 displays the 18 choice sets. However, choice situations 12 and 18 will not be presented to the respondents due to the presence of a dominant alternative. Including dominant alternatives does not provide meaningful information; therefore, these choice sets are omitted. As a result, there will be 16 choice sets remaining. Respondents will only be exposed to half of these choice sets to ensure the task does not overwhelm them.

Table 5: Choice sets

| Design | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Choice situation | flight1.price | flight1.time | flight1.co2 | flight1.type | flight2.price | flight2.time | flight2.co2 | flight2.type | Foldover block |
| 1 | 50 | 2 | 0 | 0 | 50 | 4 | 50 | 2 | 1 |
| 2 | 400 | 4 | 50 | 0 | 225 | 6 | 50 | 0 | 1 |
| 3 | 225 | 6 | 100 | 0 | 225 | 4 | 0 | 1 | 1 |
| 4 | 225 | 4 | 0 | 1 | 400 | 2 | 50 | 1 | 1 |
| 5 | 50 | 6 | 50 | 1 | 225 | 2 | 50 | 2 | 1 |
| 6 | 400 | 2 | 100 | 1 | 400 | 6 | 100 | 2 | 1 |
| 7 | 400 | 6 | 0 | 2 | 400 | 2 | 100 | 1 | 1 |
| 8 | 225 | 2 | 50 | 2 | 50 | 4 | 100 | 2 | 1 |
| 9 | 50 | 4 | 100 | 2 | 50 | 6 | 50 | 1 | 1 |
| 10 | 400 | 6 | 100 | 2 | 225 | 4 | 100 | 1 | 2 |
| 11 | 50 | 4 | 50 | 2 | 400 | 4 | 0 | 0 | 2 |
| 12 | 225 | 2 | 0 | 2 | 400 | 6 | 0 | 2 | 2 |
| 13 | 225 | 4 | 100 | 1 | 225 | 6 | 100 | 0 | 2 |
| 14 | 400 | 2 | 50 | 1 | 50 | 2 | 0 | 0 | 2 |
| 15 | 50 | 6 | 0 | 1 | 400 | 4 | 50 | 0 | 2 |
| 16 | 50 | 2 | 100 | 0 | 225 | 2 | 0 | 2 | 2 |
| 17 | 225 | 6 | 50 | 0 | 50 | 6 | 0 | 1 | 2 |
| 18 | 400 | 4 | 0 | 0 | 50 | 2 | 100 | 0 | 2 |

The attributes in Table 5 are self-explanatory, except for the attribute "flightx. type," which requires clarification. When this attribute has a value of 0, it represents the main carrier. A value of 1 corresponds to a budget carrier, while 2 represents the greenest airline. The first choice situation comprises an alternative with a ticket price of 50 euros, a duration of 2 hours, no CO2 reduction, and operated by a main carrier. The other alternative within this choice situation has a ticket price of 50 euros, a duration of 4 hours, a 50% CO2 reduction, and is operated by the greenest airline. This is presented to the respondents as follows:

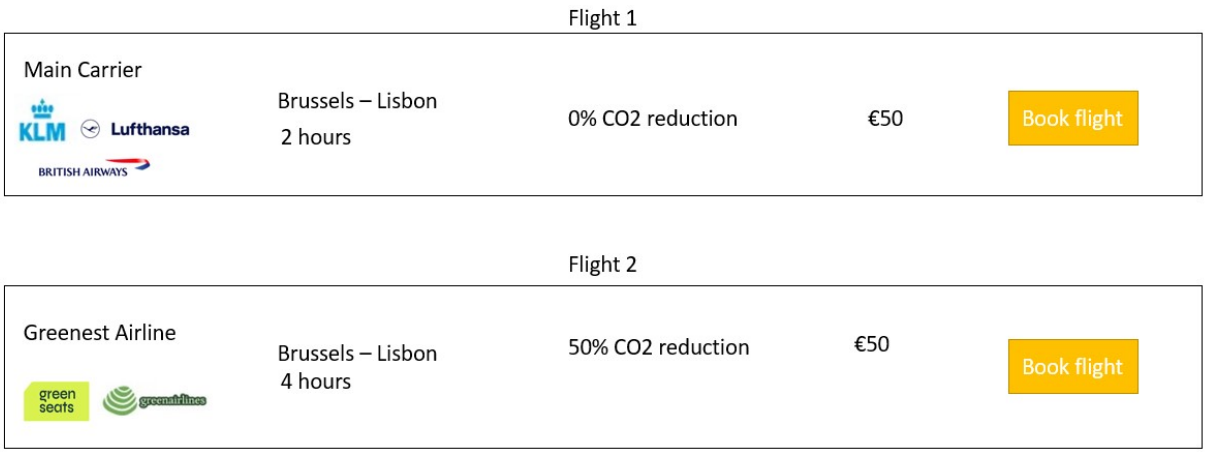


Figure 6: Choice set 1

## 4.3 Attitude

According to the conceptual model, four attitudes will be measured: environmental concern, SAF, flight shame, and type carrier. The optimal number of points to use in a Likert scale is debatable. An uneven number of points was selected to allow respondents to express a neutral opinion. Considering practical considerations, a 5-point Likert scale was chosen over a 7-point scale as it requires less time and effort and is more suitable for mobile devices (WorkTango, 2022). A 5-point Likert scale was preferred over a 3-point scale as it allows respondents to convey the direction and intensity of their opinions (Sauro, 2019). The chosen Likert scale will range from 1 (Completely Disagree) to 5 (Completely Agree).

### 4.3.1 Environmental concern

Gauging environmental concerns related to air travel is essential for understanding the motivations behind sustainable travel behavior. This information can be used to develop interventions or policies that address these concerns, such as promoting eco-friendly travel options or increasing public awareness about the impact of air travel on the environment. To operationalize the concept of environmental concern in this master thesis, the New Ecological Paradigm (NEP) scale was chosen. This measure is considered the most widely used instrument for assessing environmental concerns worldwide, as noted by Dunlap (2008).

1. We are approaching the limit of the number of people the Earth can support.
2. Humans have the right to modify the natural environment to suit their needs.
3. When humans interfere with nature it often produces disastrous consequences.
4. Human ingenuity will ensure that we do not make the Earth unlivable.
5. Humans are seriously abusing the environment.
6. The Earth has plenty of natural resources if we just learn how to develop them.
7. Plants and animals have as much right as humans to exist.
8. The balance of nature is strong enough to cope with the impacts of modern industrial nations.
9. Despite our special abilities, humans are still subject to the laws of nature.
10. The so-called "ecological crisis" facing humankind has been greatly exaggerated.
11. The Earth is like a spaceship with very limited room and resources.
12. Humans were meant to rule over the rest of nature.
13. The balance of nature is very delicate and easily upset.
14. Humans will eventually learn enough about how nature works to be able to control it.
15. If things continue on their present course, we will soon experience a major ecological catastrophe.

Figure 7: NEP

### 4.3.2 SAF

Measuring SAF attitude facilitates understanding stakeholders' awareness and engagement concerning sustainable aviation fuels. It offers insights into their knowledge levels, perceptions, and willingness to support the transition to more sustainable fuels. Moreover, assessing SAF’s attitude assists in identifying potential barriers, obstacles, or resistance against using sustainable aviation fuels. It reveals specific concerns, doubts, or misconceptions respondents hold, thereby hindering SAF's broader acceptance and implementation. These statements were self-generated and not derived from scientific literature, as there is limited research in this domain.

1. I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry to mitigate the environmental impact of air travel.
2. I am familiar with the process of converting sustainable feedstocks into SAF, such as biomass, or waste materials.
3. I am interested in learning more about the lifecycle analysis and carbon intensity of SAF production compared to traditional jet fuel, as well as ongoing efforts to improve its production efficiency and scalability.
4. I feel a personal responsibility to support airlines that prioritize the use of SAF to minimize my carbon footprint from air travel.
5. SAF is an inadequate solution to the carbon emissions caused by flying.
6. Relying solely on SAF can create a misleading perception of sustainability while failing to address the fundamental issues of air travel.
7. Encouraging and prioritizing alternatives to flying, such as video conferencing or high-speed rail, is a more effective approach than relying heavily on SAF.
8. The use of food crops for SAF production raises significant ethical concerns that cannot be overlooked
9. It is crucial to prioritize SAF production methods that minimize environmental impacts and do not compete with food production
10. Despite its adoption by the aviation industry, I remain unconvinced that SAF will lead to meaningful and substantial reductions in emissions
11. SAF has the potential to contribute positively to reducing carbon emissions in aviation when combined with comprehensive and holistic strategies
12. Investing in research and development for advanced SAF technologies and sustainable feedstock sources can lead to further improvements in its environmental performance.

Figure 8: Statements SAF

### 4.3.3 Flight Shame

Measuring the flight shame attitude is instrumental in comprehending individuals' awareness and perception regarding the environmental impact of air travel. It provides insights into how individuals are cognizant of the environmental ramifications of flying and the degree to which they experience shame or concern about air travel.

Furthermore, measuring the flight shame attitude can assist in gauging the influence of shame on individuals' behavior regarding air travel. It can offer insights into individuals' willingness to consider alternative modes of transportation, such as train travel or other forms of more sustainable transportation. In addition, statements regarding SAF (Sustainable Aviation Fuel) are presented to gauge the potential shifts in flight shame perception when SAF fuels a flight. The statements regarding flight shame were sourced from the article by Molin & Kroesen (in press). The statements about flight shame about Sustainable Aviation Fuel (SAF) were self-generated, although they were conceptually derived from the foundational statements concerning flight shame.

1. Whenever I travel by airplane, I feel uncomfortable during and after a trip
2. I feel guilty when I fly to a destination
3. When I am going to fly I fear negative reactions from other people
4. I feel guilty whenever I travel by airplane for a city trip
5. I rather do not tell others when I travel by airplane for a holiday
6. When I could fly by airplane using SAF, my feeling of discomfort during or after a flight would diminish
7. When I can fly by airplane using SAF, my feeling of guilt would diminish.
8. When I can fly by airplane using SAF, my fear of negative reactions would diminish
9. When I can fly by airplane using SAF for a city trip, my guilt would diminish
10. When I can fly by airplane using SAF, my willingness to share my holiday plans would increase

Figure 9: Statements Flight shame

### 4.3.4 Type carrier

Finally, questions about type carrier attitude are also posed. These statements were self-constructed. In general, measuring the type of carrier attitude contributes to comprehending customers' preferences, satisfaction, and requirements concerning various categories of airlines.

1. The reputation and brand image of a main carrier greatly influences my decision to choose their flights.
2. When considering a budget carrier, the most important factor for me is the affordability of fares.
3. The commitment of the Greenest Airline to sustainability and environmental initiatives positively influences my preference for their flights.
4. I am willing to pay a premium for flights with the Greenest airline due to their prioritization of sustainability and eco-friendly practices.
5. The cost savings associated with choosing a budget carrier outweigh any potential trade-offs in terms of comfort or amenities.
6. Main carriers typically provide higher quality services compared to budget carriers.
7. When choosing an airline, I prioritize the reputation and brand image of the main carriers due to their perceived quality.
8. I am not familiar with the Greenest airline and, as a result, I am uncertain about what to expect from their flights.
9. The lack of awareness about the greenest airline makes it challenging for me to consider them as a preferred option.
10. I am hesitant to choose the greenest airline because I am unsure if they can meet my expectations in terms of service and reliability.

Figure 10: Statements carrier

## 4.4 Personal Characteristics

The third component of the conceptual model is personal characteristics. This section comprises two categories: socio-demographics and flight experience. The flight experience questions will be administered first in the survey. These questions will explore factors such as the frequency of air travel per year, travel purposes, and other relevant details. Obtaining this information will allow us to identify the type of traveler we are dealing with. Towards the end of the survey, a few socio-demographic questions will be included, such as birth year and gender. These questions will provide insights into the respondents' profiles. All the questions relating to personal characteristics can be found in the appendix and the complete survey.

## 4.5 WtP for controlling overestimating

Lastly, participants will be presented with two additional questions regarding their willingness to pay for a flight with the Greenest Airline using SAF and achieving an 80% reduction in CO2 emissions. This serves as a control question to assess whether the findings from the experiment align with participants' stated preferences. Below is a combined choice, but participants will receive these questions separately in the survey.

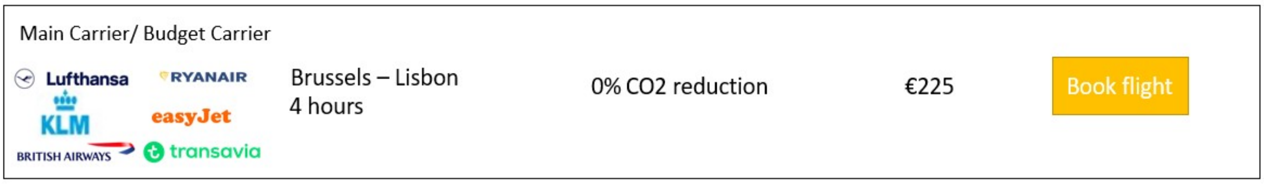



Figure 11: WTP question

By addressing this question, subquestion four can be elucidated, enabling an examination of whether respondents' Willingness to Pay (WTP) remains consistent when comparing their choices in the Stated Choice (SC) experiment and their direct responses regarding the additional amount they would be willing to pay for a flight utilizing Sustainable Aviation Fuel (SAF). The results of this analysis would contribute to the understanding of the coherence and reliability of respondents' expressed preferences across these distinct methodologies.

# 5 Data Analysis

This chapter presents the analysis of the data. This provides the input for the discrete choice models. Section 5.1 focuses on data cleaning and preparation, followed by Section 5.2, which examines the socio-demographics of the respondents. Section 5.3 delves into the analysis of flight experience, while Section 5.4 presents the factor analysis results.

## 5.1 Data cleaning and Preparation

The survey was made available to respondents for ten days. Ultimately, 387 respondents completed the survey. However, the data from these 387 respondents will not be included in the analysis. The data of respondents under 18 has been removed. These criteria were requirements for our datasets, as stated in Chapter 4. Additionally, some respondents still needed to complete the survey, often leaving the socio-demographic section unanswered, and I also had to exclude their data. In a few cases, some respondents only provided the last digits for the year, which I could correct. Consequently, the dataset consists of answers from 276 respondents.

The survey took approximately 15.6 minutes, longer than my initial estimate of 10 to 15 minutes. However, several outliers significantly influenced the average completion time during the data analysis. One respondent, for instance, took 9158 seconds to complete the survey, which is a little over 2.5 hours.

Furthermore, we examined the distribution of choice sets within the dataset to ensure they were evenly represented. There is a discrepancy in the numbers, as choice set 1 contains 119 responses, while option set 2 contains 155. This difference is due to the exclusion of respondents who still need to complete the survey. However, both choice sets still have sufficient respondents for conducting analyses, so this should be fine.

## 5.2 Socio-demographics

Table 6 presents the distribution of diverse socio-demographic characteristics within the sample of respondents. Regrettably, comprehensive distributions specific to the targeted population of this study, encompassing all Dutch or Belgian individuals aged 18 years and above who engage in air travel, remain unavailable. The table faithfully represents the socio-demographic variables that were inquired about during the survey, except for age. Since the survey requested birth years, which may be less suitable for direct presentation in the table, age has been discretized into categories. Furthermore, this table consolidates the combined attributes of Belgium and the Netherlands. Appendix B includes two supplementary tables delineating the socio-demographic characteristics of the Netherlands and Belgium, respectively.

Table 6: Socio-demographics

| Personal Characteristics | Category | Absolute Number | Sample(%) | Dutch/Belgium population (%) |
|---|---|---|---|---|
| **Gender** | Male | 151 | 54,7 | 49,0 |
| | Female | 121 | 43,8 | 50,1 |
| | I prefer not to say | 4 | 1,4 | 0,0 |
| **Age (in years)** | 18-25 | 103 | 37,3 | 9,5 |
| | 25-45 | 132 | 47,5 | 27,7 |
| | 45-65 | 38 | 13,7 | 29.1 |
| | 65+ | 4 | 1,5 | 33.7 |
| **Level of education** | No formal education | 4 | 1,4 | 6,0 |
| | High School | 13 | 4,7 | 14,0 |
| | | 18 | 6,5 | 39,0 |

| | | | | |
|---|---|---|---|---|
| | Vocational education | 62 | 22,5 | 25,0 |
| | Higher Vocational | 56 | 20,3 | 10 |
| | education | 117 | 42,4 | 6,0 |
| | Bachelor | 6 | 2,2 | 2,0 |
| | Master | | | |
| | PhD | | | |
| **Employment status** | Employed | 193 | 69,9 | 61,5 |
| | Student | 58 | 21 | 12.4 |
| | (currently) unemployed | 7 | 2,5 | 3.8 |
| | Retired | 5 | 1,8 | 19,0 |
| | Other | 13 | 4,7 | 3.3 |
| **Level of income** | <10.000 | 40 | 14,5 | 7.9 |
| | 10.001-20.000 | 29 | 10,5 | 16.6 |
| | 20.001-30.000 | 29 | 10,5 | 17.2 |
| | 30.001-40.000 | 40 | 14,5 | 14.3 |
| | 40.001-50.000 | 27 | 9,8 | 11.7 |
| | 50.001-60.000 | 23 | 8,4 | 8.5 |
| | 60.001-70.000 | 12 | 4,4 | 6,5 |
| | 70.001-80.000 | 7 | 2,5 | 5.3 |
| | 80.001-90.000 | 9 | 3,3 | 3.5 |
| | 90.001-100.000 | 6 | 2,2 | 2.7 |
| | >100.000 | 19 | 6,9 | 4.7 |
| | I would rather not say/I do not know | 34 | 12,4 | |
| **Where do you live?** | The Netherlands | 148 | 53,6 | |
| | Belgium | 128 | 46,4 | |

Table 6, as previously stated, presents the personal characteristics of the respondents. This information is pertinent to our analysis, as it may provide insights into potential explanations for certain outcomes. For instance, if the data analysis reveals a significantly elevated level of environmental concern among these respondents, this observation could be attributed to a relatively substantial number of younger participants within the dataset, as an illustrative example. It is challenging to directly compare the representativeness of this dataset with the actual population due to its inclusion of respondents from both the Netherlands and Belgium. Therefore, the 'Dutch/Belgium population' column reflects the combined averages of these two countries, resulting in a certain level of inaccuracy, albeit providing a reasonable indication. For the statistics of the Netherlands, data from CBS has been employed, while data from Statbel has been utilized for Belgium (CBS,2022; Statbel,2023).

The findings reveal a noticeable over-representation of students, which skews the sample towards a higher proportion of young individuals and those with higher educational backgrounds. Conversely, older age groups and individuals with work statuses other than students or employed are underrepresented in the sample. However, it is worth noting that the table includes substantial numbers of most other categories, allowing for a preliminary exploration of the central issue addressed in this study.

## 5.3 Travel experience

Table 7 provides an overview of the flight experiences, including the frequency of air travel per year and the purpose of the trip, among other factors. Similarly, this table encompasses the combined dataset, incorporating the flight experiences of both Dutch and Belgian participants. Additionally, Appendix B includes two separate tables, one presenting the flight experiences of Dutch individuals and the other focusing on Belgian participants.

Table 7: Travel experience

| Personal Characteristics | Category | Absolute Number | Sample(%) |
|---|---|---|---|
| **How often do you fly?** | 1 | 140 | 50,7 |
| | 2 | 58 | 21 |
| | 3 | 26 | 9,4 |
| | 4 | 18 | 6,5 |
| | 5 | 9 | 3,3 |
| | 6-10 | 12 | 4,3 |
| | 11-15 | 6 | 2,2 |
| | 16-20 | 2 | 0,7 |
| | 21-30 | 1 | 0,4 |
| | >31 | 3 | 1,1 |
| **Main reason** | Business | 33 | 12 |
| | Leisure | 187 | 67,8 |
| | Family | 42 | 15,2 |
| | Health | 0 | 0 |
| | Education | 1 | 0,4 |
| | Other | 11 | 4,0 |
| **Business travel** | Main carrier | 116 | 42 |
| | Budget Carrier | 96 | 34,8 |
| | Other | 54 | 23,2 |
| **Leisure travel** | Main carrier | 84 | 30,4 |
| | Budget carrier | 168 | 60,9 |
| | Other | 22 | 8,0 |
| **Booking** | Directly with the airline | 104 | 38,1 |
| | Online booking engine | 141 | 51,6 |
| | Other | 28 | 10.3 |

The results of Table 7 are generally clear. These results are also crucial as they can help explain the outcomes. These findings depict the type of air travelers the respondents are, shedding light on their preferences and behaviors related to air travel. Slightly more than half of the respondents fly once a year, with leisure being the main purpose of their trips. Respondents found it challenging to answer the question regarding the carrier they would choose for business travel, as many did not directly relate to this scenario. Consequently, they responded based on their assumptions of what they would do in such a situation.

