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The Importance of Direct Routes for Air Travel Itinerary Choices: Results from a Stated Preference Choice Experiment

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Abstract

Over the past years, aviation policies are more and more focussed on sustainability rather than connectivity, putting pressure on airlines to re-design the network. For this, evaluating air travellers their preferences on direct routing compared to lay-overs is needed to make well-informed design choices. This paper examines the preferences of air travellers on direct itineraries by applying a data-driven approach. To this end, a stated preference choice experiment is developed and implemented in an online survey. The results of the latent class choice model show two types of flyers with different preferences, labelled as time sensitive and price sensitive flyers. The model outcomes indicate that both are willing to pay for direct itineraries, while time sensitive flyers are willing to pay substantially more. Other flight characteristics also play an important role in air travellers' route choice, such as the distance to the airport, travel time, and transfer time. Travel motive, ticket price compensation by the employer, and experience with layovers drive whether air travellers belong to the time or price sensitive flyers. The distinction between time and price sensitive flyers and their preferences is expected to yield more tailored transport policies than a distinction between, for instance, business and non-business. Future research should focus on the societal impact of a reduction in direct itineraries for air travellers, using insights gained in this study.

1 Introduction

Governmental bodies are increasingly focussing on sustainability rather than connectivity in regulating airlines and airports. For example, the Dutch Ministry of Infrastructure and Water Management deviated from its policy in 2018 by restricting Schiphol Airport in the number of flights carried out per year. Until 2022, no more than 400,000 flights per year have been carried out (Dutch Ministry of Infrastructure and Water Management, 2022). This is a decrease of 20% compared to earlier restrictions before the COVID-19 pandemic.

Due to the restrictions on the number of flights per year, airlines are in need to re-design the network of flights carried out. For this, knowledge on the preferences of air travellers regarding direct routing is needed to make well-informed choices in the network design by airlines. In this regard, previous studies have focussed on explaining the choices made by air travellers.

A first cluster of studies has focused on the preferences of passengers regarding airport choice. For instance, Hsiao and Hansen (2011) concluded that the type of flight, price, frequency, travel time, and income are important determinants in choosing a certain airport. De Luca (2012) also found that ticket price and income determine the flight choice but in addition also the age, accessibility of the departure airport, and previous flight experiences of the travellers. While Hsiao and Hansen (2011) and De Luca (2012) studied choices between airports, Johnson et al. (2014) focused on passengers' preferences between a connecting itinerary from a nearby airfield compared to a direct itinerary from an airfield further away. This study focused on Glasgow and Edinburgh only. Nonetheless, this research showed that travellers are more inclined to choose for a direct flight even though an airport is located further away.

A second cluster of studies has focused on travellers' itinerary choices between flights from a single departure airport. SEO (2022) showed that business flyers are willing to pay for direct flights, leaving non-business flyers out of the analysis. Usami et al. (2017) concluded that business flyers are more prone to choose convenience over price, yet the link with direct routes is mitigated. Hess and Adler (2011) showed this link between business flyers and direct flights, highlighting that these business flyers are willing to pay more for direct routes. However, the notion that business flyers often travel with a non-business motive too is neglected. In addition, the frequency of flying is mitigated in both analyses. Yet, Chen and Chao (2015) concluded that frequent flyers are placing more emphasis on travel options, which involves flight schedules and routing types, by conducting a factor analysis. Overall, the analysis of this group of studies is dictated by structural characteristics such as travel motive and flight frequency.

A final cluster of studies performed research on the preferred number of connections and connecting times. Ennen et al. (2019) used revealed preference data to conclude that choices between connecting itineraries depend on the number of connections, travel duration, and connecting time. The study estimated the willingness to pay for direct routing, yet mitigated heterogeneity in this willingness to pay. Only the average willingness to pay is estimated, while one could reason that differences in willingness to pay for direct routes may exist for different types of air travellers. An increase in the number of connections will lower the chance of choosing that flight option, concluded Lurkin et al. (2018). While Lurkin et al. (2018) and Ennen et al. (2019) draw conclusions on the number of connections, Theis et al. (2006) and Herring et al. (2019) made statements on the connecting time. This study showed that air travellers do not want to have the risk of missing the next flight and a longer connecting time is not preferred either (Theis et al., 2006). Besides connecting time, Herring et al. (2019) also took the buffer time into account. Here, buffer time is defined as the difference between the connecting time and the minimum required connecting time at the specific airport. Herring et al. (2019) concluded that a relatively small positive buffer time is preferred by passengers.

Even though a number of studies are conducted on itinerary choices, preferences of air travellers on direct routes are derived based on structural characteristics such as travel motive and flight frequency. As of this, studies often conclude that business or frequent travellers prefer direct routes compared to non-business or infrequent travellers. Nonetheless, the group of travellers which prefers direct routes the most may consist of both business and non-business as well as frequent and infrequent travellers. In light of the recent need to re-design hub-and-spoke networks, well-informed decisions by airlines are required. For this, we propose a data-driven approach in which clusters of air travellers with similar preferences on direct routes are derived based on choice patterns. Afterwards, the characteristics of travellers within clusters are linked to reveal heterogeneity in the different types of travellers. New insights into itinerary choice behaviour will contribute to tailoring aviation policies of governmental bodies as well as re-designing the flight network of airlines.

To examine the preferences of air travellers on direct routing, a stated preference choice experiment is conducted among Dutch air travellers with international air travel experience. In total, 1211 responses were obtained. Using discrete choice models, travellers' preferences are revealed and translated into willingness to pay estimates. Besides the multinomial logit model as the baseline model, the nested logit and latent class logit models are estimated. The nested logit model is used to understand if the model outcomes of the multinomial logit model yield different results when accounting for the fact that connecting itineraries are likely to compete with other connecting itineraries rather than direct itineraries. The latent class logit model is used to reveal heterogeneity in the preferences of air travellers towards direct routing. The latent class logit model captures the similar preferences of respondents by grouping these respondents in a predefined number of classes.

