The Factors That Influence the Decision Between Taking the Train or the Airplane Between Amsterdam and London

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Abstract

The aim of this research was to investigate the factors that influence the decision between taking the train or the airplane from Amsterdam to London. This research was done through the use of logistic regressions based on the data of a stated preference survey. This survey was distributed through social media. The results of the current literature indicate that travel time and ticket price are the most important factors in determining if people travel by train or fly between Amsterdam and London and that the CO2 emissions caused and the luggage allowance also play a role but are less important in determining the mode of transportation people choose. No previous studies were found which addressed the effects of income on whether people travel by train or by airplane. Therefore, in this thesis the effects of income (as well as age and gender) were examined through the use of logistic regressions in an attempt to address this gap in the literature. Results were found indicating a relationship between age and train/airplane choice for travel. Gender and income were not found to impact the airplane/train choice.

Key words: Aviation, High-speed rail, Stated Preference survey, binary logistic regression, discrete choice experiment

Table of Contents

List of tables

List of figures

List of Acronyms

CO2 - Carbon dioxide

HSR - High speed rail

LCC - Low cost carriers (airplanes)

FSC - Full service carriers (airplanes)

SP survey - Stated Preference survey

RP survey - Revealed Preference survey

WTP - Willingness to pay

DCE - Discrete choice experiment

1. Introduction

The aviation industry contributes to climate change due to the large amount of greenhouse gases that are emitted. Fossil fuels are burned in order to enable airplanes to take off and this causes emissions of both carbon dioxide (CO2), Nitrous Oxide (NOX), soot particles, sulphate aerosols, water vapour, particulate matter, carbon monoxide and hydrocarbons (EASA et al., 2022). The aviation industry is currently responsible for 1.9% of global greenhouse gas emissions (Our World in data, 2023). However, by 2050, the share of global carbon emissions of the aviation industry is predicted to increase to 22% (Dolšak & Prakash, 2022).

Flying causes substantially more greenhouse gas emissions than taking the train. Peeters et al. (2004) have found that the CO2-equivalent emissions per kilometre are 0.0284 kg for trains whereas for flying they are 0.412 kg (distances under 500 km), 0.354 kg (distances between 500 km and 1000 kg), 0.351 kg (distances between 1000 and 1500 km), 0.326 kg (distances between 1500 and 2000 km) and 0.299 (distances above 2000 km). CO2 equivalents also take into account other greenhouse gases such as Nitrous Oxide (NOX). For example 1 kg of NOX is 298 kg of CO2 equivalents (CBS, 2023). Therefore, it can be concluded that for the longest distance flights (which have the lowest emissions) the emissions are still more than 10 times higher than travelling by train.

Similarly, the European Commission (2006) found that the greenhouse gas emissions from flying are six times higher than the greenhouse gas emissions for High Speed Rail (HSR). Additionally, Karpman (2022) finds that trains are the better choice environmentally. Karpman (2022) states that “HSR ridership needs to be high, energy propulsion must be powered largely by renewables, and displaced demand for intrastate air travel must not be replaced by longer-haul flights” in order to maximise the benefits of HSR.

A distinction can be made between CO2 emissions per passenger from economy class passengers and CO2 emissions per passenger due to business class passengers. The emissions of the former are about three times higher than the emissions of the latter (BBC, 2019). This is due to the fact that business class seats take up more room in the airplane than economy class seats. If airplane seating were to be made up of only economy class seats, the CO2 emissions per person would be lower than an airplane with both economy class and business class.

Moreover, the takeoff procedure of airplanes causes more emissions than when an airplane is cruising at high altitudes, as more fuel is used during take off. Therefore, takeoff accounts for a larger proportion of emissions on shorter flights (BBC, 2019). Additionally, this means that there are lower emissions for direct flights than for multi-leg trips.

In contrast to this, an older report found that "About 10 percent of aircraft emissions of all types, except hydrocarbons and CO2, are produced during airport ground level operations and during landing and takeoff. The bulk of aircraft emissions (90 percent) occur at higher altitudes. For hydrocarbons and CO2, the split is closer to 30 percent ground level emissions and 70 percent at higher altitudes." (Federal Aviation Administration, 2005)

Another crucial point in determining the CO2 emissions per passenger is if the airplane is full. On a flight that is only half full, the CO2 emissions per passenger will be twice as high compared to a full flight. In addition to this, newer airplanes can be more fuel efficient than older airplanes. A recent report found that "A latest-generation aircraft is about 15 to 20 percent more fuel-efficient than the previous generation, and new developments can be expected to continue this trajectory, including more fuel-efficient engines, lighter materials, improved aerodynamics, and similar measures'' (Esqué et al., 2022).

For trains, the main factors that determine the emissions levels are whether or not a train is an electric train or a diesel train. In the former case, the source of the electricity

determines the emission level. Diesel trains emit two times more CO2 emissions than electric trains. The source of the electricity used on electric trains is also extremely important. For example, in France, 75% of the energy generated comes from nuclear power whereas in Poland 80% of grid power comes from coal (BBC, 2019).

Examining the factors that influence the decision between taking a train or an airplane is particularly relevant for the route from Amsterdam to London as there are a significantly large number of passengers on this route. In 2017, London Heathrow was the most common destination for passengers flying from Schiphol airport with 1,688,997 passengers flights to London (Schiphol, 2017). Moreover, aside from London Heathrow there are five additional airports in London that receive flights from Schiphol Airport (Schiphol, 2023). The number of passengers flying to and from London was even four to six times higher than to other European destinations such as Paris, Copenhagen, Munchen, Frankfurt and Berlin (Huibregtse et al., 2019).

The Eurostar train between Amsterdam and London transported its first passengers on 4 April, 2018. There are two options for passengers that want to travel from Amsterdam Central Station to London St Pancras. Firstly, there are direct trains that operate on this route. Secondly, passengers can travel from Amsterdam central station to London St Pancras with a changeover at Brussels Midi station (Eurostar, 2023). In order to get a good understanding of the current passport and security checks that are needed when travelling from Amsterdam to London, a phone call was made to the customer service team of Eurostar. In this phone call it was confirmed that for direct trains the security and passport checks are solely at the departing train stations (either Amsterdam central station or London St Pancras). If passengers book a trip from Amsterdam to London with a changeover in Brussels, the security and passport checks occur at Brussels Midi station. For an indirect trip from London St Pancras back to Amsterdam with a changeover in Brussels, the passport and security trips

are done at London St Pancras station (Eurostar customer service desk, 2023). Since October 2020, border controls at Amsterdam central station allow passengers of direct trains to avoid having to go through security and passport control in Brussels in most cases. Therefore, the travel time of passengers has decreased substantially (by one hour maximum) (Ministerie van Infrastructuur en Waterstaat et al., 2020). Travel times are higher post-Brexit than in the first year of operation. Avogadro et al. (2023) found that "HSR's scheduled travel times during the first year of operation (2018) were approximately 14 min shorter than today, and that passport control activities introduced after Brexit currently impose a stop of Eurostar train of half an hour in Brussels''.

A one-way economy class airline ticket between Amsterdam and London causes between 37 and 52 kg of CO2 emissions (Google flights, 2023). Even if two flights are both direct flights, there can be a large difference in the CO2 emissions between these two flights. This is due to differences in the types of airplanes used and the number of seats there are of the different classes (economy, premium economy, business, first class). Moreover, if a slightly shorter route is taken, this can also lower the CO2 emissions of the flight.

A one-way train ticket from Amsterdam to London causes 8.4 kg of CO2 emissions (Eurostar, 2023). The calculations for this were done by Paul Watkiss Associates LTD in 2017 . This was calculated using on-board meters to measure the electricity consumption of the Eurostar trains. The Eurostar trains use 100% wind power energy in their trains in the Netherlands (Eurostar, 2023).

The Eurostar connection between Amsterdam and London has recently been in the Dutch news. Due to a renovation that will take place at the Amsterdam central train station, the passenger terminal of Eurostar will not be available. This passenger terminal is needed for passport and baggage checks which are required because Great Britain is not part of the Schengen customs zone. Consequently, the Eurostar will not run from June 2024 until May

2025 at the latest. On the 8th of June 2023, there was a debate in the Dutch house of Representatives about the issue. Only the future will tell if the situation is resolved so that the Eurostar trains can continue to operate between Amsterdam and London in this timeframe (NOS, 2023).

The number of flights from Amsterdam to London were examined using information from Schiphol's website. Four different days in the summer of 2023 were analysed to obtain data on both on how many flights came from the airports in London to Schiphol and how many flights were scheduled to leave from Schiphol to airports in London. Unfortunately, Schiphol's website only provides data for the upcoming three weeks so therefore no data could be obtained about flights in the past.

The number of Eurostar trains that were scheduled between Amsterdam and London were also examined. The data on how frequent these trains were scheduled to run was obtained from the Eurostar website. The table below (Table 1) presents the number of direct trains and, in parenthesis, the number of trains with one changeover. It is important to note that the dates that were examined were all in the summer. Avogadro et al. (2023) found that "A seasonal travel pattern is outlined for leisure passengers with higher flows during the spring and summer seasons, decreasing during fall and winter months. Conversely, business flows do not exhibit any statistically significant seasonal trend." Therefore the data in Table 1 below seems to be at peak levels in terms of the amount of flights.

Table 1. Number of airplanes and trains between Amsterdam and London

Day	Flights Amsterdam-London	Flights London-Amsterdam	Eurostar trains Amsterdam-London	Eurostar trains London-Amsterdam
Monday, 12 June 2023	54	53	4 (5)	4 (4)
Tuesday, 13 June 2023	51	49	4 (5)	4 (4)
Tuesday, 20 June 2023	47	47	4 (5)	4 (4)
Sunday, 2 July 2023	33	34	3 (4)	3 (4)

There are approximately 22.500 daily passengers who fly from Amsterdam to London (OV-Pro, 2023). A Boeing 747-400 can transport 568-660 passengers (Skybrary, 2023). 568 times 50 flights results in 28.400 passengers per day. Therefore, the airplanes that are flying would be 79.2% full (22.500/28.400*100%).