Finally, the last row is noteworthy, as some respondents selected "other" for how they booked their flight tickets. The answers revealed that respondents use Google Flights as a booking platform. Google Flights is an online flight search engine and booking platform developed by Google. It allows users to search for flights from various airlines and travel agencies, helping them find the best options based on their preferences and budgets. Additionally, many respondents mentioned a combination of methods, where they compare prices on a booking engine and then proceeded to book directly with the airline.

## 5.4 Analysis of the Statements of SAF

The respondents were presented with various statements regarding Sustainable Aviation Fuel (SAF). This information is valuable as it explains respondents' attitudes towards SAF. The statements were answered using a 5-point scale. The table displays the respondents who chose each score for a particular statement. The last column represents the average of the responses.

Table 8: Overview Statements SAF

| **Statement** | Completely Disagree(%) | Disagree(%) | Neutral (%) | Agree(%) | Completely Agree (%) | Mean |
|---|---|---|---|---|---|---|
| I am willing to pay a premium for flights using SAF | 9.9 | 22.3 | 21.6 | 39.2 | 7.0 | 3.11 |
| I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry | 1.8 | 5.9 | 17.9 | 44.0 | 30.4 | 3.95 |
| I am familiar with the process of converting sustainable feedstocks into SAF | 12.1 | 37.4 | 16.5 | 28.6 | 5.5 | 2.78 |
| I am interested in learning more about lifecycle analysis. | 5.5 | 18.3 | 24.9 | 38.5 | 12.8 | 3.35 |
| I feel a personal responsibility to support airlines that prioritize the use of SAF | 7.3 | 21.6 | 26.4 | 32.2 | 12.5 | 3.21 |
| SAF is an inadequate solution to the carbon emissions caused by flying | 1.8 | 15.4 | 50.5 | 22.7 | 9.5 | 3.23 |
| Relying solely on SAF can create a misleading | 1.5 | 3.7 | 33.7 | 43.6 | 17.6 | 3.72 |

| | | | | | | |
|---|---|---|---|---|---|---|
| perception of sustainability | | | | | | |
| Encouraging and prioritizing alternatives to flying is a more effective approach than relying heavily on SAF | 0.7 | 10.6 | 30.8 | 39.9 | 17.9 | 3.64 |
| The use of food crops for SAF production raises significant ethical concerns that cannot be overlooked | 1.1 | 6.6 | 38.8 | 36.3 | 17.2 | 3.62 |
| It is crucial to prioritize SAF production methods that minimize environmental impacts | 0.7 | 3.3 | 30.0 | 42.5 | 23.4 | 3.85 |
| I remain unconvinced that SAF will lead to meaningful and substantial reductions in emissions | 2.2 | 31.1 | 40.3 | 20.5 | 5.9 | 2.97 |
| SAF has the potential to contribute positively to reducing carbon emissions in aviation | 0.7 | 1.1 | 28.6 | 57.1 | 12.5 | 3.79 |
| Investing in research and development for advanced | 1.1 | 1.1 | 22.0 | 61.2 | 14.7 | 3.87 |

| | | | | | | |
|---|---|---|---|---|---|---|
| SAF technologies can lead to further improvements in its environmental performance | | | | | | |

The table is reasonably clear in itself. However, a brief explanation of interpreting the values will be provided. The statement "I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry" is generally scored quite high. More than 200 out of the 273 respondents scored four or higher. This indicates that respondents agree that SAF is crucial for the aviation industry. This is also evident from the average score for this statement, 3.95. For each statement related to SAF, how respondents have responded is observed, providing insights into their attitudes.

Based on the observations, it can be concluded that respondents generally view Sustainable Aviation Fuel (SAF) as a promising solution for the aviation industry. However, it is notable that respondents are cautious and do not rely solely on SAF as the complete solution. While recognizing its potential, they likely acknowledge that additional measures and strategies may be necessary to address the aviation industry's broader sustainability challenges. However, less than half of the respondents were willing to pay extra for a SAF flight. Therefore, respondents do perceive the value of SAF, but they are not readily inclined to incur additional costs for it.

The respondent's attitude toward SAF seems positive. However, they also appear to understand the need for a comprehensive approach that may involve other sustainable practices or technologies in conjunction with SAF. Therefore, it can be inferred that respondents see SAF as a valuable step towards sustainability in aviation. However, they recognize the importance of a multifaceted approach to achieve broader environmental goals in the industry.

## 5.2 Choices of the Respondents

As mentioned in Chapter 4, each respondent receives eight sets of choice scenarios, where they must select one flight from two available options. Table 9 presents the attribute levels of these choice sets and illustrates the percentage of respondents who chose each flight option.

Table 9: Choice sets and their choices

| Choice situation | Flight1. price | Flight1.time | Flight1. CO2 | Flight1. Type | Flight2 .price | Flight2. Time | Flight2. CO2 | Flight2. Type | Flight 1 (%) | Flight 2 (%) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 50 | 2 | 0 | 0 | 50 | 4 | 50 | 2 | 57.1 | 42.9 |
| 2 | 400 | 4 | 50 | 0 | 225 | 6 | 50 | 0 | 15.1 | 84.9 |
| 3 | 225 | 6 | 100 | 0 | 225 | 4 | 0 | 1 | 63.9 | 26.1 |
| 4 | 225 | 4 | 0 | 1 | 400 | 2 | 50 | 1 | 69.7 | 30.3 |
| 5 | 50 | 6 | 50 | 1 | 225 | 2 | 50 | 2 | 50.4 | 49.6 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 400 | 2 | 100 | 1 | 400 | 6 | 100 | 2 | 84.9 | 15.1 |
| 7 | 400 | 6 | 0 | 2 | 400 | 2 | 100 | 1 | 7.6 | 92.4 |
| 8 | 225 | 2 | 50 | 2 | 50 | 4 | 100 | 2 | 11.8 | 88.2 |
| 9 | 50 | 4 | 100 | 2 | 50 | 6 | 50 | 1 | 97.4 | 2.6 |
| 10 | 400 | 6 | 100 | 2 | 225 | 4 | 100 | 1 | 4.5 | 95.5 |
| 11 | 50 | 4 | 50 | 2 | 400 | 4 | 0 | 0 | 97.4 | 2.6 |
| 13 | 225 | 4 | 100 | 1 | 225 | 6 | 100 | 0 | 75.3 | 24.7 |
| 14 | 400 | 2 | 50 | 1 | 50 | 2 | 0 | 0 | 4.5 | 95.5 |
| 15 | 50 | 6 | 0 | 1 | 400 | 4 | 50 | 0 | 89,0 | 11,0 |
| 16 | 50 | 2 | 100 | 0 | 225 | 2 | 0 | 2 | 96.1 | 3.9 |
| 17 | 225 | 6 | 50 | 0 | 50 | 6 | 0 | 1 | 16.9 | 84.9 |

Most choice sets exhibit a clear preference for a specific flight option. However, drawing definitive conclusions based on these choices is challenging. Nonetheless, this indicates the potential selections made by respondents. Such data serves as an essential input for the Multinomial Logit (MNL) model and Latent Class Choice Model (LCCM), where the significance and magnitude of attributes influencing flight choices will be examined. These models aim to clarify which attributes are significant and to what extent they impact the decision-making process when selecting a flight.

## 5.3 Factor analysis

One of the survey's aims was to assess person-related attributes using a set of 5-point Likert scales. Research sub-question two from Chapter 1 aimed to investigate the person-related characteristics influencing air travelers' willingness to pay for sustainable aviation fuel. This analysis can provide insights into addressing a portion of this question. In factor analysis, two approaches are commonly used: orthogonal and oblique. Orthogonal rotation assumes no correlation among the underlying components, while oblique rotation assumes correlations between them (Kootstra, 2004). Given the anticipation of interconnected underlying components, the oblique rotation was initially chosen in this study.

The Principal Axis Factoring (PAF) method with oblique rotation was employed to identify measuring scales that genuinely capture the same latent factor. Combining the measuring scales that measure the latent factor can provide a more accurate estimate of its underlying component. High intercorrelation among variables suggests that the same factor connects them. Subsequently, an exploration was conducted to ascertain if an orthogonal rotation could yield a meaningful structure without additional variable removal. Orthogonal Rotation was determined to produce a simple structure without excluding other variables. This approach ensures that factors remain uncorrelated, facilitating a more detailed interpretation. The SPSS software was employed to perform both orthogonal and oblique rotations. Molin (2017) outlined the factor analysis procedure to execute this analysis. A detailed description of the steps followed can be found in Appendix C, outlining the specific procedures implemented by Molin's (2017) factor analysis methodology.

The analysis was based on the various attitude questions mentioned in Chapter 4. An indicator was removed if it exhibited double loadings, and those double loadings were low (less than 0.50), and if it did not fit within a factor. The analysis identified seven factors: Sustainability Pressure, Efficacy SAF, Flight Shame, Importance of Positive Image, Importance of SAF, Greenest Airline Neophobia, and Flight Shame Alleviation through SAF.

Table 10: Results Factor Analysis

| **Factor 1: Sustainability pressure** | **Loading** |
|---|---|
| The Earth is like a spaceship with very limited room and resources | 0,623 |
| We are approaching the limit of the number of people the Earth can support. | 0,591 |
| **Factor 2: Efficacy SAF** | |
| Relying solely on SAF can create a misleading perception of sustainability while failing to address the fundamental issues of air travel. | 0,720 |
| SAF is an inadequate solution to the carbon emissions caused by flying. | 0,541 |
| Despite its adoption by the aviation industry, I remain unconvinced that SAF will lead to meaningful and substantial reductions in emissions. | 0,516 |
| Encouraging and prioritizing alternatives to flying, such as video conferencing or high-speed rail, is a more effective approach than relying heavily on SAF. | 0,395 |
| **Factor 3: Flight Shame** | |
| I feel guilty when I fly to a destination | 0,925 |
| I feel guilty whenever I travel by airplane for a city trip | 0,834 |
| When I am going to fly, I fear negative reactions from other people | 0,553 |
| I rather do not tell others when I travel by airplane for a holiday | 0,482 |
| Whenever I travel by airplane, I feel uncomfortable during and after a trip | 0,424 |
| **Factor 4: Importance of Positive Image** | |
| When choosing an airline, I prioritize the reputation and brand image of the main carriers due to their perceived quality. | 0,806 |
| A main carrier's reputation and brand image greatly influence my decision to choose their flights. | 0,613 |
| **Factor 5: Importance of SAF** | |
| Investing in research and development for advanced SAF technologies and sustainable feedstock sources can further improve its environmental performance. | 0,774 |
| SAF has the potential to contribute positively to reducing carbon emissions in aviation when combined with comprehensive and holistic strategies | 0,667 |
| I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry to mitigate the environmental impact of air travel. | 0,525 |
| It is crucial to prioritize SAF production methods that minimize environmental impacts and do not compete with food production. | 0,414 |
| **Factor 6: Greenest Airline Neophobia** | |
| The lack of awareness about the greenest airline makes it challenging for me to consider them as a preferred option. | 0,937 |
| I am hesitant to choose the greenest airline because I am unsure if they can meet my expectations in terms of service and reliability. | 0,565 |
| I am not familiar with the Greenest airline, and, as a result, I am uncertain about what to expect from their flights. | 0,527 |
| **Factor 7: Flight Shame Alleviation through SAF** | |
| When I can fly by airplane using SAF, my fear of negative reactions would diminish. | 0,875 |
| When I can fly by airplane using SAF, my willingness to share my holiday plans would increase. | 0,852 |
| When I can fly by airplane using SAF for a city trip, my guilt would diminish. | 0,777 |
| When I can fly by airplane using SAF, my feeling of guilt would diminish. | 0,772 |
| When I could fly by airplane using SAF, my feeling of discomfort during or after a flight would diminish. | 0,743 |

Each factor comprises at least two indicators with high loadings (at least >0.5). Moreover, indicators that exhibit high loadings on a specific factor can be grouped based on a common label. Although specific loadings do not reach the high threshold, they are retained within the factor due to their conceptual alignment. While the ideal goal of achieving a simple structure has not been fully attained, as evidenced by two indicators loading on multiple factors, the factor solution remains interpretable. Despite not displaying notably high loadings on their respective factors, these two indicators are conceptually relevant, leading to the decision to retain them in the analysis. This applies, for instance, to the final statement in factor 2. Seven different factors have been identified, and these factors will be added to the Latent Class Choice Model (LCCM) to examine their influence on the decision to fly with Sustainable Aviation Fuel (SAF). This will be further elaborated on in Chapter 7.

## 5.4 One-way ANOVA test

The second research question is: "What person-related characteristics influence air travelers' willingness to pay for sustainable aviation fuel?" The personal traits of the respondents have been captured in Tables 6 and 7. A factor analysis has also been conducted, as it can partially address the second research question. However, it is of interest to explore whether there exist any significant differences in willingness to pay for sustainable aviation fuel among distinct groups of air travelers based on these characteristics. For instance, we aim to investigate if variations in the "Sustainability Pressure" factor can be observed across different age groups. These findings can potentially provide a more comprehensive response to the research question.

Consequently, an ANOVA test will assess whether diverse sociodemographic groups exhibit statistically significant distinctions in their scores on the psychographic scales used to measure person-related characteristics (Kroesen, 2021). The results of the ANOVA test can be found in Table 11.

Table 11: Results ANOVA test

| | Flight Shame | Importance of SAF | Flight Shame Alleviation through SAF |
|---|---|---|---|
| **Gender** | | | |
| Male | -0.21 | | -0.19 |
| Female | 0.24 | | 0.24 |
| **Employment Status** | | | |
| Employed | | | |
| Student | 0.13 | | |
| Unemployed | -0.44 | | |
| Retired | | | |
| Other | | | |
| **Education** | | | |
| No formal education | | | |
| High School | | | |
| Vocational education | | | |
| Higher Vocational education | -0.51 | -0.36 | -0.42 |
| Bachelor | 0.01 | | |
| Master | 0.31 | 0.19 | 0.25 |
| PhD | 0.69 | 0.76 | |
| **Age** | | | |
| 18-25 | -0.29 | | |
| 25-45 | 0.16 | | |
| 45-65 | | | |

| | | | |
|---|---|---|---|
| 65+ | | | |
| **Income**<br>Low<br>Middle<br>High | <br>-0.21<br>0.15 | | |

What stands out is that not all factors are included in the table. This is because for the factors "Efficacy of SAF" and "Greenest Airline Neophobia," no significant differences were observed between the groups. Additionally, the values in the tables represent standardized factor scores. The factor analysis yielded factor scores with a mean of 0, indicating a neutral attitude of the respondents toward a particular factor. A negative factor score suggests a low level of endorsement or agreement with the variables included in the analysis, indicating a negative attitude towards the examined factor. The results are explained below for each socio-demographic characteristic.

Lastly, the socio-demographic characteristic "Live" only has two groups, so an ANOVA test could not be conducted. Therefore, a t-test for independent samples was performed; the results are below:

Table 12: Results t-test for independent samples

| | **Flight Shame** | **Sustainability Pressure** | **Importance of Brand Image** | **Importance of SAF** | **Flight Shame Alleviation through SAF** |
|---|---|---|---|---|---|
| **Live**<br>Netherlands<br>Belgium | <br>-0.49<br>0.48 | <br>-0.24<br>0.20 | <br>-0.11<br>0.12 | <br>-0.15<br>0.18 | <br>-0.35<br>0.40 |

### 5.4.1 Gender

Women have higher average scores on flight shame and flight shame alleviation through SAF attitude than men. While men have an average factor score of -0.21 for flight shame and -0.19 for flight shame alleviation through SAF, women have a score of approximately 0.24 for both factors. This indicates that women have a slightly more positive attitude towards these factors and generally experience more flight shame. Additionally, women perceive a more excellent alleviation of flight shame through using Sustainable Aviation Fuels (SAF).

### 5.4.2 Employment status

Employed individuals exhibit higher average scores on flight shame compared to students. Specifically, employed individuals have an average factor score of 0.13 for flight shame, whereas students have a score of -0.44. This suggests that employed individuals are slightly more positive towards these factors and tend to experience greater flight shame.

### 5.4.3 Education

The results indicate significant differences in the factor scores for Flight Shame among individuals with different educational levels. Compared to university-educated individuals, HBO (higher professional education) students and graduates have a lower average factor score for Flight Shame, specifically -0.51. For Bachelor's degree holders or students, the score is 0.01; for Master's degree holders or students, it is 0.31; and for Ph.D. holders or students, it is 0.69. This suggests that HBO students and graduates generally have a more negative attitude towards Flight Shame and experience less flight shame.

Regarding the factor of the Importance of SAF, educational levels also have significant differences. HBO students and graduates have a lower average factor score of -0.36, while Master's and PhD. Holders and students have higher scores of 0.19 and 0.76, respectively. This indicates that HBO students and graduates generally have a more negative attitude toward the importance of SAF and, therefore, rate SAF lower in terms of its significance.

Regarding the factor Flight Shame Alleviation Using SAF, the results show that HBO students and graduates have a lower average factor score of -0.42. In comparison, Master's degree holders and students have a higher score of 0.25. This suggests that HBO students and graduates generally have a more negative attitude towards Flight Shame alleviation using SAF and, therefore, experience less alleviation of flight shame through SAF.

### 5.4.4 Age

Respondents in the 18-25 age group have a lower average factor score than those in the 26-45 age group for flight shame. With an average factor score of -0.29, they score lower on the variables than respondents in the 26-45 age group, with an average factor score of 0.16. This indicates that the 18-25 age group has a negative attitude towards the flight shame attitude.

### 5.4.5 Income

The income variable has been recoded into three groups: low income (up to 30k), middle income (30,001 to 70k), and high income (70,001 and above). Among these groups, only the flight shame attitude shows statistically significant differences. Within this attitude, there are differences between the low-income and middle-income groups. Respondents with low income have an average factor score of -0.21, while respondents with middle income have a factor score of 0.15. This indicates that the low-income group has a negative attitude towards the flight shame attitude.

### 5.4.6 Live

Due to the variable "where do you live" having only two groups, an ANOVA test cannot be conducted. To assess significant differences between the means of two independent groups, a t-test for independent samples can be employed. This test is specifically designed to compare the means of two groups. The respondents were either from the Netherlands or Belgium. It is also of interest to investigate whether there are differences between these two groups. This information could be relevant for airlines and provide valuable insights into their operations and marketing strategies.

In this context, there are significant differences observed in several factors. Flight Shame has a mean factor score of -0.49 for respondents from the Netherlands, whereas the mean factor score is 0.48 for respondents from Belgium. Thus, Belgians exhibit a more positive attitude towards Flight Shame, experiencing it to a greater extent than the Dutch.

Regarding the Importance of Images, Dutch respondents have a mean factor score of -0.11, while Belgians have a mean factor score of 0.12. Although the difference is not substantial, on average, Belgians demonstrate a slightly more positive attitude toward the Importance of Image.

For the factor Importance of SAF, Dutch respondents have a mean factor score of -0.15, whereas Belgians have a mean factor score of 0.18. Belgians display a more positive attitude toward the Importance of SAF.

Regarding Sustainability Pressure, Dutch respondents have a mean factor score of -0.20, while Belgians have a mean factor score of 0.24. Belgians exhibit a more positive attitude towards Sustainability Pressure.

Lastly, concerning Flight Shame Alleviation using SAF, Dutch respondents have a mean factor score of -0.35, whereas Belgians have a mean factor score of 0.40. Belgians possess a more positive attitude towards Flight Shame Alleviation using SAF.

# 6 Choice model estimation

The estimating process for the MNL model and the LCCM will be described in this section. This section is useful as it will explain the methodology and process behind modeling respondents' choice behavior by estimating both the MNL model and the LCCM. The following chapter will present a more in-depth analysis of the results, facilitating answers to the research questions. Section 6.1 will cover the model information of the MNL model, followed by the model estimation of the MNL model in 6.2. Finally, the model estimation for the LCCM will be discussed in 6.3.

## 6.1 Model information MNL

The respondents were presented with a choice between two alternatives. The following formulations were given for the alternatives' systematic utility functions:

$$V[[j]] = \beta_{TC} * TC_j + \beta_{TT} * TT_j + \beta_{LB} * LB_j + \beta_{TCO2} * TCO2_j + \beta_{GA} * GA_j$$

Vj (j = 1,2) = the systematic utility of flight alternative j
$\beta_{TC}$ = parameter of the travel price attribute
$\beta_{TT}$ = parameter of the travel time attribute
$\beta_{TCO2}$ = parameter of the CO2 reduction attribute
$\beta_{LB}$ = parameter of the Low-Budget Carrier (Dummy)
$\beta_{GA}$ = Parameter of the Greenest airline Carrier (Dummy)

Type carrier is a discrete variable with three levels: 0 represents the main carrier, 1 indicates the low-budget carrier, and 2 corresponds to the Greenest airline. It should be dummy-coded to treat this variable as discrete in the model. The coding scheme can be found in Table 13.