The remainder of this paper is structured as follows. Section 2 describes the experimental design and modelling approach, whereas section 3 presents the results of the study. Section 4 summarizes the findings and includes limitations of the study, possibilities for future research, and policy implications.

2 Methodology

2.1 *Survey design*

A stated preference survey was conducted among Dutch air travellers, to gather data on passengers their attitudes and perspectives. Responses were collected in the Netherlands from April 24th to May 15th, 2023. The survey was structured using three sections. The first section was devoted to respondents' recent experiences with flying, while the second section was dedicated to the choice experiment. The third section included questions regarding respondents' socio-demographic characteristics.

The first part assessed the recent air travel experience of respondents. Respondents were asked about the number of flights made in the past 12 months and their main travel purposes. Moreover, respondents were asked to indicate their booking and payment procedures, favourite departure locations, experience with travelling intercontinental, travelling with others, and travelling by connecting itineraries. When respondents did not have experience with travelling intercontinental, respondents were not allowed to participate in the choice experiment.

The second part was the experiment. Respondents needed to assess nine choice sets, each with three flight options. Based on their recent air travel experience and their socio-demographic characteristics, they were asked to choose the most attractive flight option. To estimate the difference in attitude between short and long intercontinental flights, respondents were randomly allocated to either a choice set with destination New York or Singapore. Both are well-known cities with international business centres and tourist appeal.

Flight characteristics that were included in the experiment are itinerary type, flight frequency, distance to the departure airport, (total) travel time, connecting time, chance of delay, and ticket price. The experiment included both direct and connecting itineraries. Flight frequency, travel time, connecting time, and ticket price were varied based on data obtained from Google Flights, which is dependent on the itinerary type. For direct itineraries, international flights to New York or Singapore range between one to three flights per day. Contrary, a higher flight frequency is offered for connecting itineraries. This ranges between twenty to twenty-four flights per day. While flight frequency is not necessarily dependent on the arrival location, the travel time, connecting time, and ticket price vary significantly between New York and Singapore. Moreover, distance to the departure airport plays a fundamental role in itinerary trade-offs, since Johnson et al. (2014) concluded that passengers in the United Kingdom prefer direct routing from an airport further away over connecting itineraries from an airport close by. By differentiating between different distances, competition between Schiphol Airport (AMS), Brussels Airport (BRU), and Flughafen Düsseldorf (DUS) is incorporated. While the Dutch Environmental Data Compendium stated that airports such as Flughafen Frankfurt am Main (FRA), Flughafen München Franz Josef Strauß (MUC), and Paris Charles de Gaulle (CDG) are also named competitors of Schiphol Airport (Dutch Environmental Data Compendium, 2021), these airports are excluded in this study due to their distance. It is likely that only a small share of the travellers chooses such an airport, with a distance over 250 kilometres. Lastly, the chance of delay is taken into account by varying between 0%, 5%, and 10%. The expectation is that business travellers can afford less delay than non-business travellers. Since this study focuses on the preferences of and heterogeneity between different types of travellers, the chance of delay could play a decisive role in the flight choice. Table 1 shows an example of a choice set to New York, presented to respondents.

We used an efficient design, obtained by applying priors within the Ngene software package of ChoiceMetrics. A *D*-efficient design is often preferred over the traditional orthogonal design since it maximizes the t-ratios of the parameter estimates (Bliemer et al., 2009; Araghi et al., 2014). Nonetheless, initial parameter estimates, or so-called priors, are needed to retrieve an efficient design. These priors are bested guesses for unknown parameters, which may have detrimental effect on the efficiency of the design when badly chosen (Bliemer and Collins, 2016). To obtain these best guesses, priors are often based on either a small pilot study or earlier research studies. For this study, priors are based on both earlier studies as well as a pilot study among 20 respondents. Table 2 shows the values for the priors.

Table 1. Example of a choice set

Attribute	Option 1	Option 2	Option 3
Flight frequency	2 per day	24 per day	20 per day
Itinerary	Non-stop	Layover	Layover
Airport distance	120 km	240 km	40 km
Travel time	8 hours	11 hours	14 hours
Connecting time	-	1 hour	2 hours
Delay chance	5%	10%	0%
Ticket price	€1000	€600	€800

Table 2. Priors for the attributes

Attribute	Literature*	Pilot study	D-efficient design input
Flight frequency	0.360	0.372	0.360
Airport distance	- 0.850	- 0.705	- 0.800
Travel time	- 0.007	- 0.006	- 0.006
Connecting time	- 0.008	- 0.010	- 0.010
Delay chance	- 0.012	- 0.035	- 0.020
Ticket price	- 0.250	- 0.350	- 0.350

* Sources: Theis et al. (2006), De Luca (2012), Johnson et al. (2014), Herring et al. (2019) and SEO (2022).

2.2 Participants

This study focused on air travellers with intercontinental flight experience. This flight experience is needed to be able to assess the flight options in the choice experiment and understand the consequences of choosing a certain flight. In total, 1739 respondents were recruited by distributing an internet-based Qualtrics survey. Of the 1739 respondents, 1622 had international flight experience.

