Research in Transportation Economics 104 (2024) 101427

Contents lists available at ScienceDirect

Research in Transportation Economics

journal homepage: www.elsevier.com/locate/retrec

Research paper

Modeling airport choice for a multi-airport area using a random parameter logit model

Rubén Cordera [a], Luigi dell'Olio [b,*], Silvia Sipone [b], José Luis Moura [b]

[a] Department of Geography, Urban and Regional Planning, School of Civil Engineering, Universidad de Cantabria, Av. de Los Castros 44, 39005, Santander, Cantabria, Spain

[b] Department of Transport and Projects and Processes Technology, School of Civil Engineering, Universidad de Cantabria, Av. de Los Castros 44, 39005, Santander, Cantabria, Spain

ARTICLE INFO

Keywords:
Airport choice
Stated preference survey
Logit models
Error component
Random parameter

ABSTRACT

Recent years have seen a growing demand for air transport which has led to an increase in the number of airports providing a significant number of flights in Spain and throughout the rest of Europe. Choosing which airport to use depends on the competition between the airlines operating from them and how accessible they are to the residents in the surrounding areas. This research introduces an efficient design based on D-error using a stated preferences survey to study user behaviour when choosing between competing airports. The data is modelled using a Multinomial Logit Model and a Random Parameter Error Component Logit (RPECL), a discrete choice model which allows us to study user preferences taking into account their varying systemic and random tastes, as well as find specific correlations which may exist between similar alternatives. This meant the authors were also able to calculate the direct and cross elasticities to examine the weight of the different variables involved in making the choice of airport. The results showed, for a study case in Spain (Bilbao and Seve Ballesteros - Santander airports), that increased access time to the furthest airport caused an important fall in demand (choice) for that airport. It was also shown that access fees had a lower elasticity than the flight cost and that the fewer the transfers required to reach the final destination increased the probability of choosing an airport. Therefore, in order for smaller airports to compete with larger airports they need to invest more in reducing the cost of flights, attracting more low-cost companies and offering more direct complementary destinations than those provided by larger airports.

1. Introduction

The deregulation of the air transport market that has occurred since the 1990s along with the emergence of low-cost carriers (LCC) has had a profound impact on the air transport industry, enabling market competition between airports vying for customers. This has meant that two or more airports, where there is some overlap between their catchment areas with similar routes possible from both (Cheung et al., 2020), may have seen an increase in their competition.

Around Europe, but specifically in Spain, there has been a huge increase in air transport, coinciding with the opening of more airports (International Civil Aviation Organization, 2019). The low competition between airports in the past was simply a result of limited competition between airlines and less overlapping in catchment areas. Following the deregulation of the market, some airports located in close proximity to each other have experienced increased competition and a greater search for complementarity, i.e. coordination between the types of air routes and services offered at each airport.

Generally, competition motivates the companies involved to look for cost efficiencies, improve the quality and variety of the services on offer, reduce the prices of these services and grow the amount being offered on the market, thereby benefitting society as a whole (Espino et al., 2008; Martín et al., 2007).

The present research provides an analysis of user behaviour when choosing which competing airport to use for a specific journey satisfying both their needs and expectations. The aim of the research is to design a model able to predict user choice in order to support the balancing of demand at two nearby airports. This model is applied in a study case in

* Corresponding author. Department of Transport and Projects and Processes Technology, School of Civil Engineering, University of Cantabria, Av. de Los Castros 44, 39005, Santander, Cantabria, Spain.
E-mail address: luigi.dellolio@unican.es (Luigi dell'Olio).

https://doi.org/10.1016/j.retrec.2024.101427
Received 1 June 2023; Received in revised form 3 March 2024; Accepted 26 March 2024
Available online 29 March 2024

Spain, considering two airports: Bilbao and Seve Ballesteros – Santander.

In addition, this study aims to understand how users perceive certain influential variables affecting their choice (Bellizzi et al., 2021; dell'Olio et al., 2010; Dell'Olio et al., 2011; Marcucci & Gatta, 2011; Marcucci & Gatta, 2012) between two nearby airports in order to enable strategic planning to take place across the airport network, thereby promoting specialization and complementarities. An airport choice model will be designed to consider the most important trip choice variables for a generic user. This model can then be used by different institutions to encourage growth in the number of journeys made and a more balanced use of the available infrastructure.