Table 13: Coding scheme

| Type Carrier | Low-budget Carrier | Greenest Airline |
|---|---|---|
| Main Carrier | 0 | 0 |
| Low-Budget Carrier | 1 | 0 |
| Greenest Airline Carrier | 0 | 1 |

The main carrier serves as the reference category and has a value of 0, also called the constant or the utility of the reference alternative. In Chapter 7, the results of the utility contributions will be presented. However, testing for linearity is also performed. In this context, the statistical significance of the estimated parameter for the quadratic component is assessed. If this holds, that is, if the quadratic component parameter is significant, then the effect is non-linear. The following equation includes the quadratic components:

$$V[[j]] = \beta_{TC} * TC_j + \beta_{TT} * TT_j + \beta_{LB} * LB_j + \beta_{TCO2} * TCO2_j + \beta_{GA} * GA_j + \beta_{QTCO2} * QTCO2_j + \beta_{QTT} * QTT_j + \beta_{QTC} * QTC_j$$

Vj (j = 1,2) = the systematic utility of flight alternative j
$\beta_{TC}$ = parameter of the travel price attribute
$\beta_{QTC}$= parameter of the quadratic travel price attribute
$\beta_{TT}$= parameter of the travel time attribute
$\beta_{QTT}$ = parameter of the quadratic travel time attribute
$\beta_{TCO2}$ = parameter of the CO2 reduction attribute
$\beta_{QTCO2}$ = parameter of the quadratic CO2 reduction attribute
$\beta_{LB}$ = parameter of the Low-Budget Carrier (Dummy)

$\beta_{GA}$ = Parameter of the Greenest airline Carrier (Dummy)

In the case of dummy variables, typically, no linearity assessment is performed due to their discrete nature with a fixed and limited set of possible values. Including dummy variables implies a categorical and non-linear relationship between the dummy and dependent variables.

## 6.2 Model estimation MNL

The model is estimated using the Apollo choice-modeling R package (Hess & Palma, 2019). It is assumed that all respondents have the same taste parameters while estimating the MNL model. See Appendix D for the Apollo code's syntax, which was used to estimate the MNL model. The LCCM is contrasted with the MNL model to see if accounting for respondent variability improves model estimates. The Log-Likelihood, BIC, McFaddens' $\rho^2$ and AIC statistical criteria determine which model to choose.

Less negative values of the Log-Likelihood imply a larger capacity of the model to explain the data, which is how the model's explanatory power is measured (Hauber et al., 2016). Although it can be used to compare models, the log-likelihood cannot be utilized as a stand-alone measure of Goodness-of-Fit. McFaddens' $\rho^2$ can be used to evaluate the model's fit with the data similarly to the log-likelihood. It is also recommended to utilize McFaddens' $\rho^2$ in a relative sense, and for this metric, the higher the value, the better the fit (Chorus, 2022). Because the modified R-squared adds accuracy and dependability to the R-squared, it is advised to utilize it instead of the latter (Potters & Eichler, 2022).

As a final measure of model plausibility, AIC and BIC are frequently employed (Hauber et al., 2016). The Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) are measures used to assess the relative quality of different models. A lower AIC and BIC values indicate a better fit of the model to the data. The plausibility is assessed with an emphasis on reducing information loss.

The values of the MNL model's log-likelihood, McFaddens' $\rho^2$, AIC, and BIC are shown in Table 9 below. The following section discusses the findings of the MNL model estimation.

Table 14: Statistical criteria MNL model (quadratic)

| Statistical criteria | Output |
|---|---|
| Loglikelihood | -926.67 |
| McFaddens' $\rho^2$ | 0.3803 |
| AIC | 1869.33 |
| BIC | 1914.81 |

Table 15: Statistical criteria MNL model (Lineair)

| Statistical criteria | Output |
|---|---|
| Loglikelihood | -965.69 |
| McFaddens' $\rho^2$ | 0.3564 |
| AIC | 1941.37 |
| BIC | 1969.8 |

It can be concluded that the MNL model with quadratic parameters outperforms the MNL model with linear parameters on every statistical criterion. This can be attributed to the fact that the model has more parameters. However, this does not indicate whether the parameters exhibit a linear or non-linear relationship.

## 6.3 Model estimation for LCCM

To estimate the ideal number of classes, Bertrand and Hafner (2012) advise fitting the LCCM without covariates. The covariates can then be included to fit the LCCM with a particular number of classes. See Appendix E for the Apollo code's syntax, which was utilized to calculate the LCCM. It is thought that each person has a chance of falling into each segment, which may vary depending on their personality characteristics. As a result, a class membership model that models each person's class probability as a function of his or her sociodemographic features or other characteristics, for example, attitudes, is calculated concurrently with the parameters (Boxall & Adamowicz, 2002). The class membership model explains how the segments relate to people's traits. It is possible to determine the average class probability, which gives an idea of the relative size of each population segment, by averaging the anticipated individual class probabilities across all people.

A series of models were created to raise this number from 2 to 4 to identify the number of segments. In addition, a membership function was generated using the respondent attributes as predictor variables to forecast the likelihood that respondents would belong to each class (Molin & Maat,2015).

Table 16: Estimating of number of classes for the LCCM

| Classes | Log-likelihood | Parameters | McFaddens' $\rho^2$ | BIC | AIC | Smallest class(%) |
|---|---|---|---|---|---|---|
| **1 (MNL)** | -926.67 | 8 | 0.3803 | 1914.81 | 1869.33 | 100 |
| **2** | -865.17 | 17 | 0.4151 | 1860.98 | 1764.33 | 33,16 |
| **3** | 837.53 | 26 | 0.4275 | 1844.89 | 1727.07 | 18.25 |
| **4** | -833.51 | 35 | 0.4242 | 1936 | 1737.02 | 7.95 |
| **3(with covariates)** | -799.71 | 66 | 0.4678 | 1991 | 1701.42 | 18.25 |

One thing that instantly stuck out was that the MNL model, representing one class, received the lowest scores across the board. Therefore, one could conclude that including customer heterogeneity resulted in higher model estimates. The optimum model was determined by comparing the statistical criteria of the 2-class, 3-class, and 4-class LCCMs.

The 3-class model is the one that was deemed to have the best fit. The AIC and BIC values supported that the 3-class model was superior to the 2-class- and 4-class models. The 4-class model could not be selected due to the small sample size. A general rule of thumb is a minimum of 30 respondents in each segment, according to Paetz et al. (2019).

Now that the number of classes has been determined, it is possible to incorporate the covariates. These covariates encompass all sociographic characteristics, travel purpose, and flight frequency. The sociographic characteristics were previously described in Chapters 4 and 5. Furthermore, the attitudes obtained from Chapter 5 Data Analysis have been included as covariates. The outcomes of integrating these covariates into the 3-class are presented in the last row.

# 7 Recognizing the preferences and profiles of the travelers' segments

This chapter will explain the results of the MNL and LCCM models. The first part of this chapter will explain the MNL model, while the second part will cover the LCCM model. These results will enable us to address the research questions identified in Chapter 1.

## 7.1 Results MNL model

The model is estimated using the Apollo choice-modeling R package (Hess & Palma, 2019). This model can indeed contribute to answering a part of the main research question regarding the important factors in choosing to fly with Sustainable Aviation Fuel (SAF). It is assumed that all respondents have the same taste parameters while estimating the MNL model. The parameter estimations are shown in Tables 17 and 18 below. The following should be interpreted from the parameter estimates: the number of utilities gained or lost with each additional attribute unit. The parameter estimations and the t-value are displayed together. The t-value is frequently used in research to determine whether an estimate deviates considerably from zero. It is usual practice in research to employ a t-value of 1.96, meaning that estimations with a t-value over 1.96 are substantially different from zero, while those with a t-value below 1.96 are not.

Table 17: MNL results

| **Category** | **Variable** | **Par.** | **Est.** | ***t*-value** |
|---|---|---|---|---|
| Attributes | Travel price | $\beta_{TC}$ | -0.01 | -12.43 |
| | Duration | $\beta_{TT}$ | -0.35 | -10.81 |
| | CO2 reduction | $\beta_{TCO2}$ | 0.01 | 8.05 |
| | Low-budget Carrier | $\beta_{LB}$ | 0.01 | 1.02 |
| | Greenest Airline Carrier | $\beta_{GA}$ | 0.85 | 6.96 |

These results provide insights into the factors influencing the respondents' choices in the MNL model. It indicates the significance and direction of the effects of different attributes on the choice probabilities—t-ratios greater than 1.95 in absolute value, indicating that estimates are statistically significant. The estimates are rounded to two decimal places.

When an estimate has a negative sign, the utility decreases as the parameter's value increases. In Table 17, the travel price variable has a value of -0.01. This means that for each euro increase in travel cost, the utility decreases by 0.01. This interpretation applies to all variables except for the dummy-coded variable. The interpretation of the dummy-coded variable will be elucidated in the following paragraph. In Table 14, the coefficient for the low-budget carrier is not statistically significant, indicating that its impact on utility is not considered statistically meaningful compared to the reference category.

Table 18: MNL results, including quadratic parameters

| **Category** | **Variable** | **Par.** | **Est.** | ***t*-value** |
|---|---|---|---|---|
| Attributes | Travel price | $\beta_{TC}$ | -0.01 | -2.56 |
| | Duration | $\beta_{TT}$ | -0.55 | -2.47 |
| | CO2 reduction | $\beta_{TCO2}$ | -0.04 | -5.79 |
| | Low-Budget Carrier | $\beta_{LB}$ | 0.94 | 5.62 |
| | Greenest Airline Carrier | $\beta_{GA}$ | 1.37 | 8.16 |
| | Quadratic Travel price | $\beta_{QTC}$ | 0.00 | -2.01 |
| | Quadratic Duration | $\beta_{QTT}$ | 0.04 | 1.47 |
| | Quadratic CO2 reduction | $\beta_{QTCO2}$ | 0.00 | 7.83 |

Table 18 also includes quadratic parameters to assess whether there is a nonlinear relationship between the parameters and the choice. The quadratic travel cost and CO2 reduction are statistically significant, indicating a nonlinear relationship between these parameters and the choice.

However, the estimates of the linear parameters have also changed. Upon incorporating quadratic parameters, the estimation aims to identify the optimal linear and quadratic terms that best align with the observed choice data. Consequently, the values of the linear parameters may deviate from those in the purely linear Multinomial Logit (MNL) model. The model may now allocate a portion of the explanatory influence to the quadratic terms, resulting in distinct estimates for the linear parameters.

As previously mentioned, the values in the table have been rounded to 2 decimals, resulting in both of them having an estimate of 0. However, the low values of the quadratic term give rise to suspicion. It will be examined in section 7.1.1 whether the quadratic term will significantly impact the linear relationship that was expected or if the relationship will remain essentially linear. This finding suggests that the utility gained from a flight decreases more rapidly when, for example, the travel cost increases. In Table 15, however, the quadratic parameter for the duration is not statistically significant. This implies a linear relationship between the duration variable and util.

### 7.1.1 Testing Linearity

Considering that the quadratic parameters of Price and CO2 reduction are not particularly high in Table 17, further investigation is warranted into the relationship between these variables and the dependent variable. Therefore, the relationships are graphically depicted to examine the associations.


Figure 14: Impact of price on a utility

The value of the estimate for the linear parameter of the cost was -0.005442, and that of the quadratic parameter was -0,000007683. Both parameters are negative, indicating that utility will decrease with higher prices. As there is no linear relationship, it is evident that utility declines more as the price rises. The deviation is not very substantial, partly due to the relatively low estimate of the quadratic parameter. Nevertheless, the relationship is not linear. In a linear relationship, the utility should be twice as low if the price increases from 200 to 400. However, it can be observed that the utility has decreased by more than twice in this scenario.

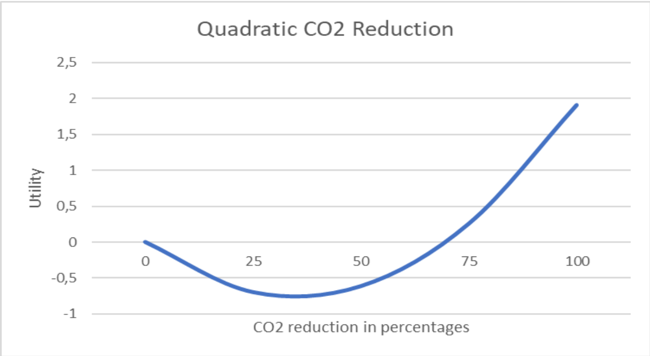


Figure 15: Impact of CO2 reduction on utility

The estimate of the linear parameter for CO2 reduction is -0.043612, while the estimate of the quadratic parameter is 0.00062649. The quadratic parameter is positive, which may increase utility with a higher level of CO2 reduction. Up to 50% CO2 reduction, the utility remains negative, whereas if the CO2 reduction exceeds 50%, the utility starts to increase. There is a significant surge in utility when CO2 reduction goes from 75% to 100%.

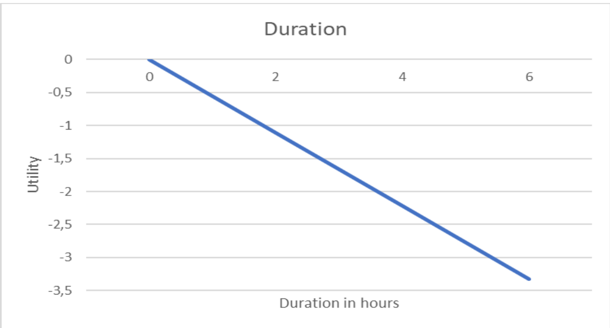


Figure 16: Impact of Duration on Utility

As expected, duration exhibits a linear relationship with the utility. As indicated in Table 17, the quadratic parameter was not statistically significant. The duration estimate was negative, implying that utility decreases proportionally as the duration increases. An increase in duration from 2 to 4 hours results in the same decrease in utility as an increase from 4 to 6 hours. This demonstrates the linearity of the relationship.

### 7.1.2 Explanation of type carrier

As mentioned earlier, the "Type carrier" variable is dummy-coded. The main carrier serves as the reference category and has a value of 0, also called the constant or the utility of the reference alternative. Table 17 shows that the "Low-budget Carrier" estimate is 0.94, and for "Greenest Airline," it is 1.37. The utility contributions of the three levels are as follows:

$$Main\ Carrier = 0.94 * Low\ budget\ Carrier + 1.37 * Greenest\ Airline = 0.94 * 0 + 1.37 * 0 = 0$$

$$Low\ budget\ Carrier\ = 0.94 * 1 + 1.37 * 0 = 0.94$$

$$Greenest\ Airline = 0.94 * 0 + 1.37 * 1 = 1.37$$

Below is the graphical representation:

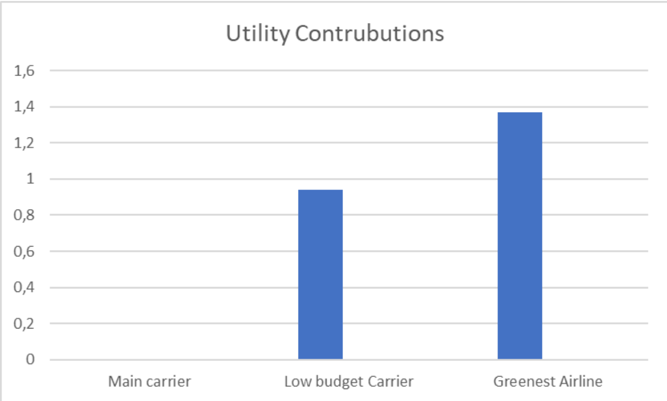



Figure 17: Utility contributions

The main carrier served as the reference category with a value of 0. The "Low-budget Carrier" has a value of 0.94, indicating a utility difference of 0.94 utils compared to the main carrier. The "Greenest Airline" has a value of 1.37, signifying a utility difference of 1.37 utils compared to the main carrier

## 7.2 The relative importance

The quadratic effects have influenced the linear effects, which are highly correlated. To calculate the importance of the attribute in the model with quadratic effects, it is necessary to determine the utility contributions of the two extreme levels based on both the linear and quadratic parameters and then calculate the utility difference. However, a different approach is applied to the "type carrier" attribute. When dealing with multiple dummy variables, the greatest difference between the two levels determines the utility range. In this case, only the difference between "greenest airline" and "main carrier" is considered, and the dummy for "low-budget carrier" does not play a role. To further calculate the relative importance, the attribute utility range for each attribute is computed and then divided by the total attribute utility range of all attributes combined.

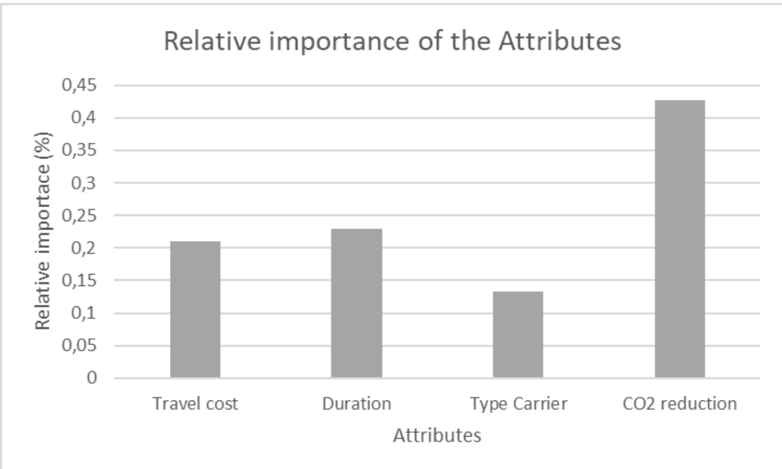



Figure 18: The relative importance of the attributes

It can be concluded that CO2 reduction has the most significant influence on the utility of an air traveler, followed by flight duration. These findings are of utmost importance as they address a key aspect of the main research question: identifying the factors influencing flying with Sustainable Aviation Fuel (SAF).

## 7.3 Results LCCM

The parameter estimates and the class membership estimations are discussed separately in this section. This paragraph addresses sub-questions 2 and 5 in Chapter 1 Introduction, which pertains to the different existing segments. The parameter estimates show how the associated attribute affects utility. The estimates of class membership describe which respondents are more likely to belong to each class.

In the MNL model, the quadratic parameter of travel cost was statistically significant. Its value was not very high and did not have a substantial impact. However, travel cost was in the LCCM not statistically high in any segment and consistently had a 0 (not rounded) value. Therefore, it was decided not to include this parameter in the model estimation.

The parameter estimations and the robust t-ratio are displayed together. As clarified, a high t-ratio indicates that the parameter significantly deviates from zero within the population. According to the t-ratio, the estimations in Table 18 with the most prominent effects on utility are those in the white color. Because they are not statistically significant, the parameter estimates in the grey-colored rows offer little information on which to base recommendations.

The covariate estimates for the other segments are calculated because the efficient traveler segment is the reference segment. The following interpretation should be made of the estimates: Given that the estimate for low income in the Economic-Environmental Sensitive Travelers segment is statistically significant and negative, it is anticipated that people with lower incomes will be more likely to belong to Segment 3(Reference)  than to Segment 1 (Price sensitive Travelers. Generally speaking, significant estimates show that they are class membership predictors (Lanza et al., 2007).

The mean probabilities for each class provide insights into the distribution of respondents among the identified classes. In this analysis, the mean probability for Class 1 is 0.31, suggesting that approximately 31% of the respondents are classified as belonging to this class. Similarly, the mean probabilities for Class 2 and Class 3 are 0.1825 and 0.5064, respectively, indicating the approximate proportions of respondents assigned to these classes.