After thorough data cleaning, 1211 respondents were kept. In this process, we gave respondents a penalty value depending on a range of criteria. First of all, a timer measured the duration of several sections taken by the respondent. This timer gave us the possibility to assess the completion time of the survey in general and the choice experiment specifically. To assess whether individuals fully understood the experiment both a short and long completion time is penalized. A short completion time might indicate that a respondent did not fully read the choice tasks, whereas a long completion time might hint towards a lack of understanding what was expected by the respondent while filling in the survey. Second of all, a control question was included in the choice experiment using the same choice set for two questions. If these choices were inconsistent to each other, a penalty was given. Also, choosing direct flights throughout the experiment was seen as an ease of answering. Lastly, respondents were given a penalty when they were inconsistent between the main motive and number of flights per year, when they had a different preferred location than the top 5 given in the survey, when they gave a large number of flights per year as survey answer, and when they had no experience with transferring. All these penalties lead up to an overall penalty for specific respondents. When passing the threshold, the respondent was excluded from the final set of respondents. As of this, respondents are only excluded when the respondent has penalties for multiple criteria. By cleaning the survey responses, the quality of the data was improved.

Table 3 shows the descriptive statistics of respondents' socio-demographic characteristics. Men, people between 30 and 49 years, and people with a high education level are strongly represented. These characteristics are in line with earlier research performed in the Netherlands (KiM Netherlands Institute for Transport Policy Research, 2018).

Table 4 shows the distribution of respondents their air travel characteristics. These characteristics show that most of the respondents travel with a non-business motive. The median indicates that there are a lot of respondents who travel a couple of times per year, whereas a smaller part of the sample travels more frequently. The median for non-business flights is two flights per year and the median for business flights is zero flights per year. A Gini coefficient of 0.61 was retrieved from the dataset. This Gini coefficient is relatively higher than the Gini coefficient for the distribution of income in the Netherlands, which ranges from 0.28 to 0.31 (KiM Netherlands Institute for Transport Policy Research, 2023). However, the KiM Netherlands Institute for Transport Policy Research (2023) stated that around 25% of the adults in the Netherlands did not fly in a time frame of five years. For this study, only respondents with recent international flying experience are considered, hence, adults that did not fly over a period of five years are not considered eligible for answering the choice experiment. As of this, these adults are excluded from the analysis yielding a different Gini coefficient. Nonetheless, the Gini coefficient retrieved for the dataset is similar to what was concluded in earlier research. For instance, the Netherlands Institute for Transport Policy Research reported a Gini coefficient of 0.56 (KiM Netherlands Institute for Transport Policy Research, 2023). However, their research was focused only on non-business flyers. Nonetheless, this implies that the Gini coefficient is relatively the same among business and non-business flyers since business flyers are almost always recreative, non-business flyers (KiM Netherlands Institute for Transport Policy Research, 2021). The booking for a business flight is commonly conducted by themselves, namely 68.9%. However, these respondents get full compensation more than eight out of ten times. The favourite departure location is Schiphol Airport. Every respondent has intercontinental flight experience, which was a requirement to fill in the survey. Besides, there is a small percentage of respondents that travel alone. The people that travel with others, adopt their flight choices based on the preferences of these other travellers in more than 80% of the cases.

Table 3. Distribution of respondents their socio-demographic characteristics (N = 1211)

Variable	Category	%
Gender	Male	90.0
	Female	7.4
	Else	2.5
Age	Younger than 30 years	9.6
	30 to 39 years	21.6
	40 to 49 years	25.5
	50 to 59 years	26.0
	60 years and older	17.4
Education	Low	1.7
	Intermediate	19.3
	High	78.8
	Else	0.2
Daily activity	Employee	64.7
	Employer	21.1
	Unemployment	0.7
	Student	3.4
	Pension	10.0
	Else	0.3
Yearly income	Less than 10.000 euros	2.5
	10.000 to 30.000 euros	5.4
	30.000 to 60.000 euros	25.3
	60.000 to 100.000 euros	31.7
	100.000 to 175.000 euros	17.7
	More than 175.000 euros	6.9
	No response	10.5

Lastly, there are a lot of respondents with transfer experience, whereas only 6.2% never made a transfer. In 1 out of 3 cases, a connecting flight is chosen over direct routing. The main reason behind this choice is the difference in ticket prices. Also, a big part of 67% is subscribed to a loyalty program.

2.3 *Model estimation approach*

The software package Apollo (version 0.2.9), a package in R Studio, was used to estimate logit models (Hess and Palma, 2019). First, a baseline multinomial logit model was estimated. In addition, the nested logit and latent class logit model structures are implemented. The nested logit model is used to enrich the insights obtained from the multinomial logit model, while the latent class logit model will reveal possible heterogeneity in the sample. Other models are not considered suitable for this study. The mixed logit model lacks the explainability of heterogeneity and is computationally more intensive than the latent class logit model. Since psychological variables are not assessed in the study on direct itinerary preferences, hybrid choice models are not suited as well.

Table 4. Distribution of respondents their air travel characteristics (N = 1211)

Variable	Category	%
Travel motive	Business	26.9
	Holiday	62.1
	Family	11.0
Number of business flights	Average	4.2
	Median	0.0
	1 flight per year	51.5
	2 flights per year	11.6
	3 flights per year	6.5
	4 flights per year	4.1
	5 flights per year	2.5
Number of non-business flights	Average	3.1
	Median	2.0
	1 flight per year	16.4
	2 flights per year	18.8
	3 flights per year	22.0
	4 flights per year	14.0
	5 flights per year	4.3
Bookings procedure	By myself	68.9
	Someone else	31.1
Payment procedure	Fully compensated	83.0
	Partly compensated	6.4
	Not compensated	10.6
Favourite departure airport	Schiphol Airport	64.7
	Rotterdam The Hague Airport	3.9
	Eindhoven Airport	7.9
	Brussels Airport	11.6
	Flughafen Düsseldorf	7.2
	Else	4.6
Intercontinental travel experience	Yes (selection criterium)	100.0
	No	0.0
Travel with others	Always alone	13.5
	Sometimes with others	35.3
	Most of the time with others	31.9
	Always with others	19.4
Account for travel company	Yes	81.5
	No	18.5
Transfer experience	Never made a transfer	6.2
	Sometimes made a transfer	64.0
	Most of the time made a transfer	25.8
	Always made a transfer	4.1
Choosing for a connecting itinerary, while direct routes available	Yes	71.5
	No	65.1
	Not sure	3.9
Main reason	Difference in ticket price	71.5