The results are not only useful in providing information about how a user reacts when choosing to fly to a destination being offered by two nearby airports, but also could help airport management to programme the supply of flights based on their knowledge about user behaviour.

The different companies can also use the results to understand the more influential variables when customers choose to make one journey over another. This information will enable them to act on these variables and provide more attractive flights to their customers. Another factor to be considered is the influence regional governments have. Their main priority needs to be to grow the airports within their region and avoid any potential loss of customers to rival nearby airports (Dobruszkes et al., 2017).

2. Literature review

Choosing an airport has become something of a complicated decision for potential passengers, especially if there are several alternatives within a reasonable distance (Leon, 2012). Travellers have a great deal of information available to them before making their choice. The choice they have to make does not only implies the airline working at the airport, but also how to get there and any possible transfers between airports, in other words, their global accessibility (Harvey, 1987; Loo, 2008; Lu et al., 2021; Pels et al., 2003).

Some studies have investigated the role of accessibility in airport choice. Adler et al. (2022) estimated travel times between airports in the Greater London region basing their study on the use of passenger data, such as demographic and socio-economic data, as well as on the airport chosen and modal characteristics of ground access. These data were obtained from Information and Communication Technologies (ICT) finding that the combination of these new data sources with traditional surveys provided a broader picture of airport choice. In addition, Adler et al. (2022) developed an algorithm using GPS data to create matrices of demand, airport market share and travel time. A regression analysis was also used to estimate the importance of demand drivers in the market. The conclusion of this study evidences, similar to previous studies (Bergantino et al., 2020; Birolini et al., 2019; Cidell, 2014; Evangelinos et al., 2021; Gokasar & Gunay, 2017; Pels et al., 2003; Sun et al., 2017, 2021, Tsamboulas and Nikoleris, 2008), that the choice of the passengers, in a multi-airport region, depend on the size of the airport, the ground transport network, the public transport services offered, the access time to the airport and the access fare.

Other research, which has addressed the issue of airport choice in multi-airport areas, has estimated the statistical relationship between airport choice probabilities and a broad set of explanatory variables such as: available routes, flight time, flight frequencies, flight cost, type of aircraft used, airport quality, demographic variables and/or variables such as journey purpose (Adler & Berechman, 2001; Choi et al., 2019; Escobari, 2017; Nesset & Helgesen, 2014; Yang et al., 2014; Zhang et al., 2017) as well as the formulation of airline and airport marketing strategies (Chen & Lei, 2017).

Some studies have focussed on estimating the efficiency and usefulness of having several airports in the same region considering information on the factors influencing passenger choice (Bergantino et al., 2020; Paliska et al., 2016)and market share (Garrow, 2010). In a similar vein, Thelle and Sonne (2018) analyse how European airports are affected by the competitive pressure between them after the many changes in the European aviation market. The starting point is that passengers have more available choices and that airports actively respond to market changes. The result is that airports must compete with each other to retain and attract air traffic. Wiltshire (2018) has shown evidence indicating that secondary airports have a limited ability to effectively compete with larger and better located neighboring airports. This conclusion is further supported by the recent trend observed among airlines, including LCC, to shift their services from secondary airports to primary airports. These findings suggest that there is an ongoing necessity for strong economic regulation of primary airports throughout Europe in order to limit their dominant position.

There are studies that have considered which variables influence the level of passenger demand to understand better how airports can use this information to attract more passengers. Pels et al. (2001) estimated a discrete choice model to analyse passengers' preferences in relation to airlines. The conclusion of the study leads the authors to consider the access time to the airport and the frequency of service as two determining factors in the choice of airport. They also stated that there is little difference between the estimates when passengers are classified as business or leisure and that passengers first choose the airport of departure and only then the airline. Wei and Cheng (2022) provided a behavioural analysis addressing passengers' modal choice in multiple airport zones. Specifically, they analysed passengers' choice intention between airports in the same region as a function of different factors such as: the quality of airport service or the airlines operating from the airports. They conclude that the choice of airport depends on different factors: type of passenger (business or leisure); speed of security checks; convenience of arriving at the airport by car. However, the type of airline did not play a role in the choice.