Table19: Results LCCM

| | Economic-Environmental Sensitivity Travelers (31.12%) | | Efficient Travelers (18.25%) | | Price-Sensitive Travelers (50.64%) | |
|---|---|---|---|---|---|---|
| | Est. | Rob. t. rat. (0) | Est. | Rob. t. rat. (0) | Est. | Rob. t. rat. (0) |
| $\beta_{TC}$ | -0.02 | -2.65 | -0.01 | -3.13 | -0,02 | -7.29 |
| $\beta_{TT}$ | -0.32 | -0.21 | -1.31 | -2.99 | 0.97 | 0.67 |
| $\beta_{TCO2}$ | -0.83 | -6.64 | -0.01 | -0.44 | 0.11 | 2.6 |
| $\beta_{GA}$ | 3.4 | 6.07 | 0.45 | 1.58 | 2.44 | 3.70 |
| $\beta_{LB}$ | 1.6 | 3.90 | -0.48 | -1.12 | 0.97 | 0.67 |
| $\beta_{QTT}$ | -0.02 | -0.11 | 0.12 | 2.13 | -0.17 | -0.93 |
| $\beta_{QTCO2}$ | 0,01 | 7.13 | 0,0 | 1.05 | 0,00 | 1,88 |
| Constant | 5.29 | 2.06 | 0.9 | 0,04 | | |
| $\gamma_{low\_inc}$ | -1.07 | -2.42 | -0,79 | -2.17 | | |
| $\gamma_{male}$ | -0,26 | -0.42 | 0.02 | 0.06 | | |
| $\gamma_{education}$ | 0.06 | 0.37 | 0,24 | 1.13 | | |
| $\gamma_{leissure}$ | -0.64 | -1.11 | -0.14 | -0.30 | | |
| $\gamma_{Age}$ | -0,15 | -0.35 | 0.10 | 0.27 | | |
| $\gamma_{Employed}$ | 0.92 | 2.11 | 0.63 | 1.98 | | |
| $\gamma_{Netherlands}$ | -1.39 | 2.38 | -1,67 | -0,28 | | |
| $\gamma_{Flightshame}$ | 0.39 | 0.91 | 0.50 | 1.25 | | |
| $\gamma_{efficacy}$ | 0.11 | 0.29 | -0.17 | 0.46 | | |
| $\gamma_{Neophobia}$ | -0.05 | 0.17 | -0.16 | -0.57 | | |
| $\gamma_{SAF}$ | -0.41 | -1.26 | -0.68 | 2.24 | | |
| $\gamma_{Image}$ | -0.08 | -0.24 | 0.17 | 0.58 | | |
| $\gamma_{Flightshame\ SAF}$ | 0.93 | 1.83 | 0.29 | 0.80 | | |
| $\gamma_{\#Flights}$ | -3.03 | -2.12 | -1.29 | -2.31 | | |

## 7.3.1 Segment 1: Economic-Environmental Sensitive Travelers

As its name suggests, the segment prioritizes price and carrier type as its main attributes. The "Low-budget Carrier" coefficient has a value of 1.6, indicating a 1.6 utils difference in utility compared to the main carrier. On the other hand, the "Greenest Airline" coefficient has a value of 3.4, representing a utility difference of 3.4 utils compared to the main carrier.

Price is also an important parameter for this segment. The price coefficient has a negative sign, indicating that a price increase will lead to a decrease in utility for the travelers in this segment. CO2 reduction is also an important parameter for this segment. The quadratic parameter is statistically significant, indicating a non-linear relationship. The positive quadratic parameter implies that utility will increase with higher levels of $CO_2$ reduction. The linear parameter acts as the corrective factor.

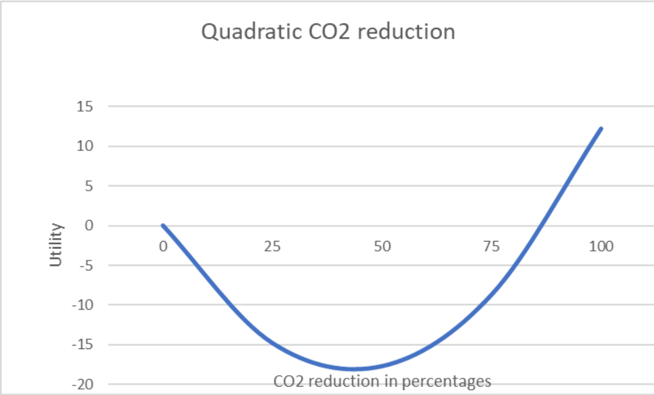


Figure 19: Impact of CO2 reduction on utility

Figure 19 illustrates that initially, as $CO_2$ reduction increases, utility decreases. However, starting from a $CO_2$ reduction of 50%, we observe a rapid and substantial increase in utility. Travelers in this class experience higher utility when the $CO_2$ reduction exceeds 50%. Furthermore, utility increases when $CO_2$ reduction goes from 75% to 100%.

Finally, the class membership estimates also reveal that low income, employment status, living in the Netherlands, and the number of flights are significant predictors of membership in the " Economic-Environmental Sensitive Travelers " segment. The coefficient for "Employed" is positive, indicating that individuals with a job are likelier to belong to this segment than Segment 3 (Reference). Furthermore, the estimates for "Low income," "Living in the Netherlands," and "Number of flights" in the "Economic-Environmental Sensitive Travelers" segment are all statistically significant and negative. This implies that individuals with lower incomes, those living in the Netherlands, and those taking fewer flights are likelier to belong to Segment 3 (Reference) than Segment 1 (Economic-Environmental Sensitive Travelers).

### 7.3.2 Segment 2: Efficient Travelers

This class exhibited distinct characteristics and preferences that set it apart from other segments. By examining the estimates of the parameters in our choice model, we gained valuable insights into the decision-making processes of individuals in this class.

Firstly, the estimated parameter for Travel Cost in this class was negative, indicating respondents preferred lower travel costs. This suggests that individuals in this segment were willing to pay less for their travel options.

Secondly, the parameter estimates for Travel Time revealed an interesting pattern. The linear estimate was negative, indicating a negative preference for longer travel times. However, the quadratic estimate is positive, indicating a non-linear relationship. It suggested that while initially, respondents in this Class showed a solid aversion to increasing travel times, the utility decreased at higher travel times. This finding implies that there may be a threshold beyond which individuals in this class become more accepting of longer travel times.

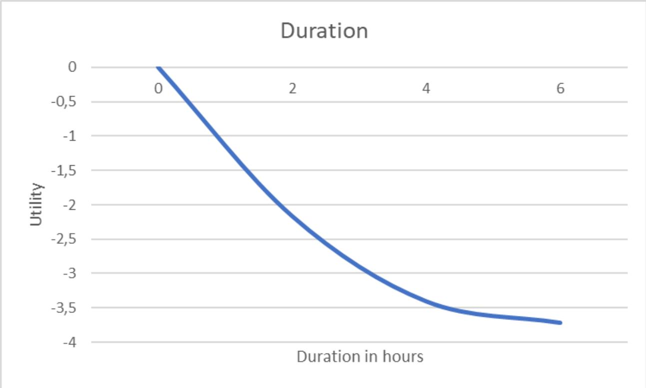



Figure 20: Impact of duration on utility

Travelers in this segment are initially sensitive to the duration of a flight. Their utility declines rapidly when the flight duration increases from 2 to 4 hours. However, after 4 hours, we observe a minimal decrease in utility. The positive quadratic term suggests that, at some point, the utility will start to increase as the duration increases. We already notice that from 4 to 6 hours, the decrease in utility is minimal, indicating that a turning point will be reached around that point. The utility will also increase as the duration increases beyond that point.

Finally, the class membership estimates indicate the importance of SAF, low income, employment, and flight as significant predictors of membership in the Efficient Travelers segment. The negative value of the importance of SAF indicates that the likelihood of someone considering the importance of SAF to be substantial is lower in this class compared to the Reference segment.

### 7.3.3 Segment 3: Price-sensitive Travelers

CO2 reduction is the most important attribute for travelers in this segment (based on the relative importance of the attributes). However, the decision not to label this segment as "economic-environmental sensitive travelers" is because Segment 1 exhibits a higher utility increase with a 100% CO2 reduction. Additionally, the quadratic CO2 reduction variable in this context demonstrates statistical significance, providing a more comprehensive understanding of the alteration in utility progression.

Travelers in this segment experience an increase in utility as CO2 reduction increases. Additionally, the utility of flying with the "Greenest Airline" is 2.44, representing a utility difference of 2.44 utils compared to the main carrier. Moreover, the ticket price is also a significant attribute for these travelers. An increase in the ticket price results in a decrease in utility.

This situation presents a dilemma. Are travelers in this segment willing to pay extra for more CO2 reduction, or do they simply state that they value CO2 reduction to feel better but would not act upon it (warm glow effect)? This dilemma will be further analyzed in this chapter and subsequent chapters. Understanding how travelers weigh their preferences for CO2 reduction, ticket price, and actual behavior will shed light on their decision-making processes and the underlying motivations driving their choices.

In conclusion, this analysis addresses research sub-question 5, which explores the existence of different segments among travelers. The results indicate the presence of three distinct segments: Price-Sensitive Travelers, Efficient Travelers, and Economic-Environmental Sensitive Travelers.

## 7.4 Profile of the classes

The capacity to calculate the posterior probability that a class member would possess a particular trait is one aspect of the LCCM. One can estimate, for instance, the proportion of men and women in each class. For all significant predictors of class membership, this will be determined. First, the posterior class allocation probability of an individual I for a specific class q is determined using the Apollo lcConditionals function. The likelihood of a person's posterior class allocation depends on the decisions they have made in the past and their likelihood given a specific class q. Each class's profile can be created using these probabilities.

Table 20: Profile of the classes

| Variable | Economic-Environmental Sensitivity Travelers | Efficient Travelers | Price-sensitive Travelers |
|---|---|---|---|
| Gender | Male | Female | Male |
| Education | Master | Higher Vocational education | Master |
| Employment status | Work | Work | Work/student |
| Live | Belgium | Netherlands | Netherlands |
| Age | 25-45 | 25-45 | 18-45 |
| Income | Middle-Income | Middle-Income | Low-income/Middle-income |
| Main reason | Leisure | Leisure | Leisure |
| Flights/year | 3-5 | 3-5 | Max 3 |

In this study, we aimed to explore and understand the distinct travel preferences and attitudes among different traveler segments. Through the analysis of survey data, we identified three distinct classes: Economic-Environmental Sensitivity Travelers (Class 1), Efficient Travelers (Class 2), and Price-Sensitive Travelers (Class 3). These classes represent unique groups of individuals with specific characteristics, preferences, and attitudes toward travel.

Starting with Class 1, the segment primarily comprises male respondents who prioritize cost and type carriers when making travel decisions. They are predominantly employers with middle incomes, aged between 25-45 years, flights between three and five times a year, and are more likely to choose leisure as their main reason for travel. They have higher educational qualifications, with many completing a master's degree.

Moving on to Class 2, the Efficient Travelers segment is characterized by a predominance of female respondents from the Netherlands. For the rest, this class appears to share many similarities with Segment 1. Class 3 represents Price-sensitive Travelers.

## 7.5 WtP for using SAF

As previously stated, unit variations prevent direct comparisons of estimations. Therefore, calculating the willingness to pay (WTP) is more insightful. Consumers' willingness to pay for a 1-unit increase or decrease in a characteristic is shown by the WtP. This analysis is conducted to answer research subquestion 3.

For attributes with a linear relationship with utility, the WtP is determined by the ratio between the attribute under consideration and the price parameter. Different formulas determine the WtP for qualities with a non-linear relationship with usefulness. When an attribute and utility have a quadratic relationship, the utility depends on both linear and quadratic terms. The utility contribution for the CO2 reduction, for instance, looks like this:

$$(\beta_{TCO2} + TCO2 * \beta_{QTCO2}) * TCO2$$

Finding the first derivative is the first step in calculating the WtP for such an attribute. The initial derivative appears as follows:

$$\beta_{TCO2} + 2 * \beta_{QTCO2} * TCO2$$

By dividing the derivative of the price's utility contribution, the WtP can be determined. The derivative equals βTC when the utility and price in the LCCM are viewed as being linearly related. Consequently, the following is the WtP of the CO2-reduction attribute calculation formula:

$$\frac{\beta_{TCO2} + 2 * \beta_{QTCO2} * TCO2}{|\beta_{QTC}|}$$

The WtP for the CO2-reduction attribute appears as follows based on the estimates for the Economic-Environmental Sensitive Travelers segment shown in Table 14:

$$\frac{-0.83 + 2 * 0.01 * TCO2}{0.02} = -41.5 + TCO2$$

The WtP for the remaining attributes can be calculated using the same formula. When the WtP is negative, a price reduction is required for consumers to purchase the goods. The WtPs are computed for each parameter and are described in more detail below.

Furthermore, if a quadratic parameter is not statistically significant, it is not considered when calculating willingness to pay (WTP). For instance, in Segment 3, the quadratic parameter of CO2 reduction is not statistically significant. The WTP is then equal to the estimate of CO2 reduction divided by the price. The non-significant parameter WtPs are displayed in colored gray.

Table 21: WTP

| **Attributes** | **Willingness to Pay** | | |
|---|---|---|---|
| | Economic-Environmental Sensitivity Travelers | Efficient Travelers | Price-Sensitive Travelers |
| **Duration** | -16 | -131+24TT | 48.50 |
| **CO2 reduction** | -41.5+TCO2 | -1.00 | 5.50 |
| **Low budget Carrier** | 80.00 | -48.00 | 48.50 |
| **Greenest Airline** | 170.00 | 45.00 | 122.00 |

## 7.5.1 Segment 1: Economic-Environmental Sensitive Travelers

This study examined the respondents' willingness to pay (WTP) for different attributes. Specifically, we focused on CO2 reduction, travel time, Low-budget carriers, and Greenest Airline. By analyzing the estimated parameters, we can gain insights into the monetary value that respondents attach to these attributes.

For the duration, the WtP is 16 euros. If a journey that currently takes 1 hour is extended to 2 hours, the Willingness to Pay (WtP) is equivalent to -16. In the case of a negative Willingness to Pay (WTP), it signifies traveler compensation. Travelers tolerate such a delay when adequately compensated, indicating a reduction in price by 16 euros. However, duration is not statistically significant in this segment. The absence of statistical significance regarding duration within this segment undermines its impact on decision-making. As a result, the influence of duration considerations on travelers' choices remains uncertain in this context. Nevertheless, it provides information and is the most relevant indication within this study.

The utility difference between flying with a Low-budget carrier and the Greenest airline was greater than zero for flying with a Main carrier. Travelers benefit more from flying with a Low-budget carrier and the Greenest airline than a Main carrier. The price of a Low-budget carrier ticket can increase by 80 euros to compensate for the utility gain compared to the Main Carrier. Similarly, the Greenest Airline's price can increase by 170 euros to compensate for the utility gain.

Finally, interpreting the willingness to pay (WTP) for CO2 reduction is somewhat challenging. Figure 20 provides a graphical representation of the WtP trend.

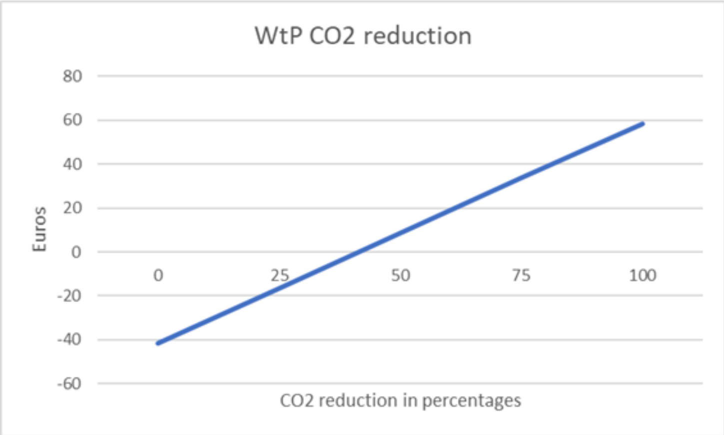



Figure 21: WtP CO2 reduction class 1

The willingness to pay (WTP) corresponds to the utility of CO2 reduction in this segment. We observe that the WTP is negative for a CO2 reduction of up to 50%. However, if the increase is more than 50%, travelers in this segment will pay more for a flight. When the CO2 savings move from 0 to 100%, travelers in this segment are willing to pay 58.50 euros.

### 7.5.2 Segment 2: Efficient Travelers

The WtP of -1.00 euro indicates diminishing returns for CO2 reduction. As more CO2 reduction is achieved, the travelers' incremental willingness to pay decreases, reflecting a less pronounced preference for further environmental improvements. As the CO2 reduction increases from 0 to 100, the Willingness to Pay (WTP) decreases by -100 euros. In the case of a negative Willingness to Pay (WTP), it signifies traveler compensation. Travelers tolerate such compensation when adequately compensated, indicating a reduction in price by 100 euros. However, this value is not statistically significant. The utility difference for flying with the Greenest airline was greater than zero for flying with a Main carrier. Travelers derive more utility from flying the Greenest airline than with a Main carrier. The Greenest Airline's price can increase by 45 euros to compensate for the utility gain. Low-budget Carrier's price must decrease by 48 euros. However, these WtPs are not statistically significant. The WtP duration is not readily deducible from the formula, which is why the WtP is graphically presented in Figure 21.

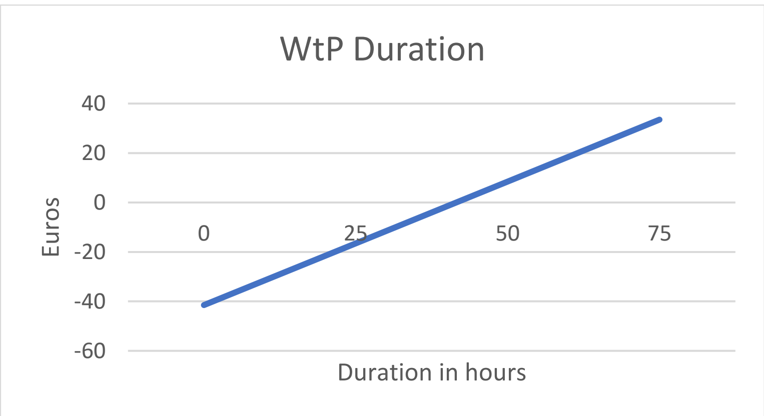



Figure 22: WtP Duration class 2

The WtP (Willingness to Pay) increases as the duration (TT) increases. For 0 to 2 hours, the WtP is -83 euros, indicating that individuals are willing to pay a negative amount. In the case of a negative Willingness to Pay (WTP), it signifies traveler compensation. However, as the duration increases from 2 to 4 hours, the WtP becomes -35 euros, which is less negative, implying that the perceived value is improving. Finally, from 4 to 6 hours, the WtP becomes positive at 13 euros, indicating that individuals are willing to pay a positive amount, signifying a higher perceived value for the flight at this longer duration.

### 7.5.3 Segment 3: Price-Sensitive Travelers

Based on the information provided, travelers from this segment are willing to pay an additional 5.50 euros for CO2 reduction. This indicates that they place a premium on environmentally-friendly practices and are willing to spend extra money to support initiatives to reduce carbon dioxide emissions. Travelers from this segment derive greater utility from flying with Greenest Airline than with a Main carrier. The price may increase by 122 euros to offset this utility gain, ensuring the overall utility remains unchanged.

## 7.6 Comparing WtP

The survey asked two questions regarding willingness to pay (WTP) for flights, one involving a main carrier and the other involving a budget carrier. Two identical questions were deliberately posed, differing only in terms of the type of carrier, to assess potential variations in the Willingness to Pay (WTP) for these different carriers. These questions were also included to examine the presence of warm glow, which refers to the intrinsic satisfaction or sense of fulfillment individuals experience when their actions align with their values or benefit others.

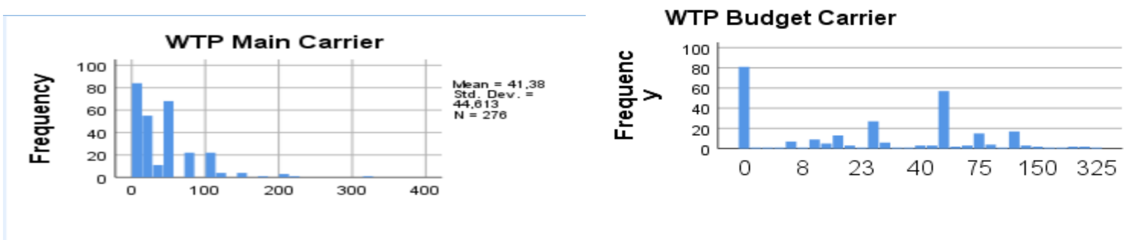



Figure 22: WTP for Main Carrier and Budget Carrier

The average amount respondents are willing to pay for a budget carrier is 37.68 euros, while for a main carrier, it is 41.39 euros. The CO2 reduction value provided in the survey was 80%. When we substitute this value into the WTP equation for the experiment, we obtain the following values: 38.50 euros for Economic-Environmental Sensitive Travelers, -80 euros for Efficient Travelers, and 440 euros for Price-Sensitive Travelers if the CO2 reduction moves from 0% to 80%.

It is also noteworthy that over 70 percent indicated an amount greater than 0 euros when asked about their willingness to pay extra for a flight that utilizes Sustainable Aviation Fuel (SAF). However, less than half of the respondents agreed, "I am willing to pay a premium for a flight that uses SAF." Notably, many respondents indicated amounts ranging between 1 and 5 euros as an additional payment; nevertheless, the disparity is striking.

There is an apparent discrepancy between what people choose and what they say they would pay. Therefore, respondents give different answers. When respondents are asked what they want to pay, they give a considerably lower amount than what is revealed by the experiment. The warm glow was already explained in Chapter 1. Warm glow refers to the psychological phenomenon where individuals derive a sense of satisfaction or positive feeling from engaging in pro-social or socially responsible behavior, such as supporting environmental causes or sustainable initiatives. In the context of willingness to pay for sustainable options, warm glow implies that respondents may be more willing to pay in surveys due to their desire to appear socially or environmentally conscious.