	Relatively small difference in travel time	1.6
	Planning	15.0
	Stretch legs between flights	3.1
	Else	8.8
Loyalty program	Yes	67.0
	No	33.0

The multinomial logit model is most often used due to the easy estimation procedure and model interpretation. McFadden (1973) developed the multinomial logit model, in which U_i represents the total utility that a respondent derives from alternative i. The alternative i with the highest utility will be chosen by the respondent. This utility has an observed part V_i and unobserved error term ε_i. Where the unobserved part ε_i follows an independently and identically distributed Extreme Value type I Gumbel distribution, the observed part V_i is assumed to have a linear additive form $\sum_{k=1}^{K} \beta_k \cdot x_{ik}$. In this, β_k expresses the weight i.e. taste regarding attribute k and x_{ik} is the value of attribute k for alternative i. Also, an alternative specific constant ASC_i for every alternative i can be included. The utility function can thus be written as:

$$U_i = V_i + \varepsilon_i = ASC_i + \sum_{k=1}^{K} \beta_k \cdot x_{ik} + \varepsilon_i \qquad (1)$$

While the multinomial logit model has an intuitive modelling approach, there are also several model limitations. For instance, the independence of irrelevant alternatives may not be realistic in applications (Lurkin et al., 2018). Moreover, heterogeneity cannot be accommodated by the model (Araghi et al., 2016). Hence, advanced logit models are needed to enrich the air travel behaviour analysis.

In itinerary choice modelling, it is expected that connecting itineraries compete more with other connecting itineraries than with direct itineraries. Consequently, the connecting itinerary options are nested in this study. The nested logit model relaxes the assumption that the error term is independently distributed (Williams, 1977; Coldren and Koppelman, 2005), and is therefore better suited to this study than the multinomial logit model.

The independence axiom is relaxed by grouping competing alternatives into a nest. These alternatives can only occur in one nest. The utility function is now expressed by two error terms, namely a common error term ε_m for every nest m and an independent error term ε_i. The utility function thus can be written as:

$$U_i = V_i + \varepsilon_i + \varepsilon_m \qquad (2)$$

Figure 1 shows the assumed nesting structure.

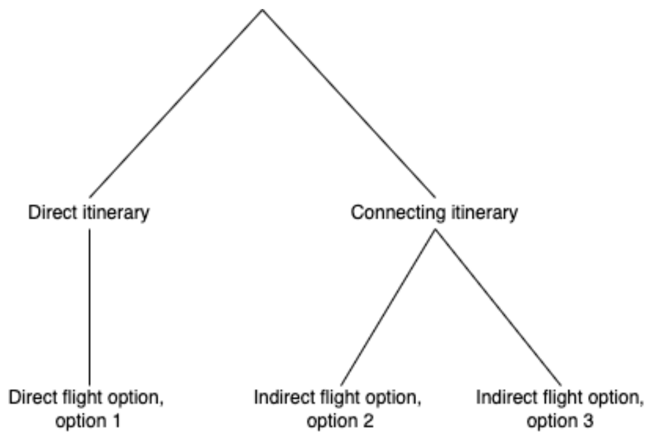

Figure 1. The nesting structure used in the nested logit model.

Not only can the multinomial logit model not relax the independence of irrelevant alternatives, but it also cannot accommodate heterogeneity effects. To incorporate the expected heterogeneity within the sample, a latent class logit model is implemented. The latent class logit model captures the similar preferences of respondents by grouping these respondents in a predefined number of classes. For every class *c*, a utility function can be defined:

$$U_{ic}= V_{ic}+ \varepsilon_{ic} \quad (3)$$

These classes are latent, meaning that they cannot be observed and thus will emerge from the estimation. As a consequence, several models with a variety of predefined number of classes need to be estimated. Commonly, the optimal number is based on model fitness as well as parameter interpretation.

3 Results

The model results are discussed in this section, respectively for the multinomial logit, nested logit, and latent class logit model.

3.1 Multinomial logit model

The multinomial logit model is estimated as the baseline model, to get first insights into passengers their preferences and attitudes. Table 5 shows the estimates, t-value and willingness to pay for the attributes included in the choice experiment. The willingness to pay is computed by dividing the taste parameter by the ticket price. For alternative specific constants, the absolute value is divided by the ticket price.

The estimate for the alternative specific constant regarding direct routing is negative, indicating that passengers derive more utility from a transfer. This is not expected. Nevertheless, this attribute is not significant on the 5% level. The sign of estimates for the other flight characteristics are in line with expectations. Passengers retrieve utility from a higher flight frequency and disutility from a higher ticket price, larger airport distance, longer travel and connecting time, and higher chances of delay.

The willingness to pay (WtP) indicates how important the attributes are for the flight choice and how much passengers want to pay for that flight characteristic. Here, the distance to the airport is the highest of all, indicating that air travellers want as little distance as possible. They are willing to pay around 300 euros for a reduction of 100 kilometres. In addition, the willingness to pay for a reduction in travel time and connecting time is also relatively high compared to the flight frequency and chance of delay, while passengers are keener to reduce connecting time rather than travel time.