On a methodological level, Multinomial Logit (MNL), Nested Logit (NL) and Mixed Logit (ML) models are examples of discrete choice models mainly used by researchers to address the factors affecting airport choice (Gokasar & Gunay, 2017; Hess et al., 2013; Yang & Liao, 2016). Although MNL models have been widely used to model airport choice due to their simplicity, they are not always reliable. Gokasar and Gunay (2020) showed that the MNL model is unreliable for the following reasons: it estimates a single coefficient for each variable (uniqueness of taste) and allows for Independence of Irrelevant Alternatives (IIA), which could be an unfulfilled assumption in the choice between more than one airport.

Birolini et al. (2019) chose the ML model to overcome these drawbacks due to its theoretical foundations and mature estimation procedures; however, their research addressed the modal choice to reach the airport rather than the actual airport choice.

Hess and Polak (2006, 2005) presented the issue of airport choice in the San Francisco Bay Area. In a first study (Hess & Polak, 2005) they used a ML model to analyse the distribution of passengers' tastes in choosing the departure airport. In a subsequent study (Hess & Polak, 2006), they formulated a model for airport choice, concluding that some factors, such as flight frequency and access time to the airport, have a significant overall impact on airport choice. However, according to their results, factors such as fare and airline characteristics are only relevant for a certain passenger profile (business/leisure, residents/visitors).

In the same airport scenario another study has showed how some non-price variables, such as airport access time, airport delay, flight frequency, availability of particular airport/airline combinations and early arrival times, strongly affect the probabilities of choice (Ishii et al., 2009). The authors found not difference in the choice of airport considering the type of passenger (business/leisure) but did according to the characteristics of the airport and the services of the airlines.

Other authors have applied NL models to capture the three key dimensions of passenger choice: airfare, surface access costs and frequency. This type of specification has been applied in a study on the problem of competition between full-service and low-cost airlines serving adjacent airports in Greater London (Pels et al., 2009).

Another issue in the literature is the problem of regulation and management of airport networks. Czerny and Lang (2023) state that this involves to understand several interrelated problems. Issues such as ownership structures and privatisation, congestion, neighbour impoverishment and competition may be more or less problematic depending on the size and structure of the airport network under consideration. Theoretical studies of complex airport networks, consisting of at least two airports, highlight the importance of the size and the structure of airport networks, i.e. the number of airports (size) and the number of regions involved (structure).

3. Methodology

3.1. Study area

The present research was undertaken from an integrated case study about two nearby airports located in the North of Spain. On the one hand, the Seve Ballesteros-Santander airport, located about 7 km from Santander city centre (Cantabria, Spain). And on the other hand, Bilbao airport located 12 km from the centre of Bilbao (Basque Country, Spain). Both airports are well connected by road infrastructure N-636, S-10, A-8/E−70, BI-30, BI-631 and N-633 and are 105.8 km apart, with a journey time by car, without considering congestion, of 1:20 h (Fig. 1). The connection between the two airports by public transport, however, is much more complicated as there is no direct service linking the two. The most direct public transport service is provided by bus from the Seve Ballesteros – Santander airport which first stops in central Santander with its final stop in the centre of Bilbao, involving a journey time of between 1:30 and 1:50 h. From the centre of Bilbao there is a direct regular bus service to the airport which leaves every 20 min with a travel time of 45 min.