The frequency with which trains run is very important in determining the market share of HSR (European Commission, 2006; Ministerie van Infrastructuur en Waterstaat et al., 2020). If trains run with higher frequencies, more travellers will opt to choose the train as there are more options. European Commission (2006) found that two routes that both had a travel time of approximately 2 hours and 30 minutes had very different market shares. The

London-Brussels route had a market share of 44%, whereas the Frankfurt-Paris CDG had a market share of 85%. This large difference can be attributed to a difference in the frequencies of the trains on these two routes (European Commission, 2006).

For example, certain consumers may prefer to travel very early in the morning or very late at night. Currently, Eurostar does not offer any direct trains from Amsterdam to London that leave before 7:47 am or after 6:47 pm (Eurostar, 2023). However, there could be a potential to attract more business travellers that want to attend a meeting in London before 11:00 am (the 7:47 am train arrives in London at 11:00 am).

In most cases, flying is cheaper than taking the train (Huibregtse et al., 2019). Consumers that want to travel by train from Amsterdam to London only have one company where they can book their tickets. Eurostar has a monopoly in the Amsterdam-London train market and can therefore set relatively high prices. It would be beneficial for consumers if more firms would enter the Amsterdam-London train market as prices would decrease and therefore the consumer surplus would increase. By contrast, there are five different airlines that offer flights between Amsterdam and London (KLM, Easyjet, Vueling, CityJet and British Airways). The fact that there is more than one airline that offers flights on this route is also a reason why flying is generally speaking cheaper than taking a train as there is more competition in the market.

Moreover, governments offer exemptions to the aviation industry. For example, there is no sales tax on flight tickets in the Netherlands, whereas on train tickets there is a 9% sales tax (Joosten, 2020). Moreover, for most flights there is no tax on kerosene (Joosten, 2020). This is due a decision that was made during the Chicago convention on International Civil Aviation in 1944 (van de Lustgraaf, 2022). As stated before, air travel causes a large amount of greenhouse gases to be emitted. The fact that there is no tax on kerosene means that the negative external costs of flying are not internalised in the market price of flight tickets. If a

tax on kerosene was introduced, it should be set equal to the social cost of carbon in order for the negative externalities to be accounted for. Pigou (1920) introduced the concept of internalising negative externalities through taxation. This concept is now known as the Pigouvian tax.

Aside from the exemptions described in the previous paragraph, the Dutch government launched a program in 2016 called 'Actieagenda Schiphol' to invest in roads and train lines in order to increase the accessibility of Schiphol (Ministerie van Infrastructuur en Waterstaat, 2016). The program will run until 2028 and the total cost is approximately 12 billion euros. These extremely high costs are not internalised into the cost of flight tickets and instead get paid with taxpayers' money. On the one hand, this program could indirectly stimulate rail travel from Amsterdam to London, as investments in the Dutch train lines could increase the accessibility to Amsterdam central station. On the other hand, the investments seem to be mainly focused on promoting air travel because at the end of the day they are aimed at making Schiphol airport more accessible and the Eurostar train from Amsterdam to London currently does not stop at Schiphol Airport. All in all, it can be concluded that there are many reasons why, generally speaking, flying is cheaper than taking the train.

When analysing the market share of both airplanes and trains, there seems to be a general consensus in the current literature. Huibregtse et al. (2019) found that for distances above 800 kilometres the aviation industry generally dominates the market, due to the fact that for these distances the travel time of flying will be much lower than the train travel time. Similarly, the European Commission (2006) found that travellers, for which travel time is the main concern, have made a switch away from flying towards high speed trains. This has led to a significant increase in market share for trains. It is important to note that for flying to certain destinations there is often a situation where travellers will be spending a large proportion of their total travel time waiting at airports in order to go through passport control

and security. Therefore, when travelling from Amsterdam to destinations such as Paris, Frankfurt, Brussels and Düsseldorf, the door to door travel time can actually be shorter for taking the train than for flying (Huibregtse et al., 2019). The destinations mentioned in the previous sentence are all EU countries and the Schengen Area whereas London is not in the EU anymore due to Brexit. This means that if a person were to travel from Amsterdam to Frankfurt, for example, they would not have to go through passport control in Germany.

Although it may seem environmentally beneficial for short-haul flights such as flights from Amsterdam to London to be replaced by HSR, there is evidence to contradict this instinctive assumption. Two previous studies have found that there could be a negative net environmental effect if HSR and airlines are integrated (Givoni & Banister, 2006, Socorro & Viecens 2013). The idea behind this is that due to a substitution from air to rail, the number of long-haul flights could increase as additional slots are opened up. For example the slot of a flight from Amsterdam to London Heathrow could be replaced by a flight from Amsterdam to New York.

At Schiphol airport the slots that would open up if flights from Amsterdam to London are replaced by HSR are distributed by Airport Coordination Netherlands (ACNL) (Joosten, 2023). These slots are legal rights that airlines have to let their airplanes take off and land at Schiphol airport. The current system for these slots is based on grandfather rights. If an airline uses at least 80% of their slots in a given year, they will keep these slots in the next year and there is currently no information what the monetary value of these slots at Schiphol airport is (Joosten, 2022). However, in 2016 KLM sold a slot at Hearthrow airport to Oman Air for 75 million USD (Collingridge & O'Connell, 2016). Slots clearly have a very large economic value as without them airlines can not legally take off or land at an airport (Joosten, 2023). An interesting case arose when a British airline, Flybe, went bankrupt. The slots that became available at Schiphol airport due to this bankruptcy were not redistributed by the

ACNL and therefore this decreased the total number of flights at Schiphol airport. Furthermore, the ACNL had a plan to implement regulations on what destinations airlines could fly to based on the societal benefits for five thousand slots (approximately 1% of the flight movements at Schiphol airport) (Joosten, 2022). However, the International Air Transport Association (IATA, an organisation that represents approximately 300 airlines) started a lawsuit against this plan. The judge that ruled in this case decided in favor of the IATA by ruling that the ACNL could not decide what destinations the slots should serve (Van Der Heide, 2021). This adds further complications to increasing train travel, as airlines will be unwilling to lose their slots, even in the face of reduced demand.

This research should be seen as a quantitative research study. However, there is also a quantitative element to this research; A short interview was conducted with a person (Martina H.) that currently works at the passport control desks of Schiphol airport (officially this is called ‘eerstelijns grensbewaking’). This person said that due to the fact that England is not in the Schengen area and the EU anymore, British people fall under the Schengen border code. Therefore, when a British person arrives at the passport control desks at Schiphol airport, they will be asked how long they intend to stay in the Netherlands and what the purpose of their trip is. Interestingly, there are many people that arrive in Amsterdam and take a flight back to London on the same day. This person observed this by examining the stamp in the passports of the British people when they arrived and could determine that they left on the same day.

The aim of this thesis is to research which factors influence the choice of consumers to either take the train or the airplane on the route from Amsterdam to London. After conducting research into the available literature, no studies were found that specifically focused on this route. However, in June 2023 there was one study that was published that focused on the route from Amsterdam to London (Avogadro et al., 2023).

In order to investigate the factors that influence if people take the train or the airplane, a stated choice experiment was carried out. The results of the stated choice experiment together with the literature review form the basis for the conclusions of this research. The main research question is: What factors influence the choice between taking the train or the airplane from Amsterdam to London?

The structure of this research will be as follows: The literature review will provide insights into the current academic literature (with a main focus on travel time and ticket price). In the third section, the research design and methodology will be explained. In the fourth section the results of the statistical analysis that was carried out will be presented. The fifth section will provide a discussion with limitations of this research and suggestions for further research. Finally, the sixth section will lay out the conclusions of this research.

2. Literature review

This section will address previous research on the different factors that influence the decision between taking the train or taking the airplane. Nurhidayat et al. (2023) found that the "eight most commonly used attributes in mode choice models are the travel time, travel cost, frequency, distance, access time, population, GDP, access time and monthly level income.'' From these eight factors, the authors identify travel time and ticket price as the most commonly used travel attributes. Therefore, in this thesis the decision was made to mainly focus on travel time and ticket price. Other factors that are considered in this literature review are CO2 emissions and luggage allowance.

There has been a substantial increase in HSR availability in many countries. Nurhidayat et al. (2023) found that "countries such as Japan, China, South Korea, France, Italy, Germany and Spain have developed different HSR rolling stock technologies and this has made HSR an effective alternative for air transport''.

Overall the increase in HSR availability has had a negative effect on the demand for flying. For example, the entry of HSR has had a strong negative effect on the air transport demand in China (Zhang et al., 2017). Similarly, Nurhidayat et al. (2023) found that there was a 27% decrease in air travel due to the introduction of HSR in China due to the introductions of HSR. Moreover, Park & Ha (2006) found that when a new train line was introduced in South Korea, the actual number of flights decreased by 20-90%. Finally, according to Bukovac & Douglas (2019), if a HSR line was introduced between Sydney and Melbourne this would decrease air transport demand.

Kroes and Savelberg (2019) found that in their ''minimum scenario'' HSR could replace 18.73 million flights in 2030 mainly due to decreases in travel times and increases in train frequencies. 76.72% of these replaced flights would be on the Amsterdam-London

route. The results of this study highlight how important the route from Amsterdam to London is in realising a substitution from air to HSR.

2a. Ticket price

This section will focus on the literature review addressing the effects of ticket price on travel demand. There is a large amount of literature addressing this issue. The airline ticket prices are determined by a complex algorithm. Airlines use these algorithms to maximise their profits by basing the price on the current demand for flights, the timing of booking and the number of seats available (Shepard, 2019). Therefore, it is very likely that passengers that are flying on the same airplane will have paid different ticket prices. From this, it is apparent that airlines practice price discrimination.

According to the available research, the ticket price is a very important factor, if not the most important factor, in determining the demand for train trips and flights. Froidh (2008) found that ticket price is especially important for price-sensitive travellers, whereas for business travellers travel time is the more important factor. Similarly Martin et al. (2007) found that leisure passengers value low ticket prices very highly and do not seem to care much about the service quality. Conversely, Gayle (2004) found that non-price factors such as frequent flyer schemers, the quality of in-flight service and the convenience of flight schedules may be just as important as price in the decision of consumers.