Table 5. Multinomial logit model results

Attribute	Estimate	T-value	WtP (€)
Ticket price/100	- 0.273 ***	- 33.747	
Direct routing	- 0.224 *	- 1.866	- 82.3
Flight frequency	0.001	0.126	- 0.4
Airport distance/100	- 0.798 ***	- 43.963	293.3
Travel time	- 0.246 ***	- 17.253	90.1
Connecting time	- 0.435 ***	- 30.177	159.3
Delay chance	- 0.018 ***	- 6.474	6.6
Model fit			
Log-likelihood	- 8970.27		
McFadden Adjusted ρ^2	0.25		

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

3.2 *Nested logit model*

Results of the nested logit model are shown in table 6. The parameter estimate for direct routing is now in line with the expectations. Also, the dissimilarity coefficient for indirect routes equals 0.694 implying correlation among the unobserved part of utility for nested alternatives (Koppelman and Bhat, 2006). In other words, the indirect routing alternatives show common unobserved factors. Besides, the willingness to pay for a reduction in distance to the departure location, travel time, and connecting time are lower compared to the multinomial logit model results. In addition, the flight frequency parameter estimate has changed significantly, whereas the delay chance did not change heavily.

While the sign of direct routing in the nested logit model is in line with expectations and became more significant compared to the multinomial logit model, the estimated parameter is not yet significant on the 5% level. Nonetheless, it is likely that heterogeneity in the preference towards direct routing is present. Therefore, the latent class logit model is estimated.

Table 6. Nested logit model results

Attribute	Estimate	T-value	WtP (€)
Ticket price/100	- 0.244 ***	17.013	
Direct routing	0.198 *	1.889	81.1
Flight frequency	0.022 ***	4.662	- 9.0
Airport distance/100	- 0.657 ***	- 20.572	269.3
Travel time	- 0.219 ***	- 17.979	89.8
Connecting time	- 0.349 ***	- 17.253	143.0
Delay chance	- 0.014 ***	- 6.557	5.7
Model fit			
IV parameter $\lambda_{indirect}$	0.694		
Log-likelihood	- 8930.64		
McFadden Adjusted ρ^2	0.22		

Significance levels: * p < 0.10, ** p < 0.05, *** p < 0.01.

3.3 *Latent class logit model*

To reveal heterogeneity among passengers, latent class logit models with different classes were estimated. By doing so, the optimal number of classes can be distinguished. Table 7 shows the results of these estimations. Based on the log-likelihood, adjusted ρ^2 and Bayesian Information Criterion, the fourth model converges optimally. However, ease of interpretation plays a role in the model choice. Based on the parameter estimates in the models, the latent class logit model with two classes is chosen over the models with three or four classes. More meaningful insights were obtained from this latent class logit model.

The model results of the latent class logit model with two classes and covariates are presented in table 8. Only significant covariates are included in table 8. These are the travel motive, arrival location, booking and payment procedure, transfer experience, loyalty program, age, and income. Whereas travel motive, arrival location, booking procedures, and loyalty program are dummy coded, paying procedures and transfer experience are measured on an ordinal scale. The age of individuals is expressed on the ratio scale. The coding of the covariates is shown in table 9, to facilitate easier interpretation. Travel motive takes either non-business or business, while the arrival locations take New York and Singapore as values. The booking procedure is either by yourself or by the employer, whereas the payment procedure varies from no compensation to partial compensation and full compensation. Transfer experience is coded using four categories, namely never, sometimes, regularly, and always taking a transfer. You either are or are not subscribed to a loyalty program. Age is measured as a continuous variable. Lastly, respondents' income is categorized into low, intermediate, and high.

The significant increase in model fit of the latent class compared to the multinomial logit model indicates heterogeneity among air travellers.

Overall, the ticket price, distance to the departure location, travel time and connecting time are still important determinants in the flight choice. They are larger in value than the flight frequency and chance of delay. In addition, the preference regarding direct routing differs between the two classes. This indicates that itinerary characteristics are also decisive.

The sign of the attributes shows that travellers are receiving utility in both classes from direct routing and reductions in distance to the departure location, travel time, connecting time, and chance of delay. The sign of the flight frequency varies over the classes, however this attribute is insignificant for class 1 travellers. In other words, this type of traveller is indifferent to high and low flight frequency.

The first class is characterized by a willingness to pay for all flight characteristics. Both direct routing and distance to the departure location have high willingness to pay. Noteworthy is that travellers in the first class are also willing to pay for a reduction in flight frequency, which is not in line with the expectations. Nonetheless, this flight characteristic is not significant on the 5% level. Looking at the covariates, class 1 travellers are more likely to either have their booking made by the employer or get a full refund from them. In addition, travellers in class 1 have a higher income and are older. Lastly, they have a loyalty program more often than class 2 travellers.

The second class is characterized by a higher price sensitivity than travellers allocated to class 1. Therefore, the willing to pay coefficients are much lower. While this class is indifferent towards direct and connecting routing, flight characteristics such as distance to the departure airport, travel time, and connecting time are important for them. They are willing to pay for these characteristics. Nonetheless, the connecting time is relatively lower compared to class 1 travellers. However, they are more likely to have experience with connecting itineraries.