In surveys, respondents may consciously or subconsciously inflate their willingness to pay for sustainable products or services, including sustainable flights, to align with their self-image or desired social image as responsible citizens. This can result in discrepancies between their stated preferences and actual real-life behavior. Many of the respondents thus exhibited a warm glow. This causes the values obtained from the experiment to not align with what will happen. The values are overestimated.

The conclusion that can be drawn is that warm glow effects have influenced the respondents' stated willingness to pay in the survey. As a result, the values obtained from the experiment, particularly regarding their willingness to pay for sustainable flights, are overestimated and may not accurately reflect their actual behavior in real-life situations.

Given the presence of a warm glow, it is important to be cautious when interpreting the survey results and making decisions based solely on respondents' stated preferences. The overestimation of willingness to pay for sustainable options may lead to unrealistic expectations and potentially misinformed strategies for sustainable flight offerings.

Finally, while the survey provides valuable information about respondents' perceptions and attitudes towards sustainable flights, the presence of warm glow effects highlights the need to be cautious when extrapolating the results to predict real-world consumer behavior accurately.

# 8 Application

The findings from section 7 will be converted into traveler recommendations in this section. Three strategies will focus on the Greenest Airline, grounded on attributes. These identical strategies will be examined using an alternative distribution of class sizes. This decision was prompted by the results from Chapter 5, which exposed instances of both overestimating and underestimating specific personal characteristics in the sample.

The impact of autonomous innovations on the market share of SAF per segment will next be examined using three plausible future scenarios. These scenarios have been created to assess and comprehend the effect of upcoming developments on the flight alternative business. Based on this, whether or not the manufacturers of SAF substitutes should anticipate reaping significant benefits from future advancements may be established. Revenues, market share, and environmental effects will all be considered when presenting the outcomes of these hypothetical future events. The existing state, the base scenario, will be contrasted with the situation following the autonomous advancements.

## 8.1 Strategies Greenest Airline

The Greenest Airline can implement various strategies to offer flight options based on attributes such as Sustainable Aviation Fuel (SAF) type, CO2 reduction, price, and flight duration. By analyzing these strategies, we can examine their potential impact on choice behavior within different segments. The utility is computed for each strategy by estimating the impact of different attributes (Table 14). Estimates that do not reach statistical significance are set to zero. Subsequently, choice probabilities are calculated for each segment, considering the derived utility values for each strategy. Finally, the choice probabilities are aggregated by summing them across all segments, with weights corresponding to the class sizes. This allows for an overall evaluation of the strategies' effectiveness in influencing choice behavior within the entire population.

### 8.1.1 Implementing HEFA

Hydroprocessed Esters and Fatty Acids (HEFA) are the most commonly used form of SAF. Greenest Airline could evaluate the choice behavior when offering flights with HEFA. HEFA has the potential to achieve approximately 80% CO2 reduction. The baseline flight price without using SAF is assumed to be 150 euros, and a flight with HEFA would cost 195 euros. The flight duration is set at 2 hours. The Utility for the Economic-Environmental Sensitive Travelers:

$$\beta_{TC} * \mathrm{TC} + \beta_{TCO2} * \mathrm{TCO2} + \beta_{GA} * 1 + \beta_{QTCO2} * \mathrm{QTCO2} = -0.02 * 195 - 0.83 * 80 + 3.4 * 1 + 0.01 * 80^2 = -2.9$$

The exact computations have been carried out for the remaining two classes. The utility for Efficient Travelers is determined to be -4.09, while the Price-Sensitive Travelers exhibit a utility of 7.34. The choice probability for each segment can be determined by applying the following formula based on the utility. For the Price-Sensitive Travelers:

$$Choice\ Probability\ Price - Sensitive\ Travelers\ = \frac{e^{uPS}}{e^{uPS} + e^{uET} + e^{uEE}} = \frac{e^{7.34}}{e^{7.34} + e^{-4.09} + e^{-1.9}} = 100\%$$

The choice probabilities have been computed for the remaining two classes as well. The probability for Efficient Travelers is approximately 0%, while Economic-Environmental Sensitive Travelers exhibit a probability of 0%. The provided values are rounded and are, therefore, not exactly equal to zero. However, these values are so small that the decision has been made to round them.

To compute the aggregated choice probabilities across all classes, the choice probability for each class should be multiplied by its respective class size. The Weighted Choice Probability for Price-Sensitive travelers is 50%, for efficient Travelers is 0%, and for the Economic- Environmental Sensitive Travelers, 0%.

In conclusion, the weighted choice probabilities are combined by summation across all classes. The resulting aggregate choice probability amounts to 50%. Consequently, the overall choice probability across all classes, taking into consideration their respective class sizes, is approximately 50%. The overall choice probability for the different flight options or strategies offered by Greenest Airline, considering the preferences and class sizes of different segments, is approximately 39.5%. This means that, on average, around 50% of the respondents in the study are likely to choose one of the flight options or strategies presented by Greenest Airline.

### 8.1.2 Implementing FT

However, the Greenest Airline predicts that Fischer-Tropsch (FT) will experience a rise in popularity. However, the current price of FT is relatively high. According to Table 6, the cost can be 6.4 times higher than the current jet fuel. Nevertheless, the introduction of FT is a promising addition to SAF, as it offers greater CO2 reduction compared to HEFA. Using Municipal Solid Waste can achieve a 94% CO2 reduction, significantly higher than with HEFA. The Greenest Airline expects the FT price to decrease rapidly and be approximately three times higher than the current jet fuel price. As part of this strategy, it is postulated that CO2 reduction will reach 100%, considering the promising advancements in this area. Consequently, the ticket price will be adjusted to 240 euros for a 2-hour flight.

The same calculations are done. The resulting aggregate choice probability amounts to 32%. %. The overall choice probability for the different flight options or strategies offered by Greenest Airline, considering the preferences and class sizes of different segments, is approximately 32%. This means that, on average, around 32% of the respondents in the study are likely to choose one of the flight options or strategies presented by Greenest Airline. This is mainly caused by the Economic-Environmentally Sensitive Travelers. The choice probability for these travelers is 99.9%, making this strategy appealing.

This strategy results in a reduction of choice probability due to its appeal to the Economic-Environmentally Sensitive Travelers. However, it should be noted that this segment is smaller in magnitude compared to, for example, Price-Sensitive Travelers. Consequently, the overall choice probability is anticipated to be lower.

### 8.1.3 Increasing Market Share

The third strategy is designed around offering a lower price. In the immediate future, this approach may lead to financial losses for Greenest Airline. However, strategically, it can prove beneficial as it fosters heightened brand recognition for Greenest Airline. This approach is commonly employed by major corporations such as Facebook, Uber, and Airbnb, among others, willing to make short-term concessions to secure long-term profitability. Consequently, the flight price for this strategy will be set at 195 euros, matching the cost of a flight with HEFA and a CO2 reduction of 100%.

The same calculations are done. The resulting aggregate choice probability amounts to 32%. %. The overall choice probability for the different flight options or strategies offered by Greenest Airline, considering the preferences and class sizes of different segments, is approximately 32%. This means that, on average, around 32% of the respondents in the study are likely to choose one of the flight options or strategies presented by Greenest Airline. This is mainly caused by the Economic-Environmentally Sensitive Travelers. The choice probability for these travelers is 99.9%, making this strategy appealing.

In conclusion, analyzing the strategies reveals the intricacy of enhancing choice probability among travelers. This complexity stems from the significance of price as a pivotal attribute within each segment. Across all segments, utility diminishes as the price increases. Furthermore, a dualistic situation arises where a subset of travelers encounters an augment in utility with an escalation in CO2 reduction. At the same time, another subgroup experiences a decrease in utility with a similar increase in CO2 reduction. This demonstrates that the strategies should not be exclusively centered around attributes. Many travelers do not perceive any utility from further CO2 reduction. Thus, even if the CO2 reduction were hypothetically increased beyond 100%, which is not possible, it would still not lead to an increase in utility for a significant segment of travelers. Consequently, the strategies should encompass more than just attributes. Travelers who do not find utility in CO2 reduction should be addressed differently. This will be elucidated in Chapter 9.

## 8.2 Revised Strategies Greenest Airline

As indicated in Chapter 5, it is acknowledged that the sample utilized in this study is not entirely representative of the broader Dutch and Belgian populations. A significant number of students in the sample skews the age distribution, resulting in a higher proportion of younger individuals than the actual population. Consequently, the class sizes derived from the sample may not accurately reflect the actual class sizes in the entire population. In light of this potential overestimation or underestimation, an effort was made to estimate the exact class sizes by examining the relationship between class membership in the sample and the target population's characteristics. While this estimation process involves speculation, the assumptions, and specific methodology were explicitly outlined and disclosed.

The size of each class may be influenced by the income disparity observed among different groups of travelers, with students and young travelers generally earning less than working individuals and older travelers. This financial disparity may contribute to price-conscious behavior among the former group, as they often operate with limited budgets. Furthermore, a Central Bureau for the Statistics (CBS) study indicates that younger individuals exhibit greater environmental awareness than older age groups, displaying higher levels of concern regarding environmental issues. The study found that 45% of young people between the ages of 18 and 25 regard ecological pollution as a significant or very significant problem (Central Bureau for the Statistics, 2019). Consequently, the class size of the Economic-Environmental Sensitive Travelers segment is more substantial, likely owing to the more extensive representation of young individuals in the sample. The class size might be overestimated in Segment 1, Economic-Environmental Sensitive Travelers. This could be attributed to older travelers favoring main carriers due to their comfort and services (Fleming, A., 2019).

Price and duration significantly influence the Efficient Traveler segment's choices. As prices rise, the utility declines, as does utility with increasing time. However, beyond the 5-hour mark, the utility no longer exhibits a diminishing trend in this segment. Instead, a quadratic effect becomes evident, suggesting the utility might increase for longer durations. It is logical for the utility to decrease with shorter flight durations, as travelers have various alternatives to reach their intended destinations. On the contrary, air travel becomes one of the few viable options for longer flights, increasing utility.

According to Skyscanner's research, price-driven travel will notably dominate priorities in 2023. Their recent surveys reveal that half of all consumers plan to take short-haul flights next year. Additionally, with Asian countries reopening their borders to international tourists, 38% of travelers have set their sights on long-haul adventures. Skyscanner's data corroborates these findings, as eight destinations on the top 20 emerging destinations are long-haul locations (Skyscanner, 2022).

However, it is essential to acknowledge that although the sample may not fully represent the entire Dutch and Belgian populations, it is likely to approximate the flying population closely. There might be a greater probability that younger individuals and those with higher educational backgrounds will have higher flying frequencies. Nevertheless, the class sizes have been modified accordingly. The Efficient Travelers segment will be assigned a class size of 33.25%, the Economic-Environmental Sensitive Travelers segment will have a class size of 26.12%, and the Price- Sensitive Travelers segment will have a class size of 40.64%.

The first strategy, incorporating HEFA with an 80% CO2 reduction, a price of 195 euros, and a duration of 2 hours, yields an aggregate choice probability of 40.7%. Considering their respective class sizes, the overall choice probability across all classes is approximately 40.7%. Consequently, considering the preferences and class sizes of various segments, the overall choice probability for the different flight options or strategies offered by Greenest Airline is approximately 40.75%. This indicates that, on average, about 40.7% of the respondents in the study are likely to select one of the flight options or strategies presented by Greenest Airline.

For the second strategy, involving FT with a 100% CO2 reduction, a price of 240 euros, and a duration of 2 hours, the resulting aggregate choice probability amounts to 27.4%. Considering their respective class sizes, the overall choice probability across all classes is approximately 27.4%.

Lastly, the third strategy, entailing a price reduction of the flight to 195 euros, results in an aggregate choice probability of 28.6%. Considering their respective class sizes, the overall choice probability across all classes is approximately 28.6%.

In conclusion, the recalibrated class sizes reveal a notable decrease in the probability of a traveler selecting a sustainable flight. This reflects a more realistic depiction, given the higher representation of younger individuals in this sample, who exhibit a greater environmental consciousness than older demographics. Nonetheless, it is essential to recognize that these class sizes are currently determined based on assumptions, introducing an element of subjectivity to the probabilities. Despite this, they provide valuable indications of potential shifts in choice behavior. Furthermore, the magnitude of CO2 reduction determines the segment in which the Choice Probability is high. For CO2 reduction values ranging from 0 to 80%, the Price-Sensitive Travelers will exhibit the highest Choice Probability for booking this ticket. Subsequently, from 80 to 100% CO2 reduction, the Economic-Environmentally Sensitive Travelers segment will manifest the highest Choice Probability. This complexity complicates drawing clear conclusions from these strategies, given that CO2 reduction is the sole predictor.

## 8.3 Revised Strategies Greenest Airline

Following this, exploring potential supplementary strategies that do not rely on attributes but rather pertain to marketing elements (awareness) is pertinent. Nevertheless, it is crucial to acknowledge that these strategies lie beyond the purview of our present model, thus representing pure speculation. Before discussing various scenarios, it is advisable to establish a base scenario for comparison to evaluate future scenarios. We have three alternatives to compare: main carriers, low-budget carriers, and the Greenest Airline. These different carriers possess distinct attributes. In the base scenario, the Main Carrier has a ticket price of 200 euros, a travel time of 2 hours, a CO2 reduction of 0%, and, naturally, the carrier type is the Main Carrier. For the Low-budget Carrier, the price is set at 100 euros, the travel time is 4 hours, there is no CO2 reduction (0%), and the carrier type is the Low-budget Carrier. Finally, the Greenest Airline has a ticket price of 260 euros, a travel time of 2 hours, a CO2 reduction of 80%, and the carrier type is the Greenest Airline.

Table 22: Base Scenario

| Attribute | Attribute value |
|---|---|
| Travel price | 100 euro |
| Travel time | 4 hours |
| CO2 reduction | 0% |
| Type carrier | Low-budget |

| Attribute | Attribute value |
|---|---|
| Travel price | 200 euro |
| Travel time | 2 hours |
| CO2 reduction | 0% |
| Type carrier | Main Carrier |

| Attribute | Attribute value |
|---|---|
| Travel price | 260 euro |
| Travel time | 2 hours |
| CO2 reduction | 80% |
| Type carrier | Greenest Airline |

$$Market\ share\ Main\ Carrier\ = \frac{e^{MC}}{e^{MC} + e^{LBC} + e^{GS}}$$

The utility for the Low budget carrier is 1.4, while the utility for the Main carrier is -4, and for the Greenest airline, it is -7.6 in the Economic-Environmental Sensitive Travelers segment. If we plug these values into the formula, the market share for the Main carrier in the Economic-Environmental Sensitive Travelers segment is equal to 2.% %. We performed the same calculations for the other segments and type carriers; the results can be found in Table 18.

Table 23: Market shares Base scenario

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 87 | 16 | 61 |
| Main Carrier | 2 | 50 | 8 |
| Greenest Airline | 11 | 35 | 31 |

In 2022, an estimated 28 million passengers transited through Belgian airports (Statbel,2023). However, precise data about the number of passengers flying to European destinations remains unavailable. As a reasonable estimate, we assume that approximately 65% of the total passenger volume is engaged in flights within Europe. This assumption is based on the prevailing travel restrictions that limited international travel beyond European borders due to the COVID-19 pandemic. Accordingly, it can be deduced that roughly 18 million passengers departed from Belgium to destinations within Europe.

By multiplying the market share by the number of passengers flying within the European Union and the flight cost, the market shares can be converted to annual revenues. When figuring out the revenues per class, it is critical to consider the class size. The number of classes is multiplied by the number of passengers flying annually. This amount is multiplied by the market share of the type carrier in that category. The final step is multiplying the last number of flights by the selling price. We will employ the estimated class sizes as they offer the most robust indicators, considering that the other approaches are founded on assumptions and conjectures.

$$Revenue = 18\, million * class\ size * Market\ share * price$$

For the Economic-Environmental sensitive travelers who choose to fly with a low-budget carrier, the revenue is equal to:

$$Revenue = 1.8million * 0.3112 * 0.87 * 100 = 484.5million\ euros$$

Table 24: Revenues in a million euros Base scenario

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 484.5 | 52.1 | 553,8 |
| Main Carrier | 26.5 | 325,7 | 194.9 |

| | | | |
|---|---|---|---|
| Greenest Airline | 159.0 | 295.3 | 73.5 |

## 8.4 Future scenarios

The rest of this chapter will examine a few likely future situations. Autonomous developments bring forth these potential futures. The Fisher-Tropsh conversion method illustrates such an independent evolution. The availability of HEFA for all types of carriers is the second possibility to be examined. The third future scenario will be the availability of FT for all types of carriers. The fourth future scenario will be discussed is the price reduction of SAF due to less expensive production methods. The existing baseline scenario will be outlined first. Then, the alternative situations will be contrasted with the first scenario. These scenarios were previously outlined exclusively for the Greenest Airline. Presently, the scope has been broadened to include all three types of carriers, aiming to investigate potential developments.

### 8.4.2 Scenario 1: Introducing Fisher-Tropsh

As described in Chapter 2, HEFA is currently the most commonly used conversion process for Sustainable Aviation Fuel (SAF). However, the Greenest Airline predicts that Fischer-Tropsch (FT) will experience a rise in popularity. However, the current price of FT is relatively high. According to Table 6, the cost can be 6.4 times higher than the current jet fuel. Nevertheless, the introduction of FT is a promising addition to SAF, as it offers greater CO2 reduction compared to HEFA. Using Municipal Solid Waste can achieve a 94% CO2 reduction, significantly higher than with HEFA. The Greenest Airline expects the FT price to decrease rapidly and be approximately three times higher than the current jet fuel price. The Main and Low-budget carriers' attribute levels will remain the same in this scenario. For the Greenest Airline, the CO2 reduction and cost will change. The price will be 320 euros, and the CO2 reduction will be 100%. Further improvements could lead to a 100% CO2 reduction. The updated data below will determine and present the market shares and revenues.

Table 25: Market shares scenario 1

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 94 | 19 | 77 |
| Main Carrier | 3 | 59 | 10 |
| Greenest Airline | 3 | 22 | 12 |

In this scenario, the market share of the Greenest Airline significantly decreases among Economic-Environmental sensitive and efficient travelers. On the other hand, the market share of low-budget carriers will further increase.

Table 26: Revenues in billion euros scenario 1

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 528.8 | 61.7 | 705.2 |
| Main Carrier | 28.9 | 385.9 | 305.4 |
| Greenest Airline | 54.3 | 236.4 | 354.8 |

In this scenario, the Greenest Airline witnesses a revenue decrease within the first two segments. However, there is a substantial increase in revenues in the Economic-Environmental-Sensitive Travelers segment. This can be attributed to the fact that CO2 reduction is now enhanced to 100% instead of 80%.

### 8.4.3 Scenario 2: HEFA for everyone

The second scenario explores the potential impact of all carriers accessing Sustainable Aviation Fuel (SAF). Given that these carriers already have a strong reputation among travelers, it is intriguing to investigate the potential outcomes of these carriers adopting SAF. The collective adoption of SAF by all carriers can have a significant positive impact on reducing greenhouse gas emissions. It aligns with the global efforts to combat climate change and promotes a more sustainable future for the aviation industry.

In the second scenario, the price for the low-budget carrier is now 130 euros, and the CO2 reduction is 80%. Similarly, for the Main carrier, the price is 260 euros, and the CO2 reduction remains at 80%. The Main carrier shares the same attribute levels as the Greenest Airline, except for the type of carrier.

Table 27: Market Shares Scenario 2

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 68 | 11 | 52 |
| Main Carrier | 1 | 57 | 4 |
| Greenest Airline | 31 | 32 | 44 |

As a result of the increased ticket prices and CO2 reduction of other carriers, the market shares have changed compared to the base scenario. The Greenest Airline's market share generally increases, except for the Efficient Travelers segment. On the other hand, the Low-budget carriers lose their market share, which could be explained by their longer travel time and higher prices.

Table 28: Revenues in billion euros scenario 2

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 382.5 | 46.9 | 615.1 |
| Main Carrier | 14.9 | 483.9 | 91.4 |
| Greenest Airline | 446.9 | 276.4 | 1048.3 |

Despite losing some market share, the Low-budget carriers have increased their revenues due to the higher ticket prices. Similarly, the Greenest Airline experiences higher revenues in this scenario, while the Main carriers suffer a significant revenue decline.

### 8.4.4 Scenario 3: Fisher-Tropsh for everyone

In an ideal world, aviation companies would eliminate CO2 emissions and achieve entire carbon savings. This possibility could be realized through the universal adoption of Sustainable Aviation Fuel (SAF). Airlines must demonstrate firm commitments and ensure that environmental degradation is avoided. In this context, low-budget carriers offer their services for 160 euros, providing a 100% CO2 reduction due to using SAF. Meanwhile, Main carriers charge 320 euros for their flights.