A study that deserves extra attention, as it is particularly relevant to the main research question of this thesis, is Inoune et al. (2015). This study used a Stated Preference survey in order to examine the effects of the start of the Chuo Shinkansen train line in Japan on the air transport demand. The SP survey asked respondents what the main reasons were that they chose their means of transportation. The results were that the main reason for choosing Low Cost (airplane) Carriers is low cost; 87% of the participants indicated that this was their

reason for choosing for LCCs. By contrast, short travel time was only chosen by 9.2% of the respondents, indicating that travel time seems to be much less important for travellers that choose LCCs. This is in line with Froidh (2008) that found that ticket prices are very important for price-sensitive travellers. The results reveal that there were five major reasons for respondents to choose Full Service (airplane) Carriers: low cost (26.6%), short travel time (24.4%), frequent flyer programs (21.8%), suitable for itinerary (20%) and accustomed to use (19.6%). Finally, the main reasons that respondents opted for the Shinkansen were: good access from origin to Shinkansen station (34.7%), short travel time (32.7%), good access from Shinkansen station to destination (23.7%), accustomed to use (22.7%), low cost (19.7%) and comfort of travelling (15.3%). All in all, the ticket price seems to be a very important factor in the decision of Japanese travellers to either take the train or the airplane. In line with the studies discussed above, Inoune et al. (2015) also found that non-business travellers were more price elastic than business travellers. Moreover, price-elasticities on short-haul routes were found to be larger than price elasticities on long-haul routes.

Avogadro et al. (2023) studied policies to increase the market share of HSR in the Amsterdam-London market. This study found that a ticket tax of 20 pounds, which would increase airline ticket prices, would decrease air traffic volume and market demand. Moreover, a decrease in HSR ticket prices would increase HSR travel. However, changes in ticket prices will not substantially increase the market share of HSR.

Table 2 contains information on all academic articles that were examined to investigate the effects of ticket price. It gives an overview of the methodology used, the location of the research and main findings of the research. The table is partly based on the work of Nurhidayat et al. (2023) but has been expanded with additional studies.

In conclusion, the ticket price has an influence on the decision of consumers to take either the train or the airplane.

Table 2. Summary of previous Studies on Effects of Ticket Price

Author(s)	Research method/data collection method	Model used	Location	Findings
Zhang et al. (2017)	Panel data	Two econometrics models	China	The start of HSR has negatively affected air transport demand
Lee et al. (2016)	Stated preference techniques	A mixed logit model	South Korea	Ticket price influences the decision of consumers
Roman et al. (2007)	Revealed preference and stated preference	Nested logit model	Spain	Ticket price influences the decision of consumers
Cascetta et al. (2011)	Revealed Preference survey	Nested logit mode choice model	Italy	Ticket price influences the decision of consumers
Behrens & Pels (2012)	Stated Preference	Multinomial logit model in combination with a mixed logit model	The London-Paris route	Consumers decide what airline they choose based on price and frequency
Albalate et al. (2015)	Panel data	Multivariate econometric regression	France, Germany, Italy and Spain	The market share of HSR and airlines gets determined in part through the ticket price
Inoue et al. (2015)	Stated Preference	Nested logit model	Japan	Low cost was the most important reason (or a very important reason) for people choosing their mode of transportation

Roman et al (2010)	Revealed Preference and Stated Preference	Nested Logit model	Spain	Travel price is the most important factor however ticket price is also important
Hofer et al. (2008)	Panel data	Ordinary Least Squares regression models	USA	There was an increase from 20.9% in 1992 to 36.5% in 2002 in the amount of passengers flying with low cost carriers.
Dobruszkes (2011)	Survey	Regression models	27 EU countries, Switzerland, Norway and Iceland	Ticket price is important in the competition between trains and airplanes
Avogadro et al. (2023)	A survey in combination with characteristics of available transport modes	A two-level aggregate nested logit model	The Amsterdam-London route	Ticket price does slightly affect demand but changes in ticket prices will not substantially increase the market share of HSR
Kroes & Savelberg (2019)	demand growth factors	A modal split model (a binary logit model)	13 European airport destinations	Decreases in ticket prices and decreases in travel time are the most important factors in order to substitute flights by HSR

2b. Travel Time

This section will focus on the effects of travel time on travel demand. There have been many studies that have investigated this.

Travel time is a very important factor, if not the most important factor in the decision of consumers to take the train or fly. Froidh (2008) found that travel time is the most important factor for trains to gain market share. Similarly, Givoni & Banister (2006) found that on routes of approximately 600 km, flying and HSR are substitutes for each other due to the fact that the travel times are very similar at that distance. Furthermore, Silla et al. (2008) found that travel time is the main factor that determines if European flights can get replaced by HSR.

As mentioned in the previous section, Avogadro et al. (2023) studied policies to increase the market share of HSR in the Amsterdam-London market. Avogadro et al. (2023) found that travel time is a very important factor, stating "A decrease of HSR travel time by 30 min, which could be achieved if less time is needed for immigration or following the implementation of measures aiming at more efficient capacity management on the HSR network, would increase the HSR market share by 7% compared to the 2019 levels.'' Moreover, an analysis was done of a situation in which the waiting time for departing flights increased by 30 minutes. The authors found that this would decrease airline traffic by approximately 25% (a reduction of almost 1.2 million passengers). From these 1.2 million passengers, 170,000 passengers would switch from flying to HSR and therefore the market share of HSR would increase by 7%. A situation in which there would be a 60 minute increase in the waiting time for departing flights would lead to a decrease of more than 2 million passengers and would increase the market share of HSR by 17.1% (Avogadro et al., 2023).

Table 3 below contains a summary of the academic articles that were examined to investigate the effects of travel time. It gives an overview of the methodology used, the location of the research and main findings of the research. The table is partly based on the work of Nurhidayat et al. (2023) but has been expanded with additional studies. In conclusion, the travel time has an influence on the decision of consumers to take either the train or the airplane.

Table 3. Summary of Previous studies on effects of Travel Time

Author(s)	Research method/data collection method	Model used	Location	Findings
Zhang et al. (2017)	Panel data	Two econometrics models	China	The introduction of HSR has led to a strong decrease in air transport demand
Lee et al. (2016)	SP techniques	A mixed logit model	South Korea	Travel time influences not only leisure travellers but also business travellers
Cascetta et al. (2011)	Revealed Preference survey	Nested logit mode choice model	Italy	Travel time influences the decision of consumers
Inoue et al. (2015)	Stated Preference	Nested logit model	Japan	Travel time is an important factor for the train, LCCs and FSCs
Roman et al. (2010)	Revealed Preference and Stated Preference	Nested Logit model	Spain	The Willingness to Pay (WTP) to decrease travel time is higher on airplanes than on trains on the route Madrid-Zaragoza but lower on airplanes on the

				route Madrid-Barcelona
Dobruszkes (2011)	Survey	Regression models	27 EU countries, Switzerland, Norway and Iceland	Travel time is an important factor for trains to gain market share
Yang et al (2018)	Panel data	Regression models	China	Travel time influences air passenger flows
Behrens & Pels (2012)	Stated Preference	Multinomial logit model in combination with a mixed logit model	The London-Paris route	Travel time and frequency are the main determinants of travel behaviour
Clewlow et al. (2014)	Panel data	Ordinary Least Squares regression models	Europe	Due to the fact that train travel times have decreased, short distance flights have decreased
Li & Sheng (2016)	Stated Preference	Multinomial logit-based discrete choice models	China	Travel time is the most important factor in determining the market shares
Wang et al. (2018)	Panel data	A difference-in-differences method	China	Travel time influences the decision of consumers
Gundelfinger-Casar & Coto-Millán (2017)	Observations on a monthly basis	Demand functions	Spain	Travel time and price are the most important factors in determining whether HSR and air travel compete or a complementary to each other
Avogadro et al. (2023)	A survey in combination with characteristics of available transport modes	A two-level aggregate nested logit model	The Amsterdam-London route	If the travel time of HSR decreases, the market share of HSR increases. If the travel time of flying increases, air traffic will decrease

Dobruszkes et al. (2014)	Cross sectional data	A Tobit regression model with removed outliers	All EU countries	If the travel time of HSR decreases, the amount of flights decreases
Kroes & Savelberg (2019)	Demand growth factors	A modal split model (a binary logit model)	13 European airport destinations	Decreases in ticket prices and decreases in travel time are the most important factors in order to substitute flights by HSR

2c. CO2 Emissions

Flight shame is a term that refers to the uneasiness that people experience during air travel due to the negative effects that air travel has on the climate (Gössling et al., 2020). This is due to the fact that air travel causes a large amount of greenhouse gases to be emitted. This is due to the fact that fossil fuels have to be burned in order for airplanes to take off. The aviation industry is responsible for 1.9% of global greenhouse gas emissions (Our World in data, 2023).

As a result of flight shame, certain airline passengers are willing to pay for CO2 offsets. The percentage of airline customers that offset their emissions voluntarily is somewhere between 1% and 3% (International Transport Association, 2020). CO2 offsets can be bought through airlines themselves or through organisations like the Gold Standard Organisation (the Gold standard, 2023). An example of a carbon offset program of an airline is the CO2 zero carbon offset program of the KLM. This program supports reforestations efforts in Panama. A Dutch advertising code committee, ‘Stichting Reclame Code’, has penalized KLM for running misleading advertisements for this carbon offset program. KLM advertised their CO2 offset program using the slogan “Be a hero, fly CO2 zero’’. However, according to ‘Stichting Reclame Code’, this was an absolute claim that the airline could not prove (Sustainable Brands, 2020). An example of a carbon offset program of the Gold

Standard is that this organisation is building a 60 megawatt Wind Power plant in India (the Gold standard, 2023).

Lu & Shon (2012) studied the Willingness to Pay (WTP) of airline passengers for CO2 emission offsets. Their research focused on more than 1000 Taiwanese passengers flying to North America, Asia, Europe and Oceania. The results of this research indicate that the ticket price, class of sets, subsidies offered, reason for travel, frequency of travelling abroad and age were factors that influenced the WTP of people. More specifically, the most important factors in determining the WTP are how effective people think that the CO2 offset schemes are, and if people are aware of the impact of their flying on the environment and actually care about this.