Whereas Santander is a medium sized city of 172,221 people with a catchment area of around 280,000, Bilbao has a population of 346,405 and a catchment area of 900,000 people in its overall metropolitan area (INE, 2021). This clear demographic difference is also reflected in the number of flights and passengers using each airport (see Fig. 1). In 2021 the Seve Ballesteros - Santander airport served a total of 503,470 travellers using 8032 flights, while these numbers rose to 2,580,911 travellers using 26,429 flights at Bilbao airport. Looking at the data before the COVID-19 pandemic (2019), the numbers were 1,174,999 travellers using 11,238 flights at the Seve Ballesteros – Santander airport and 5, 905,820 travellers using 51,591 at Bilbao (AENA, 2021). So, to summarise, the Seve Ballesteros – Santander airport served around 20% of the passenger numbers served by Bilbao and between 20% and 30% of the overall number of flights. Considering the number of destinations, in 2023 the Bilbao airport presented 55 different destination airports whose flights were operated by 25 companies including eight LCC. In the case of Seve Ballesteros - Santander the number of destinations was 23 with flights operated by seven companies, four of them LCC. In addition, Bilbao airport is more expensive than Seve Ballesteros – Santander airport in terms of landing and aerodrome service charges. Thus, Bilbao airport charges 5.16€ per tonne for landing, compared with 3.78€ in Santander. The rate for aerodrome services is 2.55€ per tonne at Bilbao and 1.99€ at Santander (AENA, 2023).

3.2. Choice context

To study the factors influencing choice between two such different airports a choice context with three alternatives is proposed.

- Choose airport A
- Choose airport B
- Decide not to travel (C)

Where airport A represents the Seve Ballesteros - Santander airport

Fig. 1. Location (top) and site of the airports of Santander (bottom - left) and Bilbao (bottom - right). Source: maps.openrouteservice.org (top). National Plan of Aerial Orthophotography of Spain (PNOA) (bottom).

and airport B represents Bilbao airport. A third alternative "Decide not to travel" was also introduced to take into account that some users might choose not to travel given the scenario shown. The survey clearly detailed Santander airport in option A and Bilbao airport in option B. We use a more generic notation "airport A″ or "airport B″ to generalize the study by considering "airport A″ to be the airport closest to the user surveyed and "airport B″ to be the one furthest away.

Having been surveyed only users from Santander who can access both airports, in this case the design is a labelled design, since option A is always the closest (Santander airport) and option B is the furthest (Bilbao airport). We also use the third option "decide not to travel" in order not to force to decide only between the two airports, since forcing can produce biases in the estimation of the model parameters, in line with Hensher's (2010) proposal.

3.3. Survey

A two-part survey was designed to cover user characterisation and stated preferences. The user characterisation phase collected personal information about passengers, including: gender, age, standard of education, occupation and monthly income. Further information was gathered about the journey to be made, typical passenger travel history (number of flights made the year before the survey, whether they travel alone or with company, for business or leisure and if they travel for business how the trip is paid for) as well as the towns where they live and work.

The second part of the survey consisted of a choice experiment where the user chose from the three travel alternatives presented in section 3.2. The variables used in the choice model were the cost of the flight ticket (TAR), the access time to reach the airport (TACC), the charge for accessing the airport (TARACC), the number of transfers (STOPS), the presence of low-cost airlines (LOWCOST) at the airports and whether the flight was for business purpose or not (BUSINESS).

For flight cost levels at airports A and B (TAR), the same values were chosen, varying between a minimum value of 80 € and a maximum value of 360 €, taking into account that for domestic or European flights these are reasonable values and that they allow simulating flights of different types on similar routes (conventional and low-cost flights). For the access fees (TARACC), a range of values from 0 € to 24 € was considered for the nearest airport to simulate both access by private car and possible access by taxi, considering that the maximum fare normally does not exceed 24 €. For the farthest airport the maximum fare considered was 180 € which corresponds to the cost of a transfer from Santander airport to Bilbao airport. For the access times we considered a range of values between 5 and 30 min for the nearest airport (A) and between 60 and 90 min for the farthest airport, in line with the average travel times estimated using the most common travel planners.

The stated preferences pilot survey was initially designed using orthogonal design (Louviere et al., 2000) and 49 users were surveyed. The pilot survey included 12 scenarios which allowed the authors to estimate a MNL model with 480 observations (Ortúzar & Willumsen, 2011). The pilot survey is a test to check the users' understanding of the survey and, at the same time, estimate the a priori parameters (Hensher et al., 2015)being used in the efficient design, all performed using NGENE software(ChoiceMetrics, 2018).

With the a priori parameters in place a stated preference survey is then created using an efficient design (Rose & Bliemer, 2009) which, apart from minimising any data correlation, also aims to generate estimated parameters with the least possible standard errors possible.