Table 29: Market shares Scenario 3

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 79 | 13 | 66 |
| Main Carrier | 1 | 59 | 3 |
| Greenest Airline | 20 | 28 | 31 |

This scenario leads to Main carriers experiencing substantial challenges. This is attributed to the inclination of travelers from this sample to favor Low-budget carriers and the Greenest Airline. Consequently, their market shares remain relatively stable, with a marginal decrease in one segment counterbalanced by a corresponding increase in another.

Table 30: Revenues in billion euros Scenario 3

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 446.4 | 66.9 | 966.8 |
| Main Carrier | 11.7 | 62.5 | 78.8 |
| Greenest Airline | 352.2 | 292.2 | 904.3 |

The low-budget carriers and Greenest Airline observe a significant revenue surge within the third segment. This is due to travelers from this segment experiencing an increase in utility with higher levels of CO2 reduction. Furthermore, the higher ticket prices contribute to the generation of enhanced revenue.

### 8.4.5 Scenario 4: Lowering the SAF price

SAF is more expensive than conventional kerosene. As mentioned in Chapter 4, a ticket's price is approximately 30% kerosene cost. When flying with SAF, this price would at least double, as HEFA, currently the most accessible SAF option, is already twice as expensive as conventional kerosene. This means a ticket that originally cost 100 euros would now cost 130 euros. The experiment revealed that respondents considered price the essential attribute, and their utility decreased the most when the price increased. Therefore, in this scenario, we will explore the potential impact of a price reduction for HEFA. This price reduction could result from improved technology/expertise and government support. In this scenario, we will examine the potential effects of a 10% price decrease.

Table 31: Market Shares Scenario 4

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 81 | 14 | 50 |
| Main Carrier | 2 | 45 | 7 |
| Greenest Airline | 17 | 41 | 43 |

This scenario leads to an increase in market share for the Greenest Airline and a decrease for the low-budget carriers. The Main carrier's market share also increases due to this scenario.

Table 32: Revenues in billion euros Scenario 4

| | Economic-Environmental Sensitive Travelers (31.12%) | Efficient Travelers(18.25%) | Price-Sensitive Travelers(50.64%) |
|---|---|---|---|
| Low-budget Carrier | 452.1 | 47.2 | 457.1 |
| Main Carrier | 24.7 | 295.3 | 144.7 |
| Greenest Airline | 22.4 | 312.7 | 918.7 |

Finally, the price decrease of SAF leads to an increase in market share and boosts the revenues of the Greenest Airline in the Economic-Environmental Sensitive Travelers Segment. Nonetheless, the revenues decline in the remaining segments, from which the other two types of carriers derive higher revenues.

In conclusion, these scenarios are naturally subject to limitations, as they rely on various assumptions and omit certain factors. Nevertheless, they offer valuable insights into the potential market share and revenue changes under different circumstances. Notably, the scenarios involving the universal adoption of Sustainable Aviation Fuel (SAF) are exciting and merit further exploration. Competition within the industry may increase SAF prices, thereby augmenting the appeal of SAF-based flights for travelers.

# 9 Conclusion & Discussion

The invention of aircraft has revolutionized global connectivity, trade, and exploration, allowing people to travel long distances quickly and efficiently. However, the aviation industry's environmental impact, particularly concerning CO2 emissions, is a cause for concern. Before the COVID-19 pandemic, commercial aviation accounted for 2-3% of anthropogenic CO2 emissions worldwide. In Europe alone, departing flights in 2016 contributed to roughly one-fifth of global aviation emissions.

Henceforth, aviation must embrace a more environmentally conscious trajectory. The aviation sector has acknowledged the imperative to transition toward ecologically sound practices, and a pivotal solution in this regard is adopting sustainable aviation fuel (SAF). SAF, which does not necessitate modifications to existing aircraft, shares identical chemical properties with conventional fossil fuels. Its production stems from sustainable origins, encompassing e-fuels derived from solar/wind energy, hydrogen, and recycled CO2 and biofuels sourced from agricultural or municipal waste byproducts. The Greenest Airline stands as an emerging aviation entity steadfastly devoted to advancing the sustainability of air travel through the utilization of Sustainable Aviation Fuel (SAF). Nevertheless, substantial uncertainties persist, given that SAF has yet to be integrated into flight operations. This research has aimed to address the following Main Question and sub-questions:

*"What are the underlying factors that influence the willingness of air travelers to pay for sustainable aviation fuel?"*

- To what extent do product-related characteristics influence the willingness to pay air travelers?
- What person-related characteristics affect air travelers' willingness to pay for sustainable aviation fuel?
- What is the willingness to pay for Sustainable Aviation Fuel, and how many individuals are willing to pay extra for it?
- How can biases in data collection be minimized to ensure the accuracy and representativeness of research findings on consumers' willingness to pay for sustainable products or services?
- What traveler sub-segments may be recognized within the possible SAF alternative adopter segment based on attribute preferences, and what do those segments' profiles look like?

## 9.1 Conclusions

This study's responses to the research inquiries were meticulously garnered through a comprehensive survey augmented by a stated choice experiment. After data collection, a rigorous analysis was undertaken to employ both SPSS and Apollo. The former platform facilitated an in-depth examination of the dataset. At the same time, the latter witnessed the execution of two distinct analytical methods: the Multinomial Logit model and the Latent Class Choice model.

Of the diverse attributes investigated, including ticket price, flight duration, type carrier, and the magnitude of CO2 emissions reduction, it was discerned through the Multinomial Logit model that the pivotal factor shaping the utility of air travelers was the degree of CO2 emissions reduction, closely followed by flight duration. This revelation illuminates the paramount importance ascribed to CO2 emissions reduction when travelers make choices regarding their flights.

It is worth noting, however, that such a broad assertion tends to oversimplify the nuanced preferences of individual travelers. A more nuanced approach was adopted by applying the Latent Class Choice model, enabling the categorizing of distinct traveler profiles. The outcome of this endeavor unveiled three discernible segments: the Economic-Environmental-Sensitive Travelers segment, the Efficient Travelers Segment, and the Price-Sensitive

Travelers segment. Approximately 31% of the survey respondents could be categorized under the Economic-Environmental Sensitive Travelers class, while the Efficient Travelers and the Price-Sensitive Travelers encompassed approximately 18.25% and 50.64% of respondents, respectively. The survey ultimately yielded responses from 276 participants.

Within the ambit of these segments, the Economic-Environmental Sensitive Travelers stand out as a group particularly pertinent to adopting Sustainable Aviation Fuel (SAF). This cohort of travelers exhibits a heightened sense of utility as the magnitude of CO2 reduction surpasses the 50% threshold. This utility continues ascending as CO2 reduction progresses from 75% to 100%. Such findings underscore the parallel increase in utility in direct proportion to the level of CO2 reduction for this particular segment.

The composite portrait of the Economic-Environmental Sensitive Travelers emerges as follows: typically male, possessing a Master's Degree in education, currently employed, residing in Belgium, aged between 25 and 45 years, enjoying a middle-income bracket, primarily traveling for leisure purposes, and undertaking a moderate annual frequency of air travel, ranging between 3 to 5 flights.

Based on these findings, the determination of willingness to pay (WTP) per segment was also achievable. For the Economic-Environmental Sensitive Travelers segment, as the CO2 reduction escalates from 0% to 80%, the WTP equates to 38.50 euros. Conversely, the WTP registers at -80 euros for the Efficient Travelers segment, while for the Price-Sensitive Travelers segment, it reaches 440 euros. As the CO2 reduction is further elevated from 0% to 100%, the respective WTP values become 58.5 euros, -100 euros, and 550 euros.

The negative Willingness to Pay (WTP) observed among efficient travelers implies a distinctive scenario where travelers seek compensation. This occurrence indicates that travelers are willing to accept a reduction in cost under the condition of receiving appropriate compensation. However, it is imperative to note that the WTP for this segment lacks statistical significance. Consequently, the extent of the influence exerted by considerations of CO2 reductions on travelers' choices remains uncertain within this context.

Significantly, the WTP for the Price-Sensitive Travelers segment stands out for its substantial magnitude. Nevertheless, this exorbitant WTP figure appears unrealistic, attributable to several factors. On the one hand, the ticket prices associated with CO2 reduction would not typically attain such heights. Additionally, the respondents were directly queried regarding their supplementary willingness to pay for flights utilizing Sustainable Aviation Fuel (SAF), revealing distinct outcomes. The average amount respondents expressed willingness to pay for a budget carrier was 37.68 euros, whereas, for a main carrier, it stood at 41.39 euros. Notably, the CO2 reduction value provided in the survey was 80%. This discernible disparity underscores that the choices participants made within the stated choice experiment do not directly align with their responses when explicitly questioned about their willingness to pay extra.

Finally, the characteristics of the Economic and Environmental Sensitive travelers are identified, and these can potentially be factors that are willing to pay extra for flights that utilize Sustainable Aviation Fuel (SAF). In addition to the personal characteristics of this segment, two attributes are of paramount importance. CO2 reduction is a primary concern for this segment, with an emphasis on achieving maximal levels of reduction. Notably, an inflection point is observed when CO2 reduction reaches the threshold of 50%, after which there is a swift and substantial escalation in utility. Travelers within this category derive enhanced utility as the $CO_2$ reduction surpasses the aforementioned 50% benchmark. Moreover, utility continues to rise as $CO_2$ reduction progresses from 75% to 100%. Concomitantly, pricing stands as a pivotal attribute for this segment. Elevated pricing exerts a diminishing effect on utility, thereby attenuating the attractiveness of booking the flight.

## 9.2 Discussion

The Willingness to Pay (WTP) derived from the experiment did not align with the responses obtained when respondents were asked about the amount they would be willing to pay for a flight powered by Sustainable Aviation Fuel (SAF). This indicates that respondents tend to provide "better" answers to hypothetical questions than what they would do in reality. In the context of this study, respondents demonstrated a higher stated WTP for SAF when presented with hypothetical scenarios compared to their actual behavior. This suggests the presence of hypothetical bias, where individuals may overestimate their willingness to pay or make more environmentally conscious choices in hypothetical situations than they would in real-life decision-making scenarios.

This can have various causes. The first one is a warm glow. Warm glow refers to the feeling of personal satisfaction or contentment that arises when people contribute positively to a social or environmentally friendly cause, such as supporting sustainable initiatives. It can be a form of intrinsic motivation that drives individuals to engage in pro-social behavior. While a warm glow is inherently positive, it can sometimes lead to biases in behavior and decision-making. Secondly, there are no actual costs involved in hypothetical questions. Respondents are not faced with the actual expenses and consequences of their choices. They do not have to spend real money or consider practical constraints. This lack of actual costs can lead to a higher willingness to pay than what would be the case in reality. Thirdly, respondents have no direct stake in the outcome. Since they are not directly affected by the consequences of their hypothetical choices, they may have fewer incentives to provide realistic and accurate answers. They may be inclined to overestimate their willingness to pay without acting on those intentions (Abbott et al.,2013).

In this study, efforts were made to mitigate the potential overestimation stemming from the warm glow effect. This was accomplished by posing two direct inquiries to the respondents regarding the additional amount they would be willing to pay if the Greenest Airline operated the flight, accompanied by an 80% reduction in $CO_2$ emissions. The outcomes of these inquiries revealed an average willingness to pay (WTP) significantly lower than that derived from the stated choice experiment. This contrast in results underscores the importance of addressing warm glow bias and indicates a more cautious approach to interpreting WTP values obtained through stated choice experiments. Furthermore, it suggests a potential discrepancy between expressed preferences in hypothetical scenarios and actual monetary commitments, emphasizing the need for further investigation into the underlying drivers of such disparities.

To address this limitation, revealed preference data would be essential. However, such data come with the drawback that they cannot evaluate alternatives not currently available in the market. Additionally, it is often unclear which alternatives respondents considered alongside their chosen option (i.e., the non-chosen alternatives). Despite these challenges, there is value in investigating whether real-life decision contexts align with the conditions presented in the experiment.

While research into implementing Sustainable Aviation Fuel (SAF) remains limited, drawing insightful parallels with existing studies can illuminate passenger preferences. Notably, a study by McKinsey offers valuable insights into passenger demands, revealing distinct segments within the market. These segments underscore the increasing importance of comfort, convenience, environmental responsibility, and sustainability (McKinsey & Company, 2022), aligning closely with the conclusions derived from my master's thesis. This research identified three distinct traveler segments, each showcasing unique preferences for various flight characteristics. These segments exhibited differing product-related inclinations and diverged in sociodemographic and psychographic traits. This segmentation pattern correlates with the one observed in the McKinsey study.

A noteworthy congruence between both studies is the prevalence of the Price-sensitive Travelers segment. In both investigations, this segment emerged as the most substantial cohort of travelers, underscoring the significance of price sensitivity among a considerable portion of the population. Furthermore, both studies underscore the escalating significance of passenger comfort and convenience as pivotal factors in decision-making. This trend mirrors the evolving expectations of travelers seeking seamless and enjoyable travel experiences.

Moreover, both studies acknowledge the increasing proportion of travelers prioritizing environmental responsibility and sustainability. This shift in consumer attitudes underscores the importance of airlines adopting eco-friendly practices, such as SAF usage.

By juxtaposing the findings of my master's thesis with those of the McKinsey study, we can identify shared trends and validate the robustness of the conclusions. These similarities offer valuable insights into the evolving landscape of passenger preferences and can guide airlines and policymakers in devising strategies that align with these changing demands.

The experiment highlighted the essential role of price and time as attributes influencing flight choices. As these factors increase, the satisfaction of air travelers diminishes—a phenomenon aligning with the concept of diminishing utility, which posits that as the price or time investment for a product or service rises, the perceived value to the consumer declines. Both price and time are pivotal factors affecting consumers' flight decisions. Various studies attest to consumers' sensitivity to price fluctuations, shaping their preferences for specific flight options. Reduced flight prices often heighten consumer willingness to book, given the direct impact on travel costs and available budgets.

Similarly, time is a critical attribute shaping consumer choices. Travelers typically contend with time constraints and seek flight schedules aligned with their preferences (Wensveen, 2015; Oxford Economics, 2018). Flight departure and arrival times significantly influence consumer decision-making, particularly for those with business obligations or tight schedules.

Finally, an intriguing observation from the experiment is the pronounced market share of low-budget carriers, in contrast to the reported European market share, typically hovering around 50% (Somsen, n.d.). Investigating the underlying reasons for this divergence is pivotal for comprehensive analysis. The sampling selection is one possible explanation for the experiment's higher market share of low-budget carriers. Considering the representativeness of the sample used in the experiment is essential. If the sample was biased toward individuals with a preference for low-budget carriers, it could have influenced the observed market share in the experiment. For instance, the participants recruited for the study might have been more inclined to choose low-budget carriers, resulting in an artificially inflated market share.

## 9.3 Limitations

This study has several limitations, which are explained in this section. First, a limitation of online surveys is that it can be difficult or even impossible to identify and characterize the specific population that had access to and took part in the survey and to what demographic the results can be applied generally (Andrade, 2020). It is critical to acquire knowledge about this particular community to generalize this study’s findings to future Sustainable Aviation Fuel (SAF) adopters. The sample employed in this study is the best approximation. Nevertheless, it offers valuable insights into flight choice behavior because such information is missing. Furthermore, the survey encompassed many questions, requiring respondents to invest an average of over 15 minutes. This extended duration could potentially influence the outcomes, as participants might resort to selecting answers at random to expedite the completion of the survey.

Secondly, the results of this study might not be generalizable to a larger population because convenient sampling was used. The survey was mainly distributed among the author's contacts and the Greenest Airline, which could have led to a sample of primarily students or employees with somewhat similar ideas. Additionally, because the survey was done online, only those with an internet connection could respond, excluding a portion of the population and possibly contributing to a lack of representation.

Furthermore, the results of this study were derived from a stated choice experiment, and thus, the ecological validity is low. Whether the choices in hypothetical scenarios accurately reflect individuals' choices in real-life situations remains uncertain. To overcome this limitation, the use of revealed preference data would be necessary, but it has the drawback of being unable to test alternatives that do not yet exist in the market, and it is typically unknown which non-chosen alternatives respondents considered. Nonetheless, it would be valuable to explore whether there are real-life decision contexts that align with the conditions presented in the experiment.

Finally, the low number of respondents indicating travel for business purposes is a limitation of this study for several reasons. Firstly, it relates to the representativeness of the sample. A representative sample is crucial for drawing accurate and generalizable conclusions about the broader population. In this case, the sample's low number of business travelers may lead to a distorted understanding of this group's attitudes, preferences, and behaviors. Business travelers may have unique needs and motivations when making their aircraft fuel choices, which could differ from those of leisure travelers. Factors such as flexible flight schedules aligning with their business obligations, corporate sustainability policies, or contractual obligations with specific airlines may carry more significance due to the sample's limited number of business travelers.

## 9.4 Recommendations

This section provides four recommendations based on the study's findings. These recommendations aim to enhance consumers' understanding and promotion of Sustainable Aviation Fuel (SAF) adoption. These recommendations can contribute to a more sustainable aviation industry by addressing the limitations and potential areas for improvement. The initial two recommendations are suggestions for further research, whereas the final two constitute policy recommendations.

The first recommendation is to investigate the motivations of the Economic-Environmental Sensitivity segment for their willingness to pay extra for flights with Sustainable Aviation Fuel (SAF). This analysis provides insights into this segment's driving factors and considerations, which displays a willingness to incur additional costs for a more environmentally friendly flight alternative. By comprehending these motivations, airlines, and policymakers can formulate targeted strategies to better align with the needs of this segment.

The second recommendation is to undertake an investigation utilizing revealed preference data. As previously mentioned, the use of revealed preference data would be necessary. However, it carries the drawback of its inability to test alternatives that are not currently available in the market, and it often remains uncertain which non-chosen alternatives respondents considered. Nevertheless, exploring the existence of real-life decision contexts that align with the conditions presented in the experiment holds substantial value. Given the significant disparities between the responses from the stated choice experiment and the two direct questions, conducting such research is imperative. This investigation would bridge the gap between hypothetical scenarios and actual decisions, providing a more comprehensive understanding of passenger preferences and contributing to the validation and refinement of the findings.

Table 8 shows that a substantial proportion of respondents recognize the potential of Sustainable Aviation Fuel (SAF) yet possess limited familiarity with its attributes. This knowledge gap could potentially influence their Willingness to

Pay (WTP). Hence, a third recommendation is directed toward the aviation industry, underscoring the imperative for them to elucidate the capabilities of SAF and consequently cultivate awareness among travelers.

A key point of inquiry pertains to the financial dynamics surrounding a reduction in SAF pricing. Addressing this matter entails investigating how cost reductions could be achieved, such as advancements in production processes, economies of scale, or governmental incentives. Subsequently, the potential impacts on demand and profitability should be thoroughly scrutinized. It becomes pivotal to discern whether a price reduction could spur a substantial increase in consumption, thereby maintaining or potentially enhancing profit margins, or if compensatory measures would be needed to balance the financial equation. Additionally, it is essential to identify the parties that might bear the cost burden of lowering SAF prices. This could involve airlines, fuel producers, governments, and regulatory bodies collaborating. Understanding the potential distribution of costs and benefits among these stakeholders is indispensable to crafting a viable strategy. Such exploration should consider the long-term sustainability of reduced SAF prices and evaluate whether they align with broader industry and environmental goals.