Brouwer et al. (2008) study whether and why airline passengers approved of measures that increased their travel costs due to the emissions of their trips as well as if airline passengers were willing to pay for compensation for the CO2 emissions caused by their flights. The results of this research were that 75% of the survey respondents were willing to pay on average 25 euros per ton of CO2 emissions using the conservative lower bound WTP estimate. The average price to offset one tonne of CO2 was found to be approximately 12 euros. The results also indicate that there are significant differences between travellers from North America, Asia, Europe and the rest of the world but that generally speaking there is a substantial demand for policies to combat climate change. It should be noted that this study likely suffers from a self-selection bias as generally speaking people who are eco conscious are more likely to have taken part in this study and are therefore likely overrepresented.

MacKerron et al. (2009) investigated the WTP of their stated preference study for carbon offsets in the context of three different co-benefits that carbon offsets generally have. Co-benefits are essentially the positive externalities that arise when people purchase carbon offsets. According to MacKerron et al. (2009) these co-benefits are “safeguarding or

promoting biodiversity, supporting human development and poverty reduction and enabling market and technology development in low-carbon sectors'' and this study focuses on whether or not these co-benefits influence the WTP of airline consumers for voluntary offsets. The results of this study indicate that the co-benefits indeed do influence consumers; consumers are willing to pay significantly more for offsets that are classified as having the three co-benefits. Therefore it can be concluded that airline consumers seem to care about the positive externalities of carbon offsets.

In conclusion, certain consumers are willing to pay to offset their CO2 emissions. The consumers who are willing to pay to offset their CO2 emissions are likely also consumers for which the CO2 emissions of their trip can be a reason for them to take the train instead of the airplane, as this is a group that is environmentally conscious. However, as the percentage of airline customers that offset their emissions voluntarily is very low (somewhere between 1% and 3%), it seems to be that CO2 emissions for most people are not an important factor in their decision between taking the train or the airplane between Amsterdam and London.

2d. Luggage Allowance

This section will focus on the WTP of passengers for luggage. A distinction can be made between LCCs and FSCs in how the sources of their revenue are determined. The revenue of LCCs comes for a large part from selling add-ons such as additional luggage, food and drinks and seat selection whereas FSCs mostly charge a higher price but include checked luggage, some food and drinks and the ability to choose your seat in this ticket price (Curran, 2023). For example, Pande (2023) found that "For the year ending March 31st, 2022, the carrier brought in €2.15 billion ($2.27bn) in ancillary revenues out of a total of €4.8bn ($5bn). This means just under 45% of the carrier's revenues came from ancillary fees last year.''

Klislinar & Widjaja (2020) studied what additional products and services respondents were planning to purchase on their flights with Garuda Indonesia. Garuda Indonesia is a FSC; however, it does own a subsidiary airline called Citilink which is a LCC (Pande, 2022). Klislinar & Widjaja (2020) found that the most commonly purchased add-on was additional luggage. This finding is interesting as Garuda Indonesia is a FSC and their tickets already include free baggage. Jou et al. (2019) studies the WTP of Japanese passengers for baggage. The findings of this study indicate differences in the WTP of passengers based on various factors. For example passengers that have already purchased additional luggage in the past have a higher WTP than passengers that have never purchased additional luggage. Moreover, for people who travel in smaller groups (1-3 persons) the WTP is lower. This is likely due to the fact that smaller groups have less pieces of baggage and the free carry-on baggage allowance prevents these passengers from needing additional luggage through checked baggage allowance. A study that focused on the differences between the WTP between short-haul and long-haul flights was Warnock-Smith et al. (2017). This study found that 28.8% of passengers are willing to pay for checked in luggage on short-haul flights compared to 42.9% of passengers on long-haul flights. Moreover, on short-haul flights the mean WTP checked-in luggage was £4.16 and on long-haul flights this was £11.59.

In conclusion, certain consumers are willing to pay more for additional luggage, however in the general literature to my knowledge there are no studies that focus on how an important factor luggage allowance is in the decision of consumers to travel by airplane or by train.

3. Research design and Methodology

This research was done through the use of a Stated Preference (SP) Experiment. In order to conduct this experiment, an online survey was published on social media using the survey tool Qualtrics. Before the final version of the survey was published on social media, a pilot survey was conducted. The feedback that the pilot survey participants gave was used to improve the final survey. Both the pilot survey and the final survey can be found in the appendix.

The survey was published on the 11th of May, 2023 and was closed on the 22nd of May, 2023. The survey was distributed through Linkedin, Facebook and many Whatsapp groups, therefore, initially convenience sampling was used. The process of exponential non-discriminative snowball sampling was used (Scribbr, 2023). In this process the certain participants provide multiple referrals and all referrals are used in the sample. Due to the limited timeframe of this research, this sampling method was used as it allows to obtain a larger sample size relatively fast. The survey was distributed to both students and to educators to obtain a wider age representation. The data that was collected was used for logistic regressions that were run in version 29 of the software package SPSS.

The first question of the survey asked respondents how likely it was that they would travel from Amsterdam to London in the next 12 months. For the possible answers to this question, the Likert rating scale was used. The main advantage of using a Likert scale for the first question was that a nuanced view can be obtained about, in this case, how likely a participant thinks they are to actually make the trip. The responses to this first question were crucial, as the group that responded to question 1 with ‘’not at all likely’’ was excluded from the statistical analysis. This decision was made because this group of respondents does not see themselves travelling to London and therefore this group is not the target group of this research.

During the time that the survey was available, 101 completed and valid responses were collected. As can be seen from Table 4, in the final sample there were 44 men (43.1%) and 58 women (56.9%). There was one respondent that did fill in gender, but did not complete the survey. This respondent was not included in the logistic regressions that were run which involved gender as a variable.

Table 4. Gender, Age and Income of Respondents

Variable	Values	Percentage	Number of respondents
Gender	Male	43.1	44
	Female	56.9	58
Age	20 or younger	4.9	5
	21-30	37.9	39
	31-40	5.8	6
	41-50	14.6	15
	51-60	16.5	17
	61-70	16.5	17
	71-80	1.9	2
	81-90	1.9	2
	91 or older	0	0
Income	< €1000	17.5	18
	€1000-3000	25.2	26

	> €3000	49.5	51
	prefer not to say	7.8	8

In order to determine the linear association between two variables, the Pearson correlation coefficient can be used. This coefficient gives a value ranging between -1 and 1 where a value of -1 implies a perfectly negative linear correlation between two variables, a value of 0 implies that there is no linear correlation between the two variables and a value of 1 implies that there is a perfectly positive linear correlation between two variables. The further away Peason correlation coefficient is from zero, the stronger the relationship is between the two variables.

Table 5 below displays the correlation matrix of the socio-economic characteristics of the respondents:

Table 5. Correlation Matrix of Socio-economic Characteristics of Respondents

	Age	Gender	Income
Age	1	0.038	0.581 **
Gender	0.038	1	-0.120
Income	0.581 **	0.120	1

** correlation is significant at the 0.01 level (2-tailed)

In the correlation, there is one relationship that is significant at a 5% level. This is the relationship between age and income. The Pearson correlation coefficient between age and

income is 0.581 which means that there is a positive linear relationship between age and income. This could have been predicted, as income generally increases with age. For example, students often have minimum-wage jobs, whereas the group from 41-60 years old will typically earn much higher wages. This is due to the fact that, generally speaking, the group from 41-60 years old has more work experience, has more educational certificates and can work more hours as this group is usually not following any education.

The Pearson correlation coefficient is relatively high and this leads to a multicollinearity problem in the research. This is because the variables age and income are not completely independent. They are linked in a positive linear relationship and therefore a multicollinearity problem exists. Therefore, during analysis of these two variables a Bonferroni adjustment to alpha was made to determine significance.

The theory used to evaluate the outcomes was the random utility maximisation theory by McFadden. This theory assumes that people try to maximise their utility when they make consumption decisions. This is in line with findings from Lee et al. (2016) which reported that respondents of the study's survey indeed do choose the mode of transportation that maximises their utility. McFadden's random utility theory is very useful for this research in combination with a Stated Choice Experiment as data can be collected.

McFadden's random utility theory (McFadden, 1973) assumes that the expected utility that consumers derive from certain consumption decisions is determined by a systematic component (V_{in}) and a random component (E_{in}). Therefore $U_{in} = V_{in} + E_{in.}$ where $V_{in} = ß\ X_{in.}$ displays the observed factors that have an impact on the systemic utility component. A consumer will make a consumption decision based on their expected utility level and will choose the consumption good with the highest expected utility level.

Respondents choose the train (option i) if this expected utility level is higher than the expected utility level of choosing the airplane (option j). Therefore, for a respondent that

chooses the train the following equation will hold true: $U_{in} > U_{jn}$. Moreover, according to the random utility theory, although the researcher does not know the utility that an individual can derive from an alternative, the researcher can observe some attributes of the alternatives that can influence the derived utility for an individual. In this research a discrete choice experiment (DCE) was used. In this DCE, participants received two alternatives and were asked to indicate which option they preferred. Each option had certain attributes and each attribute was given certain levels to accurately reflect real life situations. By evaluating which options participants chose, this research aims at capturing which factors influence the attractiveness of the product of a train trip or an airline trip from Amsterdam to London. Stated Preference data is used in order to research this. Table 6 below provides a list of the attributes and the attribute levels:

Table 6. List of Attributes and Attribute Levels

Attribute name	Attribute level
Ticket price	60 euros, 80 euros, 100 euros, 110 euros, 120 euros, 150 euros
CO2 emissions	8.4 kg of CO2 emissions, 47 kg of CO2 emissions
Travel time	4 hours 30 minutes, 5 hours, 5 hours 30 minutes

The questions of the survey were designed in a concise manner in order to achieve the highest possible completion rate. Surveys are less likely to be completed when they are too long. Furthermore, respondents pay less attention to surveys that seem long, repetitive and boring. Socio-demographic questions were asked in the survey in order to research if there were differences in the determining factors across age, gender or income. On the whole, the survey was designed in a way to try to get the highest number of respondents.

When conducting the literature review section of this thesis, it became apparent that demographic variables had not been considered in the outcomes. Therefore, this study focuses on the statistical analysis of the demographic variables of age, gender and income for possible differences.