The definitive stated preference survey included 12 scenarios, 6 for leisure trips and 6 for business trips (Table 1). The traveller is asked either of the 6 scenarios depending on the type of journey being made, previously established in the user characterisation phase of the survey.

The interviewees are presented with 4 scenarios from the 6 possible for each journey type (business or leisure). This process resulted in 393 completed surveys providing a total of 1572 observations.

Table 1
Choice situations in the SP survey.

Choice Situation	TAR (€) (A)	TACC (min) (A)	TARACC (€) (A)	TAR (€) (B)	TACC (min) (B)	TARACC (€) (B)
1	360	5	0	360	90	180
2	160	30	5	240	75	12
3	120	30	5	240	75	15
4	240	15	12	160	60	0
5	120	30	0	300	75	15
6	300	15	12	160	60	0
7	300	15	12	120	75	0
8	360	30	24	80	90	180
9	160	5	24	360	90	12
10	80	5	24	300	60	180
11	80	5	0	80	90	15
12	240	15	5	120	60	12

TAR (A or B): cost of the flight ticket (€). Levels: 80, 120, 160, 240, 300, 360.
TACC (A): access time to reach the airport A (min.). Levels: 5, 15, 30.
TACC (B): access time to reach the airport B (min.). Levels: 60, 75, 90.
TARACC (A): charge for accessing the airport A (€). Levels: 0, 5, 12, 24.
TARACC (B): charge for accessing the airport B (€). Levels: 0, 12, 15, 180.
(A): Seve Ballesteros – Santander Airport (alternative 1).
(B): Bilbao Airport (alternative 2).

Both alternatives contain the same pre-established destination and overall journey time in days from both airports as the aim is to study the choice made between two different airports in order to make the same journey. The interviewee is asked to choose their preference considering different airport characteristics such as its access and available flights. The surveys provide information about the type and cost of access to each airport as well as the cost of the flight and the number of transfers required to reach their final destination.

The interviewees are asked to choose between airport A, with certain travel characteristics, airport B with different travel characteristics from A, (except for the flight duration and final destination which are the same for both alternatives) and the option of not travelling if neither of the alternatives on offer is attractive enough to use (Fig. 2).

3.4. Choice model

The authors chose to apply a Random Parameter Error Component Logit (RPECL) (Ben-Akiva et al., 2002; Brownstone & Train, 1998; Train, 2009) to study dependence in the choice made to use either or none of two nearby airports. This type of model allows us to study the variations in user taste when choosing an airport and at the same time consider the correlation between their apparently similar alternatives (McFadden & Train, 2000). The proposed model is considered to be the most suitable for studying this kind of choice as well as overcoming the problems faced by other models unable to consider dependence between choice alternatives and randomness in user preferences(Harvey, 1987; Loo, 2008; Lu et al., 2021; Pels et al., 2003). Furthermore, the model is able to partially explain the randomness of certain variables by introducing variations in taste and making socioeconomic variables interact with those characteristics, including random parameters.

A ML model, as explained by Train (2009) can be formulated without random parameters by simply considering the error component correlating the utilities of the different alternatives in the following way:

$$U_{nj} = \alpha' x_{nj} + \mu'_{nj} z_{nj} + \varepsilon_{nj} \quad (1)$$

Where:

U_{nj} = Utility function associated to alternative j for individual n.

α' = Vector of fixed parameters.

μ'_{nj} = Vector of random parameters.

x_{nj} and z_{nj} = the vectors of the variables respectively associated with fixed and random parameters.


Airport Survey Continue Later Exit & Clear

Assume you wish to make a national or European flight. You can make this flight from your local airport (Airport A) or from another airport located about 100km away (Airport B). In this scenario, please consider the following characteristics of the journey involved.

Leisure trip

Characteristics	Airport A	Airport B
Duration of journey	2 day journey	
Access time to reach the airport (type of access)	30 minutes (car)	75 minutes (car)
Cost of reaching the airport	0 € (someone takes you to the airport)	22 € (Airport Parking)
Cost of flight ticket (type of airline)	24 € (Low-Cost Airlines)	120 € (Regular Airlines)
Number of transfers to reach destination Each transfer involves 2 hours more on the journey time and the need to check in luggage in the case of a low-cost airline	1 transfer	Direct flight

Which airport would you choose?	Airport A	Airport B	No travel

Fig. 2. Example of the survey for choosing between available alternatives.