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# Appendix A: Ngene

```
design
;alts = flight1, flight2
;rows = 9
;orth = seq
; foldover
;model:
U(flight1) =
beta.price*price[50,225,400]+beta.time*time[2,4,6]+beta.co2*co2[0,50,100]+beta.type*type[0,1,2]/
U(flight2) =
beta.price*price+beta.time*time+beta.co2*co2+ beta.type*type
$
```

| Correlations (Pearson Product Moment) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Attribute | flight1.price | flight1.time | flight1.co2 | flight1.type | flight2.price | flight2.time | flight2.co2 | flight2.type |
| flight1.price | 1 | 0 | 0 | 0 | 0 | 0 | 0.416667 | -0.25 |
| flight1.time | 0 | 1 | 0 | 0 | 0.166667 | -0.083333 | 0.083333 | -0.333333 |
| flight1.co2 | 0 | 0 | 1 | 0 | -0.166667 | 0.333333 | 0 | 0.083333 |
| flight1.type | 0 | 0 | 0 | 1 | 0.333333 | 0.083333 | 0.25 | 0.083333 |
| flight2.price | 0 | 0.166667 | -0.166667 | 0.333333 | 1 | 0 | 0 | 0 |
| flight2.time | 0 | -0.083333 | 0.333333 | 0.083333 | 0 | 1 | 0 | 0 |
| flight2.co2 | 0.416667 | 0.083333 | 0 | 0.25 | 0 | 0 | 1 | 0 |
| flight2.type | -0.25 | -0.333333 | 0.083333 | 0.083333 | 0 | 0 | 0 | 1 |

# Appendix B: Data analysis SPSS

Table B.1: Belgium

| Personal Characteristics | Category | Absolute Number | Sample(%) |
|---|---|---|---|
| **Gender** | Male | 55 | 43 |
| | Female | 77 | 54,7 |
| | I prefer not to say | 3 | 2,3 |
| **Age (in years)** | 18-25 | 17 | 37,3 |
| | 25-45 | 83 | 47,5 |
| | 45-65 | 24 | 13,7 |
| | 65+ | 4 | 1,5 |
| **Level of education** | No formal education | 1 | 0,8 |
| | High School | 6 | 4,7 |
| | Vocational education | 0 | 0,0 |
| | Higher Vocational education | 62 | 22,5 |
| | Bachelor | 31 | 24,2 |
| | Master | 77 | 60,2 |
| | PhD | 4 | 3,1 |
| **Employment status** | Employed | 108 | 84,4 |
| | Student | 7 | 5,5 |
| | (currently) unemployed | 3 | 2,3 |
| | Retired | 4 | 3,1 |
| | Other | 6 | 4,7 |
| **Level of income** | <10.000 | 6 | 4,7 |
| | 10.001-20.000 | 6 | 4,7 |
| | 20.001-30.000 | 13 | 10,2 |
| | 30.001-40.000 | 20 | 15,6 |
| | 40.001-50.000 | 11 | 8,6 |
| | 50.001-60.000 | 11 | 8,6 |
| | 60.001-70.000 | 8 | 6,3 |
| | 70.001-80.000 | 2 | 1,6 |
| | 80.001-90.000 | 8 | 6,3 |
| | 90.001-100.000 | 4 | 3,1 |
| | >100.000 | 16 | 12,5 |
| | I'd rather not say/I don't know | 22 | 17,2 |

Table B.2: Netherlands

| Personal Characteristics | Category | Absolute Number | Sample(%) |
|---|---|---|---|
| **Gender** | Male | 96 | 64,9 |
| | Female | 51 | 34,5 |
| | I prefer not to say | 1 | 0,7 |
| **Age (in years)** | 18-25 | 86 | 58,1 |
| | 25-45 | 46 | 31,1 |
| | 45-65 | 15 | 10,1 |
| | 65+ | 1 | 0,7 |
| **Level of education** | No formal education | 3 | 2,0 |
| | High School | 7 | 4,7 |
| | Vocational education | 18 | 12,2 |
| | Higher Vocational education | 53 | 35,8 |
| | Bachelor | 25 | 16,9 |
| | Master | 40 | 27,0 |
| | PhD | 2 | 1,4 |
| **Employment status** | Employed | 85 | 57,4 |
| | Student | 4 | 34,5 |
| | (currently) unemployed | 51 | 2,7 |
| | Retired | 1 | 0,7 |
| | Other | 7 | 4,7 |
| **Level of income** | <10.000 | 34 | 23 |
| | 10.001-20.000 | 23 | 15,5 |
| | 20.001-30.000 | 16 | 10,8 |
| | 30.001-40.000 | 20 | 13,5 |
| | 40.001-50.000 | 16 | 10,8 |
| | 50.001-60.000 | 12 | 8,1 |
| | 60.001-70.000 | 4 | 2,7 |
| | 70.001-80.000 | 5 | 3,5 |
| | 80.001-90.000 | 1 | 0,7 |
| | 90.001-100.000 | 2 | 1,4 |
| | >100.000 | 3 | 2,0 |
| | I’d rather not say/I don’t know | 12 | 8,1 |

Table B.3: Netherlands

| Personal Characteristics | Category | Absolute Number | Sample(%) |
|---|---|---|---|
| **How often do you fly?** | 1 | 87 | 58,8 |
| | 2 | 37 | 25 |
| | 3 | 9 | 6,1 |
| | 4 | 9 | 6,1 |
| | 5 | 2 | 1,4 |
| | 6-10 | 3 | 2,0 |
| | 11-15 | 0 | 0,0 |
| | 16-20 | 1 | 0,7 |
| | 21-30 | 0 | 0,0 |
| | >31 | 0 | 0,0 |
| **Main reason** | Business | 6 | 4,1 |
| | Leisure | 106 | 71,6 |
| | Family | 30 | 20,3 |
| | Health | 0 | 0 |
| | Education | 0 | 0,0 |
| | Other | 5 | 3,4 |
| **Business travel** | Main carrier | 40 | 27 |
| | Budget Carrier | 71 | 28 |
| | Other | 25 | 16,9 |
| **Leisure travel** | Main carrier | 26 | 17,6 |
| | Budget carrier | 106 | 71,6 |
| | Other | 16 | 10,8 |
| **Booking** | Directly with the airline | 56 | 37,8 |
| | Online booking engine | | |
| | Other | 85 | 56,8 |
| | | 7 | 4,7 |

Table B.4: Belgium

| Personal Characteristics | Category | Absolute Number | Sample(%) |
|---|---|---|---|
| **How often do you fly?** | 1 | 53 | 41,4 |
| | 2 | 21 | 16,4 |
| | 3 | 17 | 13,3 |
| | 4 | 9 | 7,0 |
| | 5 | 7 | 5,5 |
| | 6-10 | 9 | 7,0 |
| | 11-15 | 6 | 4,7 |
| | 16-20 | 1 | 0,8 |
| | 21-30 | 1 | 0,8 |
| | >31 | 3 | 2,3 |
| **Main reason** | Business | 27 | 21,1 |
| | Leisure | 81 | 63,3 |
| | Family | 12 | 9,4 |
| | Health | 0 | 0,0 |
| | Education | 1 | 0,8 |
| | Other | 6 | 4,7 |
| **Business travel** | Main carrier | 76 | 59,4 |
| | Budget Carrier | 25 | 19,5 |
| | Other | 13 | 10,2 |
| **Leisure travel** | Main carrier | 58 | 45,3 |
| | Budget carrier | 62 | 48,4 |
| | Other | 6 | 4,8 |
| **Booking** | Directly with the airline | 48 | 37,5 |
| | Online booking engine | | |
| | Other | 67 | 52,3 |
| | | 11 | 8,6 |

# Appendix C: SPSS output

The survey asked two questions regarding willingness to pay (WTP) for flights, one involving a main carrier and the other involving a budget carrier. These questions were included to examine the presence of warm glow, which refers to the intrinsic satisfaction or sense of fulfillment individuals experience when their actions align with their values or benefit others.

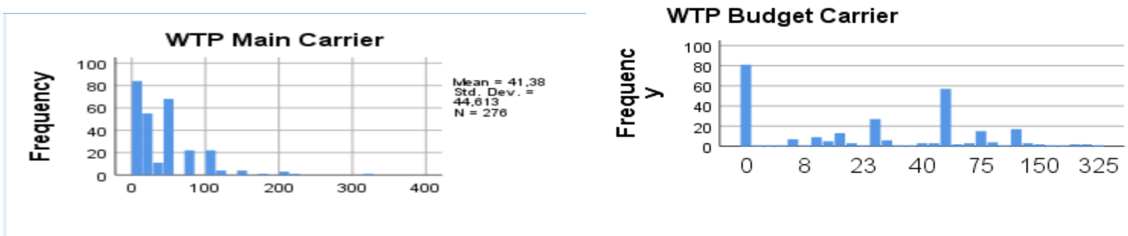


Figure 13: WTP for Main Carrier and Budget Carrier

The average amount respondents are willing to pay for a budget carrier is 37.68 euros, while for a main carrier, it is 41.39 euros. In Chapter 4, it was mentioned that kerosene accounts for approximately 30 to 35% of the price of a flight ticket. Considering a ticket price of 225 euros, the maximum amount that should be paid when the flight is operated with Sustainable Aviation Fuel (SAF) using Hydroprocessed Esters and Fatty Acids (HEFA) is 67.50 euros. For Fischer-Tropsch, the corresponding price would be 135 euros, but it was not considered further due to a few outliers.

A new variable was created to capture the difference between the respondents' reported WTP and the amount of 67.50 euros. Subsequently, two groups were formed: respondents who paid more than 67.50 euros and respondents who paid less or exactly 67.50 euros. The analysis revealed that 58 respondents paid more than 67.50 euros for a flight with a main carrier, while 57 respondents paid more for a flight with a budget carrier. The average WTP for a main carrier was 109 euros, whereas, for the budget carrier, it was 96.75 euros. This indicates that approximately 20% of the respondents overestimate the price of flying with Sustainable Aviation Fuel (SAF).

The average factor scores of the respondents can partially explain this. They exhibit a positive attitude towards each factor, except for Greenest Airline Neophobia. This indicates that they are open to flying with the Greenest Airline. However, what stands out is their positive average factor score for efficacy, suggesting that they scored higher on indicators that temper the effectiveness of Sustainable Aviation Fuel (SAF). This implies that they perceive the efficacy of SAF to be more favorable than anticipated.

| | Mean |
|---|---|
| Factor score FC | ,5277490 |
| Factor score eff | ,2086744 |
| Factor score NEO | -,0265791 |
| Factor score image | ,1774187 |
| Factor score SAF | ,3734031 |
| Factor score Sus | ,2873640 |
| Factor score FSSAF | ,4924860 |

Figure 14: Average Factor scores of the respondents

Lastly, On average, most of the 58 and 57 respondents are from Belgium, are female, have a middle-class income, and are employed. Furthermore, they are predominantly between the ages of 25 and 45.

**Pattern Matrix**[a]

| | Factor | | | | | | |
|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| When I can fly by airplane using SAF, my fear of negative reactions would diminish | ,854 | | | | | | |
| When I can fly by airplane using SAF, my willingness to share my holiday plans would increase | ,850 | | | | | | |
| When I can fly by airplane using SAF for a city trip, my guilt would diminish | ,752 | | | | | | |
| When I can fly by airplane using SAF, my feeling of guilt would diminish. | ,731 | | | | | | |
| When I could fly by airplane using SAF, my feeling of discomfort during or after a flight would diminish | ,731 | | | | | | |
| Relying solely on SAF can create a misleading perception of sustainability while failing to address the fundamental issues of air travel. | | ,694 | | | | | |
| SAF is an inadequate solution to the carbon emissions caused by flying. | | ,528 | | | | | |
| Despite its adoption by the aviation industry, I remain unconvinced that SAF will lead to meaningful and substantial reductions in emissions | | ,511 | | | | | |
| Encouraging and prioritizing alternatives to flying, such as video conferencing or high-speed rail, is a more effective approach than relying heavily on SAF. | | ,382 | | | | | |
| The lack of awareness about the greenest airline makes it challenging for me to consider them as a preferred option. | | | ,924 | | | | |
| I am hesitant to choose the greenest airline because I am unsure if they can meet my expectations in terms of service and reliability | | | ,564 | | | | |
| I am not familiar with the Greenest airline and, as a result, I am uncertain about what to expect from their flights. | | | ,525 | | | | |
| Investing in research and development for advanced SAF technologies and sustainable feedstock sources can lead to further improvements in its environmental performance. | | | | ,738 | | | |
| SAF has the potential to contribute positively to reducing carbon emissions in aviation when combined with comprehensive and holistic strategies | | | | ,685 | | | |
| I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry to mitigate the environmental impact of air travel. | | | | ,516 | | | |
| It is crucial to prioritize SAF production methods that minimize environmental impacts and do not compete with food production | | | | ,403 | | | |
| When choosing an airline, I prioritize the reputation and brand image of the main carriers due to their perceived quality. | | | | | ,776 | | |
| The reputation and brand image of a main carrier greatly influences my decision to choose their flights | | | | | ,644 | | |
| We are approaching the limit of the number of people the Earth can support. | | | | | | ,619 | |
| The Earth is like a spaceship with very limited room and resources | | | | | | ,593 | |
| I feel guilty when I fly to a destination | | | | | | | -,908 |
| I feel guilty whenever I travel by airplane for a city trip | | | | | | | -,847 |
| When I am going to fly I fear negative reactions from other people | | | | | | | -,587 |
| I rather do not tell others when I travel by airplane for a holiday | ,357 | | | | | | -,484 |
| Whenever I travel by airplane, I feel uncomfortable during and after a trip | | | | | | | -,399 |

Extraction Method: Principal Axis Factoring.
Rotation Method: Oblimin with Kaiser Normalization.

a. Rotation converged in 12 iterations.

# Appendix D: MNL model

```
rm(list = ls())
library(apollo)
apollo_initialise()
apollo_control=list(
  modelName = "MNL",
  modelDescr = "MNL",
  indivID = "ID"
)
database=read_excel("2022-2023/Thesis chapters los/DatasetGAExperiment.xlsx")
database <- database[order(database$ID), ]
apollo_beta = c(BETA_TC=0,
                BETA_TT=0,
                BETA_LB=0,
                BETA_GA=0,
                BETA_TCO2=0,
                BETA_QTC=0,
                BETA_QTT=0,
                BETA_QTCO2=0



              )
apollo_fixed= c()
apollo_inputs = apollo_validateInputs()
apollo_probabilities= function(apollo_beta, apollo_inputs,functionality="estimate"){
  apollo_attach(apollo_beta,apollo_inputs)
  on.exit(apollo_detach(apollo_beta,apollo_inputs))
  P=list()
  V=list()
  V[['alt1']]=
BETA_TC*TCA+BETA_TT*TTA+BETA_TCO2*TCO2A+BETA_LB*LBA+BETA_GA*GAA+BETA_QTC*QTC
A+BETA_QTT*QTTA+BETA_QTCO2*QTCO2A
  V[['alt2']]=
BETA_TC*TCB+BETA_TT*TTB+BETA_TCO2*TCO2B+BETA_LB*LBB+BETA_GA*GAB+BETA_QTC*QTC
B+BETA_QTT*QTTB+BETA_QTCO2*QTCO2B
  mnl_settings= list(
    alternatives= c(alt1=1, alt2=2),
    avail = list(alt1=1,alt2=1),
    choiceVar = Choice,
    V = V
  )
  P[['model']]=apollo_mnl(mnl_settings,functionality)
  P = apollo_panelProd(P,apollo_inputs,functionality)
  P = apollo_prepareProb(P,apollo_inputs,functionality)
  return(P)

}
model=apollo_estimate(apollo_beta,apollo_fixed,apollo_probabilities,apollo_inputs)
apollo_modelOutput(model,modelOutput_settings = list(printPVal=TRUE))
apollo_saveOutput(model)
```

# Appendix E: LCCM

```
# ################################################################# #
#### LOAD LIBRARY AND DEFINE CORE SETTINGS                      ####
# ################################################################# #

### Clear memory
rm(list = ls())

### Load Apollo library
library(apollo)
library(readxl)

### Initialise code
apollo_initialise()

### Set core controls
apollo_control = list(
  modelName       = "LCCM3classes",
  modelDescr      = "LCCM3classes",
  indivID         = "ID",
  outputDirectory = "output",
  panelData       = TRUE
)

# ################################################################# #
#### LOAD DATA AND APPLY ANY TRANSFORMATIONS                    ####
# ################################################################# #

database <- read_excel("2022-2023/Thesis chapters los/DatasetGAExperiment.xlsx")
database <- database[order(database$ID), ]

# ################################################################# #
#### DEFINE MODEL PARAMETERS                                    ####
# ################################################################# #

### Vector of parameters, including any that are kept fixed in estimation
apollo_beta = c(BETA_TC_A=0,
BETA_TC_B=0,
BETA_TC_C=0,
BETA_TT_A=0,
BETA_TT_B=0,
BETA_TT_C=0,
BETA_LB_A=0,
BETA_LB_B=0,
BETA_LB_C=0,
BETA_GA_A=0,
BETA_GA_B=0,
BETA_GA_C=0,
BETA_TCO2_A=0,
BETA_TCO2_B=0,
BETA_TCO2_C=0,
```

```
BETA_QTCO2_A=0,
BETA_QTCO2_B=0,
BETA_QTCO2_C=0,
BETA_QTC_A=0,
BETA_QTC_B=0,
BETA_QTC_C=0,
BETA_QTT_A=0,
BETA_QTT_B=0,
BETA_QTT_C=0,
GAMMA_INC_A=0,
GAMMA_INC_B=0,
GAMMA_INC_C=0,
GAMMA_GEN_A=0,
GAMMA_GEN_B=0,
GAMMA_GEN_C=0,
GAMMA_EDU_A=0,
GAMMA_EDU_B=0,
GAMMA_EDU_C=0,
GAMMA_MR_A=0,
GAMMA_MR_B=0,
GAMMA_MR_C=0,
GAMMA_AGE_A=0,
GAMMA_AGE_B=0,
GAMMA_AGE_C=0,
GAMMA_EMP_A=0,
GAMMA_EMP_B=0,
GAMMA_EMP_C=0,
GAMMA_FS_A=0,
GAMMA_FS_B=0,
GAMMA_FS_C=0,
GAMMA_EFF_A=0,
GAMMA_EFF_B=0,
GAMMA_EFF_C=0,
GAMMA_NEO_A=0,
GAMMA_NEO_B=0,
GAMMA_NEO_C=0,
GAMMA_SAF_A=0,
GAMMA_SAF_B=0,
GAMMA_SAF_C=0,
GAMMA_IMA_A=0,
GAMMA_IMA_B=0,
GAMMA_IMA_C=0,
GAMMA_FSSAF_A=0,
GAMMA_FSSAF_B=0,
GAMMA_FSSAF_C=0,
delta_a=0,
delta_b=0,
delta_c=0


)

### Vector with names (in quotes) of parameters to be kept fixed at their starting value in apollo_beta, use
apollo_beta_fixed = c() if none
```

```
apollo_fixed = c('delta_c',
'GAMMA_INC_C','GAMMA_GEN_C','GAMMA_EDU_C','GAMMA_MR_C','GAMMA_AGE_C','GAMMA_EM
P_C',
'GAMMA_FS_C','GAMMA_EFF_C','GAMMA_NEO_C','GAMMA_SAF_C','GAMMA_IMA_C','GAMMA_FSSA
F_C')

# ################################################################# #
#### DEFINE LATENT CLASS COMPONENTS                              ####
# ################################################################# #

apollo_lcPars=function(apollo_beta, apollo_inputs){
  lcpars = list()

  lcpars[["BETA_TT"]]= list(BETA_TT_A,BETA_TT_B,BETA_TT_C)
  lcpars[["BETA_TC"]]= list(BETA_TC_A,BETA_TC_B,BETA_TC_C)
  lcpars[["BETA_LB"]]= list(BETA_LB_A,BETA_LB_B,BETA_LB_C)
  lcpars[["BETA_TCO2"]]= list(BETA_TCO2_A,BETA_TCO2_B,BETA_TCO2_C)
  lcpars[["BETA_QTCO2"]]= list(BETA_QTCO2_A,BETA_QTCO2_B,BETA_QTCO2_C)
  lcpars[["BETA_GA"]]= list(BETA_GA_A,BETA_GA_B,BETA_GA_C)
  lcpars[["BETA_QTC"]]= list(BETA_QTC_A,BETA_QTC_B,BETA_QTC_C)
  lcpars[["BETA_QTT"]]= list(BETA_QTT_A,BETA_QTT_B,BETA_QTT_C)

  V=list()
  V[["class_a"]] =
delta_a+GAMMA_INC_A*INC+GAMMA_GEN_A*GEN+GAMMA_EDU_A*EDU+GAMMA_MR_A*MR+GAM
MA_AGE_A*AGE+GAMMA_EMP_A*EMP+GAMMA_FS_A*FS+GAMMA_EFF_A*EFF+GAMMA_NEO_A*N
EO+GAMMA_SAF_A*SAF+GAMMA_IMA_A*IMA+GAMMA_FSSAF_A*FSSAF
  V[["class_b"]] =
delta_b+GAMMA_INC_B*INC+GAMMA_GEN_B*GEN+GAMMA_EDU_B*EDU+GAMMA_MR_B*MR+GAM
MA_AGE_B*AGE+GAMMA_EMP_B*EMP+GAMMA_FS_B*FS+GAMMA_EFF_B*EFF+GAMMA_NEO_B*N
EO+GAMMA_SAF_B*SAF+GAMMA_IMA_B*IMA+GAMMA_FSSAF_B*FSSAF
  V[["class_c"]] =
delta_c+GAMMA_INC_C*INC+GAMMA_GEN_C*GEN+GAMMA_EDU_C*EDU+GAMMA_MR_C*MR+GAM
MA_AGE_C*AGE+GAMMA_EMP_C*EMP+GAMMA_FS_C*FS+GAMMA_EFF_C*EFF+GAMMA_NEO_C*
NEO+GAMMA_SAF_C*SAF+GAMMA_IMA_C*IMA+GAMMA_FSSAF_C*FSSAF

  classAlloc_settings = list(
    classes      = c(class_a=1, class_b=2, class_c=3),
    utilities    = V
  )

  lcpars[["pi_values"]] = apollo_classAlloc(classAlloc_settings)

  return(lcpars)
}

# ################################################################# #
#### GROUP AND VALIDATE INPUTS                                   ####
# ################################################################# #

apollo_inputs = apollo_validateInputs()

# ################################################################# #
#### DEFINE MODEL AND LIKELIHOOD FUNCTION                        ####
```

```
# ################################################################# #

apollo_probabilities=function(apollo_beta, apollo_inputs, functionality="estimate"){

  ### Attach inputs and detach after function exit
  apollo_attach(apollo_beta, apollo_inputs)
  on.exit(apollo_detach(apollo_beta, apollo_inputs))

  ### Create list of probabilities P
  P = list()

  ### Define settings for MNL model component that are generic across classes
  mnl_settings = list(
    alternatives = c(alt1=1, alt2=2),
    avail        = list(alt1=1, alt2=1),
    choiceVar    = Choice
  )

  ### Loop over classes
  for(s in 1:3){

    ### Compute class-specific utilities
    V=list()
    V[["alt1"]] = TCA*BETA_TC[[s]] + TTA*BETA_TT[[s]] + LBA*BETA_LB[[s]] + TCO2A*BETA_TCO2[[s]] +
QTCO2A*BETA_QTCO2[[s]]  + GAA*BETA_GA[[s]] + QTCA*BETA_QTC[[s]] + QTTA*BETA_QTT[[s]]
    V[["alt2"]] = TCB*BETA_TC[[s]] + TTB*BETA_TT[[s]] + LBB*BETA_LB[[s]] + TCO2B*BETA_TCO2[[s]] +
QTCO2B*BETA_QTCO2[[s]]  + GAB*BETA_GA[[s]] + QTCB*BETA_QTC[[s]] + QTTB*BETA_QTT[[s]]

    mnl_settings$utilities = V
    mnl_settings$componentName = paste0("Class_",s)

    ### Compute within-class choice probabilities using MNL model
    P[[paste0("Class_",s)]] = apollo_mnl(mnl_settings, functionality)

    ### Take product across observation for same individual
    P[[paste0("Class_",s)]] = apollo_panelProd(P[[paste0("Class_",s)]], apollo_inputs ,functionality)
  }

  ### Compute latent class model probabilities
  lc_settings   = list(inClassProb = P, classProb=pi_values)
  P[["model"]] = apollo_lc(lc_settings, apollo_inputs, functionality)

  ### Prepare and return outputs of function
  P = apollo_prepareProb(P, apollo_inputs, functionality)
  return(P)
}

# ################################################################# #
#### MODEL ESTIMATION                                            ####
# ################################################################# #

### Optional starting values search
# apollo_beta=apollo_searchStart(apollo_beta, apollo_fixed,apollo_probabilities, apollo_inputs)
```

```
model = apollo_estimate(apollo_beta, apollo_fixed, apollo_probabilities, apollo_inputs)

# ################################################################# #
#### MODEL OUTPUTS                                               ####
# ################################################################# #

# ----------------------------------------------------------------- #
#---- FORMATTED OUTPUT (TO SCREEN)                               ----
# ----------------------------------------------------------------- #

apollo_modelOutput(model)

# ----------------------------------------------------------------- #
#---- FORMATTED OUTPUT (TO FILE, using model name)               ----
# ----------------------------------------------------------------- #

apollo_saveOutput(model)
```