4. Results

4.1 Logistic Regression

A logistic regression was conducted in SPSS in which the independent variables age, gender and income were regressed on five different dependent variables. These dependent variables displayed if a respondent chose the train or the airplane in question 5 to question 9 of the survey. The results of the logistic regression indicate that none of the independent variables were significant except for age in question 9 (the decision of respondents to take the train and pay 50 euros more to reduce their travel time by one hour). Therefore, this research supports the conclusion that age, gender and income do not influence whether people take the train or the airplane for all of the questions except question 9. However, this could be due to a lack of power in this research. In the next paragraph the results of the logistic regression of question 9 will be further explained.

A logistic regression analysis was conducted to investigate if there is a relationship between age, gender and income and the decision of respondents to take the train and pay 50 euros more to reduce their travel time by one hour. The predictor variable, age, in the logistic regression analysis was found to contribute to the model. The unstandardized Beta weight for the constant; $\boldsymbol{B} = 2.796$, SE = 1.543, Wald = 3.281, $p < .001$. The unstandardized Beta weight for the predictor variable: $\boldsymbol{B} = (-0.657)$, SE = 0.2228, Wald = 8.292, $p < .001$. The estimated odds ratio indicates a decrease of nearly 48.2% [Exp ($\boldsymbol{B}$) = 0.519, 95% CI (0.332, 0.811)] for the chance that a respondent will travel by train and thus pay 50 euros more to reduce their travel time by one hour every one unit increase of age.

A one unit increase in the age of participants decreased the log odds of a person taking the train by 0.657, all else equal. The equation used is $e^{-0.657} = 0.518$. Therefore a one unit increase in the age of participants decreases the odds of a person taking the train by 48.2%, all else equal. However, it should be noted that age and income are highly correlated

(the Pearson correlation coefficient between age and income is 0.581). Therefore, similar variables were actually being measured. The full results can be found in the Table 7 below:

Table 7. Logistic Regression Results for Age, Gender and Income

	Coefficient	Standard Error	Wald Coefficient	P-value
Age	-0.657	0.2228	8.292	0.004
Gender	-0.176	0.690	0.065	0.798
Income	0.894	0.486	3.378	0.066
Constant	2.796	1.543	3.281	0.070

Examination of independent demographic variables

For the second part of the statistical analysis, this research focused on if there were interesting observations across age, gender and income for respondents that switched from train to airplane. A switcher is defined as someone who was willing to pay 20 euros to avoid 38.6 kg of CO2 emissions (they chose the train in question 5) but is apparently not willing to pay 50 euros to avoid 38.6 kg of CO2 emissions (they chose the airplane in question 6). Therefore, the switchers changed their answers when the ticket price difference became 50 euros instead of 20 euros. This will be discussed in section 4.2.

Similarly, a switcher is also someone who was willing to pay 20 euros to reduce their travel time by one hour (they chose the airplane in question 8) but is apparently not willing to pay 50 euros to reduce their travel time by one hour (they chose the train in question 9). This will be discussed in section 4.3. In order to investigate if gender, age and income were variables that were associated with each other, a chi-squared test was carried out in SPSS.

For all of the logistic regressions that were run, chi-squared tests were carried out. None of the logistic regressions had a p-value of less than 0.05, except for the logistic regression that was run where the respondents are divided up into two age groups with the cutoff at 50 years old. Therefore, in all other chi-squared tests the results were not significant.

4.2 Switchers between question 5 and question 6:

This section is about the logistic regressions that were run to compare the switchers between question 5 and question 6. The respondents that made this switch were willing to pay 20 euros to avoid 38.6 kg of CO2 emissions but were not willing to pay 50 euros in order to avoid the same CO2 emissions. Therefore they made a switch from train to airplane.

A logistic regression was run in order to investigate if there were differences across gender in the respondents that switched from train to airplane. The results of this logistic regression confirm that this is not the case, as the results are insignificant (the p-value is equal to 0.276 and this is larger than 0.05).

Table 8. Logistic regression results for Switchers between Q5 and Q6 based on gender

	Coefficient	Standard Error	Wald Coefficient	P-value
Gender	0.441	0.405	1.187	0.276
Constant	0.675	0.669	1.019	0.313

As can be seen by the frequency data below (Table 9), among the switchers there is an almost identical number of men that switch and women that switch. However, in general, women seem to fall into the category of not switching more often.

Table 9. Frequency of Gender of Switchers

	Male	Female	Total
Do not switch	19	32	51
Switch	24	26	50
Total	43	58	101

Secondly, a logistic regression was run where the respondents are divided up into two age groups with the cutoff at 50 years old, significant results emerge. The cutoff was chosen at 50 years old because roughly half of the respondents were up to 50 years old and roughly half of the respondents were over the age of 50. This division was also chosen in order to meet the requirement in a chi-square test of a minimum expected value of five in each cell. With this division the minimum expected count is 17.8.

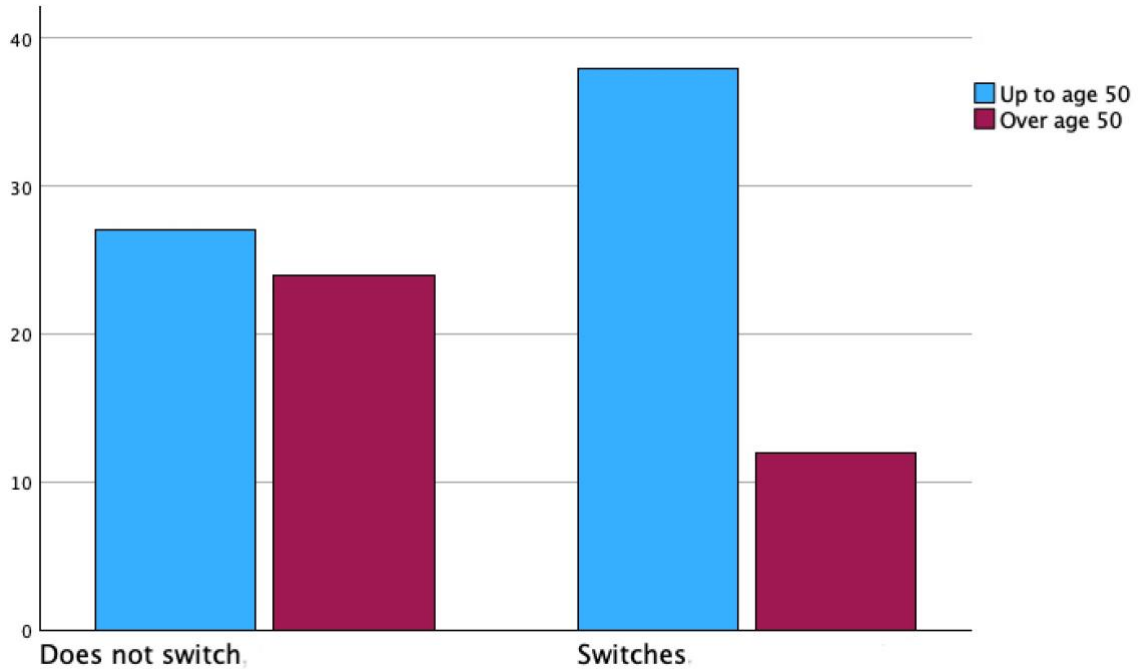
Table 10. Chi squared results for age (under and over 50 years)

	Value	Degrees of freedom	Asymptotic significance (2 sided)
Pearson Chi-Square	5.852	1	0.016
Number of valid cases	101		

As can be seen from the results of the chi-squared test above (Table 10), the p-value is less than 0.05 (P=0.016) and therefore the results are significant when the switchers between question 5 and 6 are divided up into two age groups. A switcher in this case was someone who was willing to pay 20 euros to avoid 38.6 kg of CO2 emissions (they chose the train in

question 5) but is apparently not willing to pay 50 euros to avoid 38.6 kg of CO2 emissions (they chose the airplane in question 6). As the p-value here is smaller than 0.05, the null hypothesis that states that the two variables are independent of each other can be rejected. The chi-squared test met the criteria of having no cells that have an expected value less than 5.

Figure 1. Dichotomous Age Groups of Swithers



As can be seen from the bar chart above (Figure 1), respondents up to the age of 50 are much more likely to switch from train to airplane than respondents over the age of 50 which indicates that the former group is more price sensitive than the latter group. This can also be seen in the frequency data below (Table 11).

Table 11. Frequency results for switchers/ non-switchers age

	Up to age 50	Over age 50	Total
Does not switch	27	24	51

Switches	38	12	50
Total	65	36	101

A logistic regression analysis was performed to investigate if there were differences in the switchers between question 5 and question 6 for the two different age groups. A switcher in this case was someone who was willing to pay 20 euros to avoid 38.6 kg of CO2 emissions (they chose the train in question 5) but is apparently not willing to pay 50 euros to avoid 38.6 kg of CO2 emissions (they chose the airplane in question 6). The predictor variable, age, in the logistic regression analysis were found to contribute to the model. The unstandardized Beta weight for the Constant; ***B*** = 1.377, SE = 0.615, Wald = 5.008, $p < .001$. The unstandardized Beta weight for the predictor variable: ***B*** = (-1.035), SE = 0.434, Wald = 5.686, $p < .001$. The estimated odds ratio indicates a decrease of nearly 64.5% [Exp (***B***) = 0.519, 95% CI (0.332, 0.811)] for the chance that a respondent would travel by train and thus pay 50 euros more to reduce their travel time by one hour with every one unit increase of age.

Table 12. Logistic regression results for Switchers between Q5 and Q6 based on age

	Coefficient	Standard Error	Wald Coefficient	P-value
Age	-1.035	0.434	5.686	0.017
Constant	1.377	0.615	5.008	0.025

The results of logistic regression that was run are presented in Table 12. The group of respondents over the age of 50 has 0.355 times the odds of the group up to the age of 50 of

switching between question 5 and question 6. This 0.355 was calculated by $e^{-1.035} = 0.355$. The group over the age of 50 has 64.5 percent times less odds of switching between question 5 and 6 compared to the group up to the age of 50. A switcher is defined as someone who was willing to pay 20 euros to avoid 38.6 kg of CO2 emissions (they chose the train in question 5) but is apparently not willing to pay 50 euros to avoid 38.6 kg of CO2 emissions (they chose the airplane in question 6). The calculated coefficient is significant (p=0.017). Moreover, from the table above (Table 12) the standard error of the coefficient is 0.434.