ε_{nj} = Extreme value identically distributed independent error term.

The terms z_{nj} represent the error component which, with ε_{nj}, defines the stochastic portion of the utility. If z_{nj} is equal to zero we obtain a MNL model which does not consider correlation between alternatives and results in the problem of IIA.

The Kernel logit proposed by Ben-Akiva et al. (2002) is based on the idea of Brownstone and Train (1998) which incorporates unobserved heterogeneities through the errors associated with the individual preferences between the different choice alternatives. Therefore, equation (1) can be expanded by adding an additional term W_{nk} with $k \leq j$ in the specific utility functions to allow correlations and create additional nests to more specifically study dependence between the alternatives. In the present case, to study any existing correlations between the alternatives corresponding to the two nearby airports (although other combinations were tested they were not statistically significant). Therefore, the functional form of the model for this research was specified in the following way:

$$U_{n1} = \alpha' x_{n1} + \mu'_{nj} z_{n1} + \varepsilon_{n1} + W_{nk}$$

$$U_{n2} = \alpha' x_{n2} + \mu'_{nj} z_{n2} + \varepsilon_{n2} + W_{nk}$$

$$U_{n3} = \alpha' x_{n3} + \mu'_{nj} z_{n3} + \varepsilon_{n3}$$

4. Results

4.1. Survey results

The following results presented in Table 2 were obtained from the 393 completed surveys.

100% of the interviewees were resident in the metropolitan area of Santander in order to be consistent with the choice model where option A is the closest airport and option B is the farthest airport. As shown in the table, 82% of the interviewees were travelling for leisure purpose, as opposed to only 18% who were travelling on business. In terms of the gender analysis, the study wanted to assess if any preferences could be found that were determined by gender, or if either gender was a more frequent flyer than the other.

Table 2
Sample socioeconomic characteristics.

Gender	Female	56%
	Male	44%
Travelling purpose	Leisure	82%
	Business	18%
Age	<25	37%
	25–34	8%
	35–44	20%
	45–54	24%
	55–64	9%
	>65	2%
Occupation	Full time	48%
	Part time	11%
	Occasional work	2%
	Unemployed	3%
	Student	29%
	House Work	3%
	Pensioner	1%
	Other	3%
Number of journeys	0-2 Journeys/year	63%
	3-5 Journeys/year	23%
	>6 Journeys/year	14%
Income	<900€/month	24%
	900-1500€/month	19%
	1500-2500€/month	20%
	>2500€/month	17%
	NR/DK[a]	20%

[a] No response/Do not know.

Slightly more than half of the interviewees were female. Age was evaluated to see if any particular age range contained a greater number of users than the others. The age range containing the most users was the younger range of under 25 years old, followed by the group aged between 45 and 54. These two age ranges contain more than half the total number of interviewees.

By distributing the interviewees according to their occupation, the study was able to separate the users into a range of different employment activities. Most of the users were in full time employment, followed by university students. The interviewees were also asked how many flights each potential passenger had made during the year preceding the survey, considering outbound and return flights separately. Most of the users had made between 0 and 2 flights over the year, well above the 23% who had made between 3 and 5 flights and those who made 6 or more over the year.

The data addressing income level enabled the research to identify the buying power of frequent fliers. Given that this kind of sensitive question usually results in a certain reluctance to answer, the users were offered the possibility of avoiding the question with the option NR/DK (No response/Do not know). It can be seen that 20% of the interviewees chose not to answer this particular question about their monthly income. Most of the interviewees were found to be in the lower income group, followed by the group earning between 1500 and 2500 euros per month.

4.2. Model results

The survey data was used to estimate several MNL and RPECL discrete choice models obtaining the final specification shown in Table 3. The MNL model considers the effect of the main variables involved in making a choice between the Seve Ballesteros – Santander airport (alternative 1, airport A), Bilbao airport (alternative 2, airport B), or choosing not to travel (alternative 3, alternative C). The model presents high disutility parameters in the case of cost of the flight ticket (TAR) and the charge for accessing the airport (TARACC), especially in the case of airport A. Only the parameter of access time to reach the airport (TACC) was found to be non-significant in the case of Seve Ballesteros – Santander Airport.