Table 7. Latent class logit model results for multiple classes

Classes	No. of parameters	Log-likelihood	McFadden Adjusted ρ^2	BIC
2	15	- 7340.45	0.38	14820.32
3	23	- 6955.79	0.42	14125.36
4	39	- 6825.33	0.43	13938.60

Table 8. Latent class logit model results

	Class 1 Time sensitive flyers (32.36%)			Class 2 Price sensitive flyers (67.64%)		
Attribute	Estimate	T-value	WtP (€)	Estimate	T-value	WtP (€)
Ticket price/100	- 0.160 ***	- 6.337	-	- 0.480 ***	- 25.294	-
Direct routing	0.490 *	1.950	306.3	0.136	0.880	28.3
Flight frequency	- 0.020 *	- 1.732	12.5	0.059 ***	8.820	- 12.3
Airport distance/100	- 0.994 ***	- 15.313	621.3	- 1.062 ***	- 28.746	221.3
Travel time	- 0.322 ***	- 6.903	201.3	- 0.340 ***	- 18.753	70.8
Connecting time	- 0.263 ***	- 3.895	164.4	- 0.175 ***	- 6.413	36.5
Delay chance	- 0.032 ***	- 3.529	20	- 0.031 ***	- 8.844	6.5
Covariate						
Travel motive	Ref.	-	-	- 1.365	- 5.852	-
Arrival location	Ref.	-	-	- 0.029	- 1.692	-
Booking procedures	Ref.	-	-	- 0.713	- 2.330	-
Paying procedures	Ref.	-	-	- 0.193	- 1.846	-
Transfer experience	Ref.	-	-	1.195	7.680	-
Loyalty program	Ref.	-	-	- 0.486	- 2.595	-
Age	Ref.	-	-	- 0.034	- 4.832	-
Income	Ref.	-	-	- 0.403	- 2.288	-

Significance levels: * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9. Coding of background variables

Covariate	Description
Travel motive	0 if non-business, 1 if business
Arrival location	0 if New York, 1 if Singapore
Booking procedures	0 if by self, 1 if by employer
Paying procedures	0 if no compensation, 1 if partial compensation, 2 if full compensation
Transfer experience	0 if no experience, 1 if some experience, 2 if moderate experience, 3 if extensive experience
Loyalty program	0 if no loyalty program, 1 if loyalty program
Age	Number of years
Income	0 if low, 1 if medium, 2 if high

The class membership probabilities for the background variables are shown in table 10. These probabilities are based on the taste parameters per class and the characteristics of respondents. For each respondent, the probability of belonging to a certain class is determined. Afterwards, the distribution of individuals' characteristics within one class is computed. Table 10 shows that air travelers with a business motive have a higher chance of being allocated to class 1. While air travelers with a non-business motive are more prone to be allocated to class 2, a relatively large share of around 20% is allocated to class 1. Individuals for which the booking procedures are performed by the employer are more often allocated to the first class, whereas the larger share of individuals which book flights by themselves are allocated to the second class. While no compensation at all increases price sensitivity of the individual, individuals with full compensation are not necessarily more likely to fall in the first class. To a large extent, transfer experience determines class allocation. Individuals with moderate or extensive transfer experience are more likely to be allocated to the price sensitive flyers class rather than the time sensitive flyers class. A loyalty program or lower income increases this chance too. Yet, in line with the class membership probabilities for the paying procedure, individuals with a high income are not more likely to be allocated to the time sensitive rather than price sensitive flyers.

Table 10. Class membership probabilities based on background variables

	Class 1 Time sensitive flyers (32.36%)	Class 2 Price sensitive flyers (67.64%)
Travel motive		
Non-business	21%	79%
Business	63%	37%
Arrival location		
New York	31%	69%
Singapore	34%	66%
Booking procedures		
Self	28%	72%
Employer	74%	26%
Paying procedures		
No compensation	21%	79%
Partial compensation	52%	48%
Full compensation	42%	58%
Transfer experience		
No experience	47%	53%
Some experience	37%	63%
Moderate experience	21%	79%
Extensive experience	8%	92%
Loyalty program		
No loyalty program	22%	78%
Loyalty program	38%	62%
Income		
Low	8%	92%
Medium	23%	77%
High	40%	60%

3.4 *Discussion*

The results of the multinomial logit model show that an aversion is shown towards direct routes. In addition, in line with earlier research, more utility is derived from a reduction of connecting time compared to travel time. Moreover, a larger distance to the departure location is disliked heavily. The willingness to pay for a reduction of 100 kilometres is almost equal to 300 euros. This is in line with the estimates by De Luca (2012). The willingness to pay values are commonly overestimated by stated preference choice experiments, which could be the reason for a relatively high parameter value for the distance to the departure location. Lastly, the results show that flight frequency does not play a decisive role in the flight choice.

The nested logit model results show, contrary to the multinomial logit model results, that direct routing is preferred over connecting itineraries by travellers. However, the multinomial and nested logit models differ with respect to the correlated options. Where the multinomial logit model cannot account for correlations between options, the nested logit model can (McFadden, 1974; McFadden, 1977). The connecting itineraries in the choice set were expected to correlate since they share the same characteristics. Namely, a longer travel time, lower ticket price, and higher flight frequency than the flight option with a direct itinerary. Therefore, the multinomial logit model is more likely to wrongly estimate travellers' preferences towards itinerary choices. In the nested logit model, direct itineraries are preferred over connecting itineraries. In addition, the distance to the departure location, travel time, and connecting time are less decisive in the nested logit model compared to the multinomial logit model. Besides, the importance of the flight frequency increased. Nonetheless, a big limitation of both the multinomial and nested logit model is that it cannot capture heterogeneity within the sample.