The intercept β0 is 1.377 and by using the following formula we find:

$e^{ßo} / (1+e^{ßo}) = e^{1.377} / (1+e^{1.377}) = 0.80$. Therefore, the probability that a person in the group up to the age of 50 will switch from question 5 to question 6 is 0.80.

Thirdly, a logistic regression was run where the respondents were divided up into two groups based on their income. This was done in order to examine if there were differences in switchers between the group that earns under 1000 euros and the group that earns over 1000 euros. The cutoff was not only examined at a 1000 euros level. The research also looked at two different groups with every permutation of cutoff for the income, but none of the results were significant. Therefore, it can be concluded that there are no significant differences in switchers between various income groups. The full results of this logistic regression are displayed in Table 13.

Table 13. Logistic regression results for Switchers between Q5 and Q6 based on income

	Coefficient	Standard Error	Wald Coefficient	P-value
Income	0.100	0.628	0.025	0.873
Constant	-1.353	1.166	1.347	0.246

As can be seen by the frequency data below (Table 14), the group with an income above 1000 euros contains more switchers although it should be noted that this group is also substantially larger than the group with an income below 1000 euros.

Table 14. Frequency results for switchers/non-switchers income

	Under 1000 euro	Over 1000 euro	Total
Do not switch	6	38	44
Switch	12	37	49
Total	18	75	93

4.3 Switchers between question 8 and question 9:

This section explains the logistic regressions that were run to compare the switchers between question 8 and question 9. The switchers were respondents that were willing to pay 20 euros to avoid one hour of travel time, but were not willing to pay 50 euros in order to avoid the same travel time. Therefore, they made a switch from airplane to train.

Firstly, a logistic regression was run in order to investigate if there were differences across gender in the respondents that switched from airplane to train. The results of this logistic regression, which can be seen in Table 15, confirm that this is not the case as the results are insignificant.

Table 15. Logistic regression results for Switchers between Q8 and Q9 based on gender

	Coefficient	Standard Error	Wald Coefficient	P-value
Gender	0.087	0.490	0.032	0.858
Constant	-1.417	0.813	3.035	0.082

As can be seen by the frequency data below (Table 16), there is a relatively even balance across gender both for the switcher group and for the group that does not switch. There is no significant difference between the two genders.

Table 16. Frequency results for switchers/non-switchers gender

	Male	Female	Total
Do not switch	34	45	79
Switch	9	13	22
Total	43	58	101

Secondly, a logistic regression was run where the respondents are divided up into two age groups with the cutoff at 50 years old. It was investigated if there were significant differences in the switchers between these two categories however it was found that this was not the case as the results were insignificant (the p-value was 0.672 and therefore it was higher than 0.05). The full results of this logistic regression can be found in Table 17. This

could be due to the fact that there is low power in this study due to a relatively small sample size.

Table 17. Logistic regression results for Switchers between Q8 and Q9 based on age

	Coefficient	Standard Error	Wald Coefficient	P-value
Age	-0.217	0.514	0.179	0.672
Constant	-0.987	0.724	1.857	0.173

As can be seen by the frequency data below (Table 18), there were roughly twice as many respondents in the category up to 50 years old. When the switchers were examined, it became apparent that there were approximately twice as many switchers in the category up to 50 years old. Likewise, in the non-switchers there were approximately twice as many respondents in the category up to 50 years.

Table 18. Frequency results for switchers/non-switchers age

	Up to age 50	Over age 50	Total
Do not switch	50	29	79
Switch	15	7	22
Total	65	36	101

Thirdly, a logistic regression was run where the respondents were divided up into two groups based on their income. This was done in order to examine if there were differences in

switchers between the group that earns under 1000 euros and the group that earns over 1000 euros. The research also looked at two different groups with every permutation of cutoff for the income, but none of the results were significant. The full results of this regression can be found in Table 19. Therefore, it can be concluded that there were no differences in switchers between various income groups, again taking into account that a small sample size was used.

Table 19. Logistic regression results for Switchers between Q8 and Q9 based on income

	Coefficient	Standard Error	Wald Coefficient	P-value
income	-0.531	0.882	0.362	0.547
Constant	-1.549	1.570	0.973	0.324

As can be seen by the frequency data below (Table 20), the group with an income above 1000 euros contained more switchers although it should be noted that this group was also substantially larger than the group with an income below 1000 euros.

Table 20. Frequency results for switchers/non-switchers income

	Under 1000 euro	Over 1000 euro	Total
Do not switch	14	57	71
Switch	4	18	22
Total	18	75	93

4.4 Analysis of Question 7 and Question 10

Logistic regressions were also run for question 7 (the question about if people were willing to travel one hour longer to avoid 38.6 kg of CO2 emissions) and for question 10 (the question where respondents choose between 80.48 euros in cash or one additional item of hold luggage). No significant results were found for these logistic regressions.

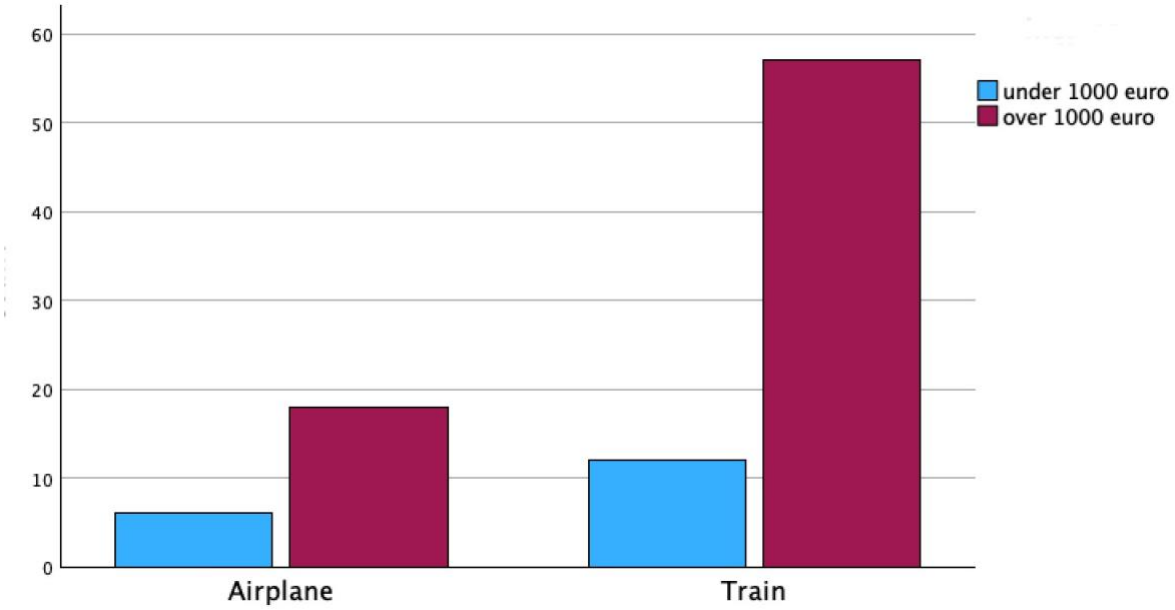
The results from question 7 showed that from the valid responses roughly 75% of respondents were willing to take the train even when the travel time was one hour longer in order to avoid 38.6 kg of CO2 emissions. The full frequency data results of this question can be found in Table 21.

Table 21. Frequency results for question 7

		Frequency	Percent	Valid Percent	Cumulative percent
Valid	Airplane	26	23.0	25.7	25.7
	Train	75	66.4	74.3	100
	Total	101	89.4	100	
Missing		12	10.6		
Total		113	100		

This data is also visualised in Figure 2 below:

Figure 2. Bart chart question 7



Question 10 of the survey was used in order to investigate if people would rather choose 80.48 euros in cash back or one additional item of checked luggage. Before this question was asked, respondents were told to imagine that they were taking a 5-day trip from Amsterdam to London that included one carry-on but no checked luggage. Next, respondents were told to imagine that they received an email with a special offer. This offer was due to the 100-year anniversary of the airline. After this the question described above was asked. The table below presents the results of this question:

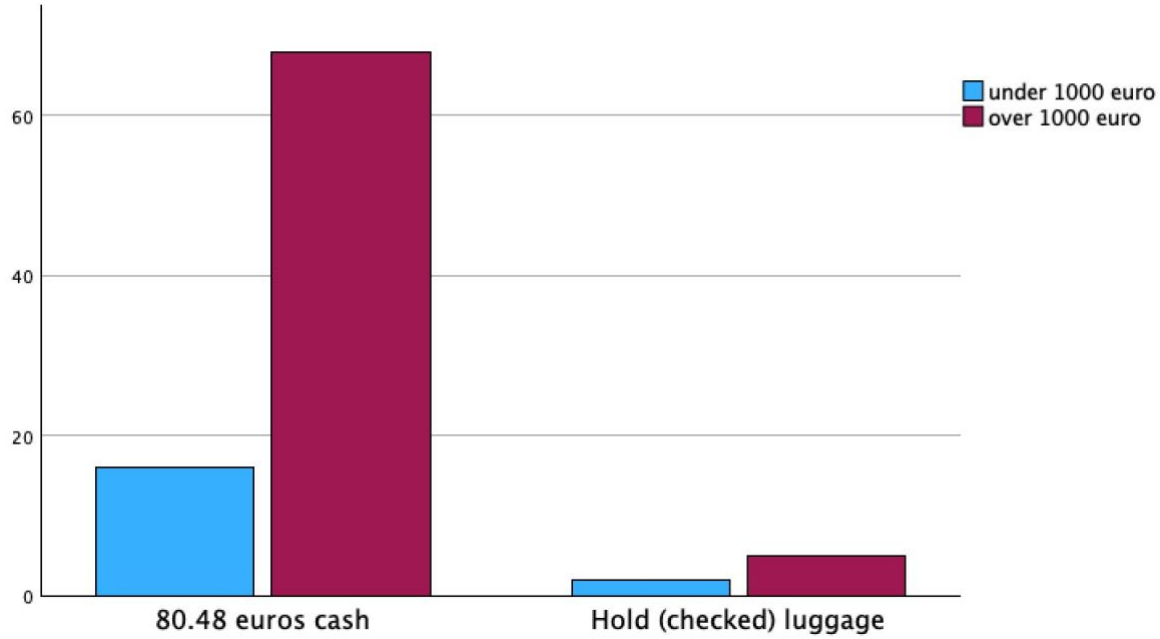
Table 22. Frequency of results for Question 10

		Frequency	Percent	Valid Percent	Cumulative percent
Valid	80.48 euros cash	89	78.8	89.9	89.9
	Hold luggage	10	8.8	10.1	100
	Total	99	87.6	100	

Missing		14	12.4		
Total		113	100		

This data is also visualised in the bar chart below:

Figure 3. Bar chart question 10



As can be seen above, from the valid responses only 10.1% of respondents chose the checked luggage option. Additionally, no significant results emerged from the logistic regression that was run.