# Appendix F: Choice sets

Flight 1

| Main Carrier<br>KLM Lufthansa<br>BRITISH AIRWAYS | Brussels – Lisbon<br>2 hours | 0% CO2 reduction | €50 | Book flight |
|---|---|---|---|---|

Flight 2

| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>4 hours | 50% CO2 reduction | €50 | Book flight |
|---|---|---|---|---|

Flight 1

| Main Carrier<br>KLM Lufthansa<br>BRITISH AIRWAYS | Brussels – Lisbon<br>4 hours | 50% CO2 reduction | €400 | Book flight |
|---|---|---|---|---|

Flight 2

| Main Carrier<br>KLM Lufthansa<br>BRITISH AIRWAYS | Brussels – Lisbon<br>6 hours | 50% CO2 reduction | €225 | Book flight |
|---|---|---|---|---|

Flight 1

| Main Carrier<br>KLM Lufthansa<br>BRITISH AIRWAYS | Brussels – Lisbon<br>6 hours | 100% CO2 reduction | €225 | Book flight |
|---|---|---|---|---|

Flight 2

| Budget Carrier<br>RYANAIR easyJet<br>transavia | Brussels – Lisbon<br>4 hours | 0% CO2 reduction | €225 | Book flight |
|---|---|---|---|---|

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>4 hours | 0% CO2 reduction | €225 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>2 hours | 50% CO2 reduction | €400 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>6 hours | 50% CO2 reduction | €50 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>2 hours | 50% CO2 reduction | €225 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>2 hours | 100% CO2 reduction | €400 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>6 hours | 100% CO2 reduction | €400 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>6 hours | 0% CO2 reduction | €400 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>2 hours | 100% CO2 reduction | €400 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>2 hours | 50% CO2 reduction | €225 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>4 hours | 100% CO2 reduction | €50 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>4 hours | 100% CO2 reduction | €50 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>6 hours | 50% CO2 reduction | €50 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Greenest Airline | Brussels – Lisbon<br>6 hours | 100% CO2 reduction | €400 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Budget Carrier | Brussels – Lisbon<br>4 hours | 100% CO2 reduction | €225 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Greenest Airline | Brussels – Lisbon<br>4 hours | 50% CO2 reduction | €50 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Main Carrier | Brussels – Lisbon<br>4 hours | 0% CO2 reduction | €400 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier | Brussels – Lisbon<br>4 hours | 100% CO2 reduction | €225 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Main Carrier | Brussels – Lisbon<br>6 hours | 100% CO2 reduction | €225 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>2 hours | 50% CO2 reduction | €400 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Main Carrier<br>KLM Lufthansa BRITISH AIRWAYS | Brussels – Lisbon<br>2 hours | 0% CO2 reduction | €50 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet transavia | Brussels – Lisbon<br>6 hours | 0% CO2 reduction | €50 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Main Carrier<br>KLM Lufthansa BRITISH AIRWAYS | Brussels – Lisbon<br>4 hours | 50% CO2 reduction | €400 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Main Carrier<br>KLM Lufthansa BRITISH AIRWAYS | Brussels – Lisbon<br>2 hours | 100% CO2 reduction | €50 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Greenest Airline<br>green seats greenairlines | Brussels – Lisbon<br>2 hours | 0% CO2 reduction | €225 | Book flight |

Flight 1

| | | | | |
|---|---|---|---|---|
| Main Carrier<br>KLM Lufthansa<br>BRITISH AIRWAYS | Brussels – Lisbon<br>6 hours | 50% CO2 reduction | €225 | Book flight |

Flight 2

| | | | | |
|---|---|---|---|---|
| Budget Carrier<br>RYANAIR easyJet<br>transavia | Brussels – Lisbon<br>6 hours | 0% CO2 reduction | €50 | Book flight |

# Appendix G: Survey

# Greenest Airline

Start of Block: Introduction

Q1 Dear participant,
You have been invited to take part in a research study titled 'Exploring the Determinants of Air Travelers' Willingness to Pay for Sustainable Aviation Fuel.' My name is Yassir Ouaj, an MSc student from TU Delft, and I am conducting this study in collaboration with the Greenest Airline as part of my master's thesis project.

The purpose of this research study is to investigate the factors that influence air travelers' preferences for alternative aviation fuel. The data collected from this study will be used for academic research, potential publication, application in the field of sustainable aviation, and teaching at TU Delft. Your contribution is crucial in helping us gain valuable insights into this topic. You will be asked to complete an online survey, which is estimated to take approximately 15 minutes of your time.
To ensure the confidentiality of your participation, this study guarantees anonymity. No personally identifiable information or personally identifiable research data will be collected. Your responses will be stored securely, and all data will be de-identified or anonymized to protect your privacy. As a responsible research team, we strictly adhere to data protection regulations and guidelines to safeguard your personal information. Since the survey is completely anonymous, it will not be possible to remove your data once submitted. However, please note that no identifiable information is being collected, ensuring that the data cannot be linked back to individual participants.

Participation in this study is voluntary, and you have the freedom to omit any questions or withdraw from the study at any time without penalty. Your involvement is greatly appreciated, and your input will contribute significantly to advancing knowledge in the field of sustainable aviation. If you have any questions or concerns about the study, please feel free to contact me.

Thank you for considering participation in this research study.

Best regards, Yassir Ouaj
Y.Ouaj@student.tudelft.nl.

End of Block: Introduction

Start of Block: Intro fly experience

Q2 The following questions are about your flying experience

End of Block: Intro fly experience

Start of Block: Questions about flying

Q3 How often do you fly on average per year? (A round trip is considered as 1 flight)

- 0 (1)
- 1 (2)
- 2 (3)
- 3 (4)
- 4 (5)
- 5 (6)
- 6-10 (7)
- 11-15 (8)
- 16-20 (9)
- 21-30 (11)
- >31 (12)

Q4 What is the main reason for your air travel(s)?

- Business (1)
- Leisure (2)
- Family (3)
- Education (4)
- Health (5)
- Other (6) ________________________________________________

Q5 We would like to clarify two terms we will be using: "Main Carriers" and "Budget Carriers."
Main carriers, also referred to as traditional airlines, are typically larger airlines that offer global connectivity. They usually have an extensive network of destinations and provide a wide range of services. Examples of main carriers include KLM, Lufthansa, and British Airways.
Budget carriers, also known as low-cost airlines, prioritize offering affordable flights with basic services at lower costs. Examples of budget carriers include Ryanair, Easyjet, and Transavia

---

Q6 What type of airline do you usually choose for business travel(s)?

○ Main carrier ( For example, KLM, Lufthansa, British Airways) (1)

○ Budget carrier ( For example, Ryanair, Easyjet, Transavia) (2)

○ Other (3) ________________________________________________

---

Q7 What type of airline do you usually choose for leisure travel(s)?

○ Main carrier (For example, KLM, Lufthansa, British Airways) (1)

○ Budget carrier ( For example, Ryanair, Easyjet, Transavia) (2)

○ Other (3) ________________________________________________

---

Q8 Do you prefer booking directly with the airline, or would you consider booking via an online booking engine like Skyscanner or Kayak if that allows you to travel more sustainably?

○ Directly with the airline (1)

○ Online booking engine (For example Skyscanner or Kayak) (2)

○ Other (3) ________________________________________________

End of Block: Questions about flying

---

Start of Block: Setting Experiment

Q9 Imagine you're planning a trip from Brussels to Lisbon and you're about to book a flight. In the following part, we will present two flights and ask you to choose which one you would prefer. Alongside the options of a main carrier and a budget carrier, there is a new airline you can choose called the "Greenest Airline."

The "Greenest Airline" refers to an airline that is dedicated to environmentally friendly practices and sustainability. Airlines of these type take measures to reduce their environmental impact, such as investing in fuel-efficient aircraft, reducing $CO_2$ emissions, and promoting sustainable initiatives. This reduction in $CO_2$ emissions is made possible by the use of Sustainable Aviation Fuel (SAF).

SAF serves as an eco-friendly substitute for conventional aviation fuel and offers a promising solution to reduce the carbon footprint associated with air travel. It is derived from renewable sources like plant-based feedstocks, renewable-based fuel (eSAF), or waste materials. SAF significantly lowers greenhouse gas emissions compared to traditional jet fuel and can seamlessly replace fossil-based aviation fuel, making it an effective means to mitigate the environmental impact of the aviation industry. The $CO_2$ emissions of Sustainable Aviation Fuel (SAF) can vary depending on the production method used, resulting in higher or lower levels of $CO_2$ emissions being achieved.

Please note that you will be presented with a total of eight choices throughout this experiment.

End of Block: Setting Experiment

---

Start of Block: Choiceset1

Q10
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight1 (1)

○ Flight2 (2)

---

Q11
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

---

Q12
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

Q13
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q14
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q15
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q16
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q17
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

End of Block: Choiceset1

Start of Block: Choiceset2

Q18
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q19
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q20
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q21
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

- Flight 1 (1)
- Flight 2 (2)

Q22
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

---

Q23
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

---

Q24
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

---

Q25
You are going to fly, and these are the available tickets to your destination. Which flight will you choose?

○ Flight 1 (1)

○ Flight 2 (2)

**End of Block: Choiceset2**

---

**Start of Block: Intro type carrier**

Q26 The following questions are about different types of carriers

**End of Block: Intro type carrier**

Start of Block: Type Carrier

Q27 The reputation and brand image of a main carrier greatly influences my decision to choose their flights

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q28 When considering a budget carrier, the most important factor for me is the affordability of fares

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q29 The commitment of the Greenest Airline to sustainability and environmental initiatives positively influences my preference for their flights.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Page Break

Q30 I am willing to pay a premium for flights with the Greenest airline due to their prioritization of sustainability and eco-friendly practices

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q31 The cost savings associated with choosing a budget carrier outweigh any potential trade-offs in terms of comfort or amenities

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q32 Main carriers typically provide higher quality services compared to budget carriers

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q33 When choosing an airline, I prioritize the reputation and brand image of the main carriers due to their perceived quality.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q34 I am not familiar with the Greenest airline and, as a result, I am uncertain about what to expect from their flights.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q35 The lack of awareness about the greenest airline makes it challenging for me to consider them as a preferred option.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q36 I am hesitant to choose the greenest airline because I am unsure if they can meet my expectations in terms of service and reliability

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

End of Block: Type Carrier

---

Start of Block: Intro SAF

Q37 The following questions pertain to Sustainable Aviation Fuel (SAF)

End of Block: Intro SAF

---

Start of Block: SAF

Q38 I believe transitioning to Sustainable Aviation Fuel (SAF) is crucial for the aviation industry to mitigate the environmental impact of air travel.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q39 I am familiar with the process of converting sustainable feedstocks into SAF, such as biomass, or waste materials.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q40 I am interested in learning more about the lifecycle analysis and carbon intensity of SAF production compared to traditional jet fuel, as well as ongoing efforts to improve its production efficiency and scalability.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q41 I feel a personal responsibility to support airlines that prioritize the use of SAF to minimize my carbon footprint from air travel.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

End of Block: SAF

---

Start of Block: Is SAF the solution?

Q42 SAF is an inadequate solution to the carbon emissions caused by flying.

○ Completely disagree (1)

○ Disagree (2)

○ Neutral (3)

○ Agree (4)

○ Completely agree (5)

---

Q43 Relying solely on SAF can create a misleading perception of sustainability while failing to address the fundamental issues of air travel.

○ Completely disagree (1)

○ Disagree (2)

○ Neutral (3)

○ Agree (4)

○ Completely agree (5)

---

Q44 Encouraging and prioritizing alternatives to flying, such as video conferencing or high-speed rail, is a more effective approach than relying heavily on SAF.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q45 The use of food crops for SAF production raises significant ethical concerns that cannot be overlooked

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q46 It is crucial to prioritize SAF production methods that minimize environmental impacts and do not compete with food production

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q47 Despite its adoption by the aviation industry, I remain unconvinced that SAF will lead to meaningful and substantial reductions in emissions

◯ Completely disagree (1)

◯ Disagree (2)

◯ Neutral (3)

◯ Agree (4)

◯ Completely agree (5)

---

Q48 SAF has the potential to contribute positively to reducing carbon emissions in aviation when combined with comprehensive and holistic strategies

◯ Completely disagree (1)

◯ Disagree (2)

◯ Neutral (3)

◯ Agree (4)

◯ Completely agree (5)

---

Q49 Investing in research and development for advanced SAF technologies and sustainable feedstock sources can lead to further improvements in its environmental performance.

◯ Completely disagree (1)

◯ Disagree (2)

◯ Neutral (3)

◯ Agree (4)

◯ Completely agree (5)

**End of Block: Is SAF the solution?**

Start of Block: Intro flight shame

Q50 The following questions are about how you feel when you fly.

End of Block: Intro flight shame

---

Start of Block: Flight Shame

Q51 Whenever I travel by airplane, I feel uncomfortable during and after a trip

- ◯ Completely disagree (1)
- ◯ Disagree (2)
- ◯ Neutral (3)
- ◯ Agree (4)
- ◯ Completely agree (5)

---

Q52 I feel guilty when I fly to a destination

- ◯ Completely disagree (1)
- ◯ Disagree (2)
- ◯ Neutral (3)
- ◯ Agree (4)
- ◯ Completely Agree (5)

---

Q53 When I am going to fly I fear negative reactions from other people

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q54 I feel guilty whenever I travel by airplane for a city trip

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q55 I rather do not tell others when I travel by airplane for a holiday

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Page Break

Q56 When I could fly by airplane using SAF, my feeling of discomfort during or after a flight would diminish

- Completely disagree (21)
- Disagree (22)
- Neutral (23)
- Agree (24)
- Completely agree (25)

---

Q57 When I can fly by airplane using SAF, my feeling of guilt would diminish.

- Completely disagree (6)
- Disagree (7)
- Neutral (8)
- Agree (9)
- Completely agree (10)

---

Q58 When I can fly by airplane using SAF, my fear of negative reactions would diminish

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q59 When I can fly by airplane using SAF for a city trip, my guilt would diminish

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

---

Q60 When I can fly by airplane using SAF, my willingness to share my holiday plans would increase

- Completely disagre (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

End of Block: Flight Shame

---

Start of Block: Intro environmental concern

Q61 In the following series of questions, we will focus on environmental matters

End of Block: Intro environmental concern

---

Start of Block: Environmental concern

Q62 We are approaching the limit of the number of people the Earth can support.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q63 Humans have the right to modify the natural environment to suit their needs.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q64 When humans interfere with nature it often produces disastrous consequences

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q65 Human ingenuity will ensure that we do not make the Earth unlivable

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q66 Humans are seriously abusing the environment.

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q67 The Earth has plenty of natural resources if we just learn how to develop them

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q68 Plants and animals have as much right as humans to exist

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q69 The balance of nature is strong enough to cope with the impacts of modern industrial nations

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q70 Despite our special abilities, humans are still subject to the laws of nature

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

Q71 The so-called “ecological crisis” facing humankind has been greatly exaggerated

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

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Q72 The Earth is like a spaceship with very limited room and resources

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

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Q73 Humans were meant to rule over the rest of nature

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

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Q74 The balance of nature is very delicate and easily upset

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

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Q75 Humans will eventually learn enough about how nature works to be able to control it

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

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Q76 If things continue on their present course, we will soon experience a major ecological catastrophe

- Completely disagree (1)
- Disagree (2)
- Neutral (3)
- Agree (4)
- Completely agree (5)

**End of Block: Environmental concern**

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**Start of Block: Intro WTP**

Q77 Next, we will present two flights from Brussels to Lisbon. One with the main carrier and one with the budget carrier.

End of Block: Intro WTP

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Start of Block: WTP

Q78
How much extra would you be willing to pay to take the same flight with the Greenest Airline that utilizes Sustainable Aviation Fuel (SAF) and offers a minimum $CO_2$ reduction of 80%? (Enter 0 if you wouldn't pay anything extra)

________________________________________________________________

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Q79 How much extra would you be willing to pay to take the same flight with the Greenest Airline that utilizes Sustainable Aviation Fuel (SAF) and offers a minimum $CO_2$ reduction of 80%? (Enter 0 if you wouldn't pay anything extra)

________________________________________________________________

End of Block: WTP

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Start of Block: Intro pb

Q80 Lastly, we would like to ask you a few questions about your personal background.

End of Block: Intro pb

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Start of Block: Socio-demographics

Q81 Which year were you born?

________________________________________________________________

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Q82 What is your gender?

◯ Male (1)

◯ Female (2)

◯ Prefer not to say (3)

◯ Other (4)

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Q83 What is your highest level of education?

◯ No formal education (1)

◯ High school (2)

◯ Lower vocational education (LBO) (8)

◯ Vocational education (MBO) (3)

◯ Higher vocational education (HBO)(studying towards or completed) (7)

◯ University Bachelor's Degree (studying towards or completed) (4)

◯ University Masters Degree (studying towards or completed) (5)

◯ University PhD degree (studying towards or completed (6)

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Q84 What is your current employment status?

- Employed (1)
- (Currently) unemployed (2)
- Student (3)
- Retired (4)
- Other (5)

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Q85 What is your gross annual income?

- (1)
- 10.001-20.000 (2)
- 20.001-30.000 (3)
- 30.001-40.000 (4)
- 40.001-50.000 (5)
- 50.001-60.000 (6)
- 60.001-70.000 (7)
- 70.001-80.000 (8)
- 80.001-90.000 (9)
- 90.001-100.000 (10)
- >100.000 (11)
- I'd rather not say/ I don't know (12)

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Q86 Where do you live?

- ◯ The Netherlands (1)
- ◯ Belgium (2)

Page Break