The substantial increase in model fitness of the latent class logit model indicates that heterogeneity is indeed present in the sample. In total, two types of travellers are identified. These are time and price sensitive flyers. The largest part of the sample is represented by price sensitivity. Where time sensitive flyers show high willingness to pay values for almost all flight characteristics, this is not the case for price sensitive flyers. Nonetheless, both traveller types show a positive willingness to pay for direct routing. For time sensitive flyers this willingness to pay is 306.30 euros and for the price sensitive flyers 28.30 euros. The main difference between the groups is that time sensitive flyers are fully compensated by the employer in most cases and travel for business occasions more often. Price sensitive flyers have more experience with transfers. Consequently, their willingness to pay for direct routing is much lower than for time sensitive flyers. This indicates that there are advantages associated with transfers, however when these benefits are not experienced by the traveller it is less likely that this flyer will choose for connecting itineraries.

From the results can be concluded that the distinction between price and time sensitive flyers provides more insights than a single distinction between business and non-business or frequent and infrequent flyers. While business flyers are more prone to be allocated to the first class, a large share of non-business flyers is still allocated to this class. In addition, air travellers with full employee compensation are not per se time sensitive rather than price sensitive flyers. Besides, individuals with a high income or individuals which are fully compensated by their employer are not necessarily more likely to be allocated to the time sensitive flyers class. Consequently, whether an individual belongs to the class with time sensitive or price sensitive flyers depends on a combination of characteristics rather than a single choice factor. This contradicts earlier research, in which was concluded that business flyers or frequent flyers are by definition willing to pay more for direct routing than non-business or infrequent flyers.

However, the so-called no choice alternative is not included in the choice experiment. Nonetheless, other options than direct and connecting itineraries are also an option for travellers. Video calling is more often used for business meetings, reducing the need to travel. In addition, travelling with other travel modes such as the car or train are all doable possibilities for short and medium distances. As a consequence, the parameter estimate for direct routing could well be overestimated.

4 Conclusions

Revealing heterogeneity in the preference of air travellers regarding itinerary choice played a key role in this study. By conducting a stated preference choice experiment in the Netherlands, insights were gained. Two types of air travellers are identified. These are time sensitive and price sensitive flyers. Overall, these flyers show a different preference towards direct routing. Both are willing to pay for direct itineraries, however, time sensitive flyers are keen to pay a lot more. For time sensitive flyers, the travel time, connecting time, and airport distance i.e. accessibility of the departure location are relatively important. However, this type of flyer is willing to pay more for a reduction in travel time rather than connecting time. Travel motive in combination with booking and payment procedures as well as transfer experience are drivers of categorising individuals as either time or price sensitive flyer.

Although heterogeneity in the direct routing preferences is revealed, five limitations can be identified. Firstly, not all flight characteristics relevant for all passengers in making their flight choices can be considered in the choice experiment. However, this also indicates that several trade-offs made by the travellers are not captured in the experiment. Secondly, the stated preference choice experiment is subject to pre-defined priors for the parameter estimates. While these priors are based on a literature study and pilot study, uncertainty around the precise prior estimates arises. Thirdly, the no-choice alternative is not included in the choice experiment, possibly leading to overestimating passengers' preferences on direct and connecting itineraries. Fourthly, it is unsure whether the sample used in this study is representative for the population, since population data on internationally experienced Dutch flyers is not available. Lastly, the risk of wrong interpretation of the flight characteristics is also present. For instance, it is with uncertainty that respondents understood the impact of a higher or lower flight frequency. Whether respondents related the number of flights per day with restricted departure or arrival times is also unsure.

This study offers several implications for policymakers and practitioners. First, heterogeneity in the preferences of direct routes is revealed by making the distinction between time and price sensitive flyers. This distinction seems to suit better than distinctions often made, such as business and non-business flyers or frequent and infrequent flyers, since socio-demographic characteristics such as travel motive and travel frequency do not determine the preference towards direct routes individually. Business travellers are not always in a hurry, whereas non-business travellers do not choose the cheapest flight option on every occasion. Rather, it is a combination of socio-demographics such as travel motive and transfer experience that drives the preferences of air travellers towards direct routes. Second, transfer experience determines the preference towards direct routes to a large extent. Experiencing a connecting itinerary may result in a shift in preference towards direct routes. Adjusting the network design accordingly, by offering more connecting rather than direct itineraries, could reduce the aversion towards connecting routes. Third, distance to the departure airport seems to determine flight preferences to a large extent, even more than the routing type. In policy and practice, this preference of air travellers should be taken into account.

Future research should focus on the societal impact of a reduction in direct routing itineraries for air travellers, using insights gained in this study. Since several limitations are formulated, studies on air travellers' preferences regarding direct itineraries should evaluate the effects of including other flight characteristics and the no-choice alternative. Also, thorough studies on the implications of airport distance on travel patterns might provide more insights on air travellers their preferences.

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References

Araghi, Y., Kroesen, M., Molin, E., & van Wee, B. (2014). Do social norms regarding carbon offsetting affect individual preferences towards this policy? Results from a stated choice experiment. *Transportation Research Part D: Transport and Environment*, 26(6), 42-46.

Araghi, Y., Kroesen, M., Molin, E., & Van Wee, B. (2016). Revealing heterogeneity in air travelers' responses to passenger-oriented environmental policies: A discrete-choice latent class model. *International Journal of Sustainable Transportation*, 10(9), 765-772.

Bliemer, M., Rose, J.M., & Hensher, D.A (2009). Efficient stated choice experiments for estimating nested logit models. *Transportation Research Part B: Methodological,* 43(1), 19–35.

Bliemer, M.C.J., & Collins, A.T. (2016). On determining priors for the generation of efficient stated choice experimental designs. *Journal of Choice Modelling, 21,* 10-14.

Chen, H. T., & Chao, C. C. (2015). Airline choice by passengers from Taiwan and China: A case study of outgoing passengers from Kaohsiung International Airport. *Journal of Air Transport Management*, 49(8), 53-63.