5. Discussion

The main limitations of this research were that the sample size was relatively small and that there was a low degree of power. Power and sample size are related to each other in that a larger sample size gives more power. For this research there was relatively low power due to a relative low sample size. Therefore, it is less likely that statistically significant results will be found, even if they exist.

Power is a statistical term that refers to the likelihood of finding a statistically significant result. Having a high degree of power is crucial for a strong experimental design of research. Power can be calculated through both the null hypothesis and the alternative hypothesis in a manner in which the study can find an answer to the research question. The null hypothesis is a scenario where no noteworthy effect is found in the research whereas the alternative hypothesis is the often-expected result of the study.

In this research, sampling error occurred. The sampling error decreases as the sample size increases because larger samples tend to have a smaller margin of error. Therefore, a larger sample size would have increased the quality of this research. Obtaining a large sample size was challenging due to the limited time frame that was available for this research and also due to the fact that there was no budget available to facilitate this research.

As described earlier in the methodology section, convenience sampling was used. A limitation that arises through the use of this sampling method is that the research is drawn based on convenience and not on equal probability. Therefore, there is no statistically balanced selection of the population and sampling bias can occur (Nikolopoulou, 2022). Sampling bias arises when some members of a population are systematically more likely to be included in a sample than others. This is an issue because sampling bias is a threat to external validity. External validity refers to the extent to which findings can be generalized in other contexts and sampling bias threatens this as it limits the generalizability of findings.

Self-selection bias is another bias that likely occurred in this research. This bias arises due to the fact that individuals are allowed to choose whether they want to participate in a research study (in the case of this research if they complete the survey). This leads to a distorted representation of a true population (Heckman, 2010).

Another bias that likely occurred in this research is the undercoverage bias. This bias occurs because some members of the population are underrepresented in the collected sample. In this research, certain age groups are underrepresented, and other groups are overrepresented. A group that was underrepresented is the 80+ age group. In the general Dutch population this group in 2022 was 5% of the total population whereas in this research this group was only 1.9% (CBS, 2022). A possible reason for this is that people that are 80 years or older are less likely to own an electronic device to do the survey on. A group that was overrepresented in this research was the group between 21 and 40 years old. In this research 43.7% of respondents were between 21 and 40 years old whereas in the general Dutch population this group in 2022 was only 26% of the population (CBS, 2022).

In this research, certain factors such as comfort level and internet connection on board were not examined. Avogadro et al. (2023) state that both business passengers and leisure passengers prefer to travel by train stating "This can be traced back to the greater comfort onboard, the availability of an internet connection, and the possibility of carrying luggage without any relevant restriction.''

A limitation of this research is that it has solely focused on leisure travel between Amsterdam and London. Further research can investigate the factors that influence commercial companies, governmental organisations and NGO's. Transport & Environment is an organisation that has started Travel smart, a global campaign that aims to encourage commercial companies to reduce their corporate air travel emissions. This report found that 85% of global companies do not have company guidelines or policies to decrease corporate

flying emissions (Travel Smart, 2023). Moreover, there were only 50 companies from the 322 companies that were examined that have set targets to decrease business travel. Clearly there is a lot of room for improvement in decreasing corporate air travel emissions and further research is needed to investigate the factors that influence the decision of companies (but also governmental organisations and NGO's) to encourage employees to take the train or the airplane.

One study that did focus on business travellers between Amsterdam and London was conducted by Avogadro et al. (2023). This study found that ''While business passengers are more sensitive to average weekly frequency and travel time, leisure passengers exhibit a higher sensitivity to monetary costs.'' Avogadro et al. (2023) used information from the International passenger survey that was conducted by the Office for National Statistics. The information that they obtained from this survey included age, gender and country of residence but did not include any information about education or income. This thesis analyses the effects of income in the decision of consumers to take the train or fly between Amsterdam and London however education level was not considered. Therefore, future research could dive into the role that education level plays in determining if consumers travel by train or fly between Amsterdam and London.

One issue not addressed was the possibility of interaction effects between age, gender and income. For example, it is possible that young men (30 years old or younger) might have different preferences towards travelling by train or by airplane than young women (30 years old or younger). Therefore if subgroups like the group of men under 30 were examined, more significant results could have emerged in this study.

Another limitation of this research is that this research was mainly conducted through quantitative research and almost no qualitative research was done. One interview was conducted with a person that works at the passport control desks of Schiphol airport and one

phone call was conducted with an employee at Eurostar's customer service team, however future research could conduct more interviews with relevant parties. For example, future researchers could conduct an interview with members of the Eurostar executive committee (such as Eurostar's CEO Gwendoline Cazenave) in order to gain a better understanding of how full the Eurostar trains to and from London are dependent on other variables such as the day of the week. Moreover, it would be interesting to research if there are plans to add more trains on the route from Amsterdam to London and research what hurdles would have to be overcome to achieve this (acquiring enough workers to build additional train tracks, getting permits to do so, raising the money to build additional train tracks). Moreover, future research could conduct interviews with representatives of KLM, Easyjet and British airways as well as representatives of Schiphol airport and the six airports of London. Lastly, interviews with government officials could be conducted in order to achieve a good understanding of the current consumer market for travel between Amsterdam and London.

Beyond the issue of changing passenger behavior, changes to the proportion of airplane and train trips is also influenced by other issues, including the previously mentioned problem of airline slot usage. In short, the substitution from air to HSR on the route from Amsterdam to London could have a negative net environmental effect if slots that become available due to this substitution get used for long-haul flights integrated (Givoni & Banister, 2006, Socorro & Viecens 2013). Therefore, politicians but also judges have the power to determine what happens to the slots at Schiphol airport and this will have an impact on the total environmental damages that flying causes. Other political issues, such as taxes and subsidies also impact the ticket prices of both flying and HSR. For example, kerosene is currently not taxed and therefore the negative external effects of kerosene (the CO2 emissions that it causes) are not internalised in the ticket prices of flying.

All in all, this research into income, and gender on travel choices indicates some possible interesting results. However, it should be considered preliminary, and further investigation into these relationships is needed.

6. Conclusion

The aim of this research was to investigate the factors that influence the decision between taking the train or the airplane from Amsterdam to London. There were two ways through which this research question was investigated. Firstly, a stated preference survey was carried out in order to determine the effects of age, gender and income of respondents on the decision to take the airplane or the train. Logistic regressions were run in order to investigate this. In most cases, there were insignificant results. This could be due to a low degree of power in this research due to a relatively low sample size. This was partly due to the fact that there was a limited timeframe for data collection. Age was significant; with an increase of one unit (10 years) in the age of participants, the odds of a person taking the train, and thus paying 50 euros more to decrease their travel time by one hour, decreased by 48.2%, all else equal.

Secondly, logistic analyses were carried out in order to investigate the effects of age, gender and income on people who switched between question 5 and 6 and between question 8 and 9 of the stated preference survey. A switcher is defined as someone who was willing to pay 20 euros to avoid 38.6 kg of CO2 emissions (they chose the train in question 5) but was apparently not willing to pay 50 euros to avoid 38.6 kg of CO2 emissions (they chose the airplane in question 6). Similarly, a switcher is someone who was willing to pay 20 euros to reduce their travel time by one hour (they chose the airplane in question 8) but is apparently not willing to pay 50 euros to reduce their travel time by one hour (they chose the train in question 9). Again, in most cases there were insignificant results (and again this could be due to a low degree of power in this research). Nevertheless, a finding that did arise was that the group over the age of 50 had 64.5% less chance of switching between question 5 and 6 than the group up to the age of 50.

This research focused solely on leisure travel between Amsterdam and London. Avogadro et al. (2023) have researched the effects of different policies on the possibility to increase the market share of HSR in the context of not only leisure travellers but also business travellers. However, the information that this study used did not include any information about education levels. Therefore future research could dive into the role that education level plays in determining if consumers travel by train or fly between Amsterdam and London. Future research could also investigate the impact of age by year on the results rather than by decade in order to determine if the age variable's refined scale would find a relationship.

Importantly for policymakers, in order to avoid a negative net environmental effect due to substitution from air to HSR, politicians that are in office must implement policies that prevent the displaced short distance flights from being replaced by long distance flights. A negative environmental effect can arise if slots that become available due to a substitution from air to HSR get used for long-haul flights. Therefore, politicians but also judges have the power to determine what happens to the slots at Schiphol airport and this will have an impact on the total environmental damages that flying causes.

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Appendix:

Before the final version of the survey was published on social media, a pilot survey was conducted. Feedback from this was that ‘’option a: airplane’’ should be renamed simply to ‘’airplane’’ and ‘’option b: train’’ should be renamed to ‘’train’’. This feedback was given because it would make the survey clearer to read and straighter to the point.

Other feedback that was given was that in the introductory text before question 10 it should be specified how long the trip to London would be as if the trip was very long it is much more likely that respondents will choose the hold luggage option.

Lastly, feedback from the pilot group indicated that in question 10 ‘’hold luggage’’ should be changed to ‘’hold (checked) luggage’’ as hold luggage is usually called checked luggage in English. In order to make this clearer this change was also implemented. Both the pilot survey and the final survey can be found below.

Appendix a: Design of the survey: pilot

Introduction:
For my masters thesis at the Vrije Universiteit Amsterdam I am carrying out a survey to research **what factors influence the decision between taking the train or the airplane from Amsterdam to London**.

Completing the survey will take about **5 minutes**. Any information that you provide for the survey will remain completely confidential.

Thank you in advance for helping me!

Question 1: How likely is it that you will travel from Amsterdam to London in the next 12 months?

Option A: extremely likely
Option B: very likely
Option C: somewhat likely
Option D: not so likely
Option E: not at all likely

Question 2: What is your age?

Option A: 20 years or younger
Option B: 21-30 years

Option C: 31-40 years
Option D: 41-50 years
Option E: 51-60 years
Option F: 61-70 years
Option G: 71-80 years
Option H: 81-90 years
Option I: 91 years or older

Question 3: What is your gender?

Option A: male
Option B: female
Option C: other
Option D: prefer not to say

Question 4: What is your monthly household income (net)?

Option A: < €1000
Option B: €1000-3000
Option C: > €3000
Option D: prefer not to say

Assume you are planning a 5 day trip for leisure. You can either take the train or fly on an airplane. You will now get 5 questions where you have to choose between flying or taking the train.

Question 5:

In the situation below, what option would you choose?

Option A: Airplane	Option B: Train
60 euros	80 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	4 hours 30 minutes

Motivation behind this question:

This question is to see if people are willing to pay 20 euros more to avoid 38.6 kg of CO2 emissions

Question 6:

In the situation below, what option would you choose?

Option A: Airplane	Option B: Train
60 euros	110 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	4 hours 30 minutes

Motivation behind this question:

This question is to see if people are willing to pay 50 euros more to avoid 38.6 kg of CO2 emissions

Question 7:

In the situation below, what option would you choose?

Option A: Airplane	Option B: Train
100 euros	100 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	5 hours 30 minutes

Motivation behind this question:

Are people willing to travel for 1 hour more to avoid 38.6 kg of CO2 emissions?

Question 8:

In the situation below, what option would you choose?

Option A: Airplane	Option B: Train
120 euros	100 euros
47 kg of CO2 emissions	47 kg of CO2 emissions
4 hours	5 hours

Motivation behind this question:

Are people willing to pay 20 euros more to reduce their travel time by 1 hour?

Question 9:

In the situation below, what option would you choose?

Option A: Airplane	Option B: (train)
150 euros	100 euros
47 kg of CO2 emissions	47 kg of CO2 emissions
4 hours	5 hours

Motivation behind this question:

Are people willing to pay 50 euros more to reduce their travel time by 1 hour?

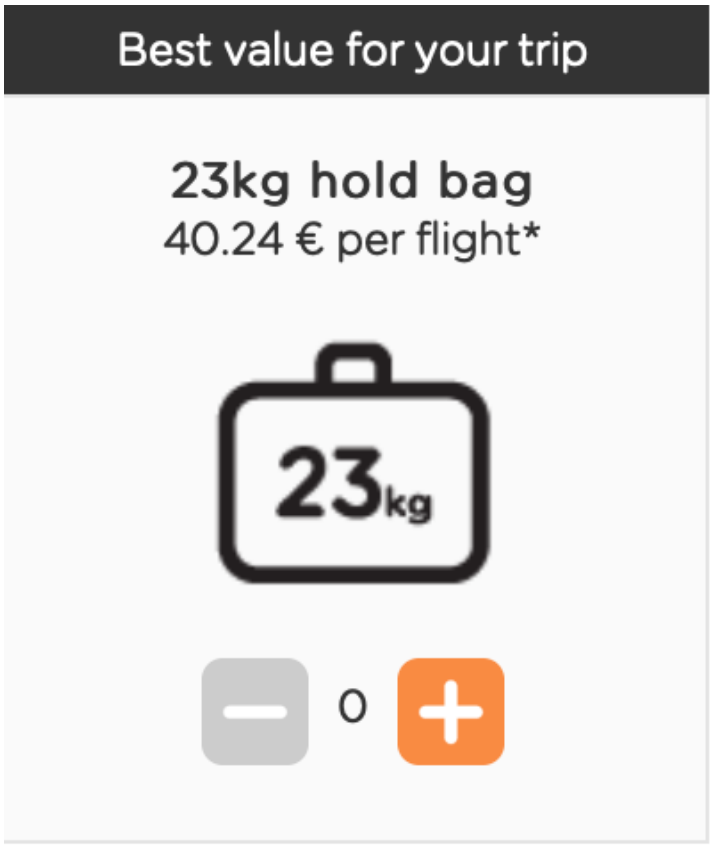
Imagine you booked a flight from Amsterdam to London. Your ticket includes 1 carry-on but no hold luggage. A few days after booking your flight your airline sends you an email with a special offer because it's their 100 year anniversary.

Question 10: They offer you 80.48 euros cashback from your ticket price or you get to bring one additional item of hold luggage. What would you choose?

Option A: 80.48 euros cash
Option B: hold luggage

Motivation behind this question:

Easyjet charges 40.24 euros per flight for a 15kg hold bag if you choose their standard plus option (the middle option).



Appendix b: Design of the survey: final version

Introduction:
For my masters thesis at the Vrije Universiteit Amsterdam I am carrying out a survey to research **what factors influence the decision between taking the train or the airplane from Amsterdam to London**.

Completing the survey will take about **5 minutes**. Any information that you provide for the survey will remain completely confidential.

Thank you in advance for helping me!

Question 1: How likely is it that you will travel from Amsterdam to London in the next 12 months?

Option A: extremely likely
Option B: very likely
Option C: somewhat likely
Option D: not so likely
Option E: not at all likely

Question 2: What is your age?

Option A: 20 years or younger
Option B: 21-30 years
Option C: 31-40 years
Option D: 41-50 years
Option E: 51-60 years
Option F: 61-70 years
Option G: 71-80 years
Option H: 81-90 years
Option I: 91 years or older

Question 3: What is your gender?

Option A: male
Option B: female
Option C: other
Option D: prefer not to say

Question 4: What is your monthly household income (net)?

Option A: < €1000
Option B: €1000-3000
Option C: > €3000
Option D: prefer not to say

Assume you are planning a 5 day trip for leisure. You can either take the train or fly on an airplane. You will now get 5 questions where you have to choose between flying or taking the train.

Question 5:

In the situation below, what option would you choose?

Airplane	Train
60 euros	80 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	4 hours 30 minutes

Motivation behind this question:

This question is to see if people are willing to pay 20 euros more to avoid 38.6 kg of CO2 emissions

Question 6:

In the situation below, what option would you choose?

Airplane	Train
60 euros	110 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	4 hours 30 minutes

Motivation behind this question:

This question is to see if people are willing to pay 50 euros more to avoid 38.6 kg of CO2 emissions

Question 7:

In the situation below, what option would you choose?

Airplane	Train
100 euros	100 euros
47 kg of CO2 emissions	8.4 kg of CO2 emissions
4 hours 30 minutes	5 hours 30 minutes

Motivation behind this question:

Are people willing to travel for 1 hour more to avoid 38.6 kg of CO2 emissions?

Question 8:

In the situation below, what option would you choose?

Airplane	Train
120 euros	100 euros
47 kg of CO2 emissions	47 kg of CO2 emissions
4 hours	5 hours

Motivation behind this question:

Are people willing to pay 20 euros more to reduce their travel time by 1 hour?

Question 9:

In the situation below, what option would you choose?

Airplane	Option b (train)
150 euros	100 euros
47 kg of CO2 emissions	47 kg of CO2 emissions
4 hours	5 hours

Motivation behind this question:

Are people willing to pay 50 euros more to reduce their travel time by 1 hour?

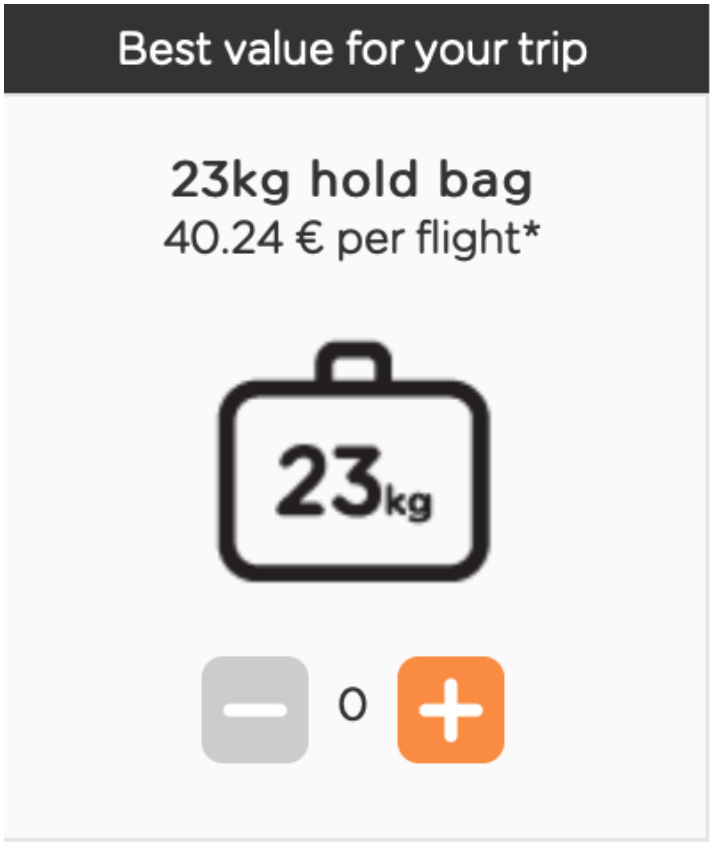
Imagine you booked a flight from Amsterdam to London. Your trip will be 5 days and your ticket includes 1 carry-on but no hold luggage. A few days after booking your flight your airline sends you an email with a special offer because it's their 100 year anniversary.

Question 10: They offer you 80.48 euros cashback from your ticket price or you get to bring one additional item of hold luggage. What would you choose?

Option A: 80.48 euros cash
Option B: hold luggage

Motivation behind this question:

Easyjet charges 40.24 euros per flight for a 15kg hold bag if you choose their standard plus option (the middle option).


Best value for your trip
23kg hold bag
40.24 € per flight*
23kg
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