Coldren, G. M., & Koppelman, F. S. (2005). Modeling the competition among air-travel itinerary shares: GEV model development. *Transportation Research Part A: Policy and Practice,* 39(4), 345-365.

Decisio. (2015). *Economisch belang van de mainport Schiphol (Economic interest of the mainport Schiphol).* https://decisio.nl/wp-content/uploads/Economisch-belang-mainport-Schiphol.pdf

Decisio. (2020). *Actualisatie economische betekenis Schiphol (Update on economic meaning Schiphol).* https://decisio.nl/wp- content/uploads/Economisch-belang-mainport-Schiphol.pdf

De Luca, S. (2012). Modelling airport choice behaviour for direct flights, connecting flights and different travel plans. *Journal of Transport Geography*, 22(16), 148-163.

Dutch Environmental Data Compendium. (2021, December 15). *Luchtvaartnetwerk van Schiphol, 2004 – 2020.* https://www.clo.nl/indicatoren/nl215706-luchtvaartnetwerk-van-schiphol-2004-2020

Dutch Ministry of Infrastructure and Water Management. (2021, December 8). *Verantwoord vliegen naar 2050, Luchtvaartnota 2020 – 2050.* https://www.rijksoverheid.nl/documenten/rapporten/2020/11/20/bijlage-1-luchtvaartnota-2020-2050

Dutch Ministry of Infrastructure and Water Management. (2022, June 24). *Hoofdlijnenbrief Schiphol.* https://www.rijksoverheid.nl/documenten/kamerstukken/2022/06/24/hoofdlijnenbrief-schiphol

Ennen, D., Allroggen, F., & Malina, R. (2019). *Non-stop versus connecting air services: Airfares, costs, and consumers' willingness to pay*. MIT International Center for Air Transportation. https://dspace.mit.edu/bitstream/handle/1721.1/121459/ICAT-2019-3_Florian.pdf

Herring, J., Lurkin, V., Garrow, L. A., Clarke, J. P., & Bierlaire, M. (2019). Airline customers' connection time preferences in domestic US markets. *Journal of Air Transport Management*, 79, 101688.

Hess, S., & Adler, T. (2011). An analysis of trends in air travel behaviour using four related SP datasets collected between 2000 and 2005. *Journal of Air Transport Management*, *17*(4), 244-248.

Hess, S., & Palma, D. (2019). Apollo: A flexible, powerful and customisable freeware package for choice model estimation and application. *Journal of Choice Modelling,* 32.

Hsiao, C. Y., & Hansen, M. (2011). A passenger demand model for air transportation in a hub-and-spoke network. *Transportation Research Part E: Logistics and Transportation Review*, 47(6), 1112-1125.

Johnson, D., Hess, S., & Matthews, B. (2014). Understanding air travellers' trade-offs between connecting flights and surface access characteristics. *Journal of Air Transport Management*, 34(11), 70-77.

KiM Netherlands Institute for Transport Policy Research. (2018, March 22). *De Vliegende Hollander (The Flying Dutchman).* https://www.kimnet.nl/publicaties/rapporten/2018/03/22/de-vliegende-hollander

KiM Netherlands Institute for Transport Policy Research. (2021, November 23). *Zakelijk vliegen.* https://www.kimnet.nl/publicaties/publicaties/2021/11/23/zakelijk-vliegen-de-reiziger-de-reizen-de-motieven-en-de-vooruitzichten

KiM Netherlands Institute for Transport Policy Research. (2023, July 4). *Klimaatbesef en minder vliegen?* https://www.kimnet.nl/publicaties/publicaties/2023/07/04/klimaatbesef-en-minder-vliegen

Koppelman, F.S., & Bhat, C. (2006). A Self Instructing Course in Mode Choice Modelling: Multinomial and Nested Logit Models. *U.S. Department of Transportation, Federal Transit Administration.* https://its.uci.edu/~mmcnally/reports/SICMCM-UManual-K+B.pdf

Lurkin, V., Garrow, L. A., Higgins, M. J., Newman, J. P., & Schyns, M. (2018). Modeling competition among airline itineraries. *Transportation Research Part A: Policy and Practice*, 113(11), 157-172.

McFadden, D. (1973). The measurement of urban travel demand. Journal of Public Economics, 3(4), 303-328.

McFadden, D. (1986). The Choice Theory Approach to Market Research. *Marketing Science*, 5(4), 275-297.

SEO Economisch Onderzoek. (2015, January 1). *Economisch belang van de hubfunctie van Schiphol.* https://www.seo.nl/publicaties/economisch-belang-van-de-hubfunctie-van-schiphol/

SEO Economisch Onderzoek. (2020, January 14). *Het maatschappelijk belang van het Schipholnetwork.* https://www.seo.nl/publicaties/het-maatschappelijk-belang-van-het-schipholnetwerk/

SEO Economisch Onderzoek. (2022, November 17). *Connectiviteit in kaart.* https://www.seo.nl/wp-content/uploads/2022/11/2022-81-Connectiviteit-in-kaart.pdf

Theis, G., Adler, T., Clarke, J. P., & Ben-Akiva, M. (2006). Risk aversion to short connections in airline itinerary choice. *Transportation Research Record: Journal of the Transportation Research Board,* 1951(1), 28-36.

Usami, M., Manabe, M., & Kimura, S. (2017). Airport choice and flight connectivity among domestic and international passengers–Empirical analysis using passenger movement survey data in Japan. *Journal of Air Transport Management*, 58(3), 15-20.

Williams, H. C. W. L. (1977). On the formation of travel demand models and economic evaluation measures of user benefit. *Environment and Planning A: Economy and Space*, 9(3), 285-344.