The RPECL model is also able to test for the presence of heterogeneity in the taste parameters, as well as for any correlation appearing between the answers given by the same individual and correlation between the random errors of the alternatives (Revelt et al., 1998; Sillano & de Dios Ortúzar, 2005). With this information we are able to more realistically consider diversity in user preference and the presence of more complex substitution patterns than those found by the MNL model.

The RPECL model was estimated with simulated maximum likelihood using a Halton sequence of 2500 draws (Hensher & Greene, 2003; Krinsky & Robb, 1986). The model presented a good goodness of fit to the data, having an adjusted ρ^2 of 0.45, clearly superior to that found using the constants only model (Likelihood Ratio Test = 1956.61, p – value: 0.000). The large difference in the likelihoods of the MNL and RPECL models is mainly due to considering the panel effect in the RPECL model. In this case a Likelihood Ratio Test can be performed, since the two models are a restricted version of each other (12 degrees of freedom difference). Applying the Likelihood ratio test we obtain: $-2(-943.998 - (-748.711)) = 390.574 > 21.026$ and therefore the RPECL model is clearly preferred.

The parameters of the variables corresponding to the ticket cost of the flights from each of the airports (TAR) had a negative sign and a similar magnitude (−15.3 in airport A and −16.3 in airport B), both being clearly significant. The TAR variable was estimated dividing it by the income of each user in order to estimate its relative relevance. Both parameters were also specified as random with a normal distribution with deviations that were significantly different from zero.

The choice of the random parameters, as well as the distribution associated with each of them, was the result of an exhaustive search after several models' estimations (trial and error).

Different socioeconomic variables were introduced with the aim of explaining this heterogeneity in the preferences. Females were found to have a lower disutility for the fare at both airports, especially at airport B, whereas younger people (under 25) presented greater disutility, although the parameters were not clearly significant. Frequent fliers (more than 15 trips per year) also clearly showed greater disutility for the fare, above all at airport A, which is assumed to be due to their greater use and expenditure on flying. Finally, people who flew with family showed an equally greater disutility for the fare, in this case only being significant at airport B (−16.34-4.72 = −21.06).

Table 3
Mixed Logit model estimated for travel and airport choice (N = 1572).

Variable Name (Alternative)	Multinomial Logit Model (MNL)		Random Parameter Error Component Logit with panel effect (RPECL)	
	Estimate	z-test	Estimate	z-test
Random parameters in the utility functions				
TAR (A)	–	–	−15.314	−6.26
TAR (B)	–	–	−16.345	−6.26
Non-random parameters in the utility functions				
ASC (B)	2.261	3.95	2.904	3.20
ASC (C)	−4.909	−17.12	−10.351	−12.49
TAR (A)	−7.793	−10.36	–	–
TAR (B)	−8.657	−10.25	–	–
TACC (A)	−0.011	−1.31	−0.002	−0.13
TACC (B)	−0.046	−6.64	−0.052	−4.44
TARACC (A)	−27.538	−6.88	−28.614	−3.11
TARACC (B)	−5.731	−4.06	−11.293	−5.13
STOPS (A)	−1.344	−9.95	−1.695	−7.27
STOPS (B)	−0.722	−5.35	−1.083	−5.33
BUSINESS (A)	1.939	3.67	6.603	2.63
BUSINESS (B)	1.650	3.06	5.898	2.32
LOWCOST (A)	0.849	3.98	1.132	2.94
Interactions of random parameters with socio-economic variables				
TAR&SEX (1 = Women) (A)	–	–	4.034	2.26
TAR & SEX (1 = Women) (B)	–	–	7.655	3.22
TAR &AGE <25 (A)	–	–	−3.233	−1.75
TAR & AGE <25 (B)	–	–	−2.361	−0.98
TAR & AGE 35–44 (B)	–	–	−4.194	−1.59
TAR & AGE 55–65 (A)	–	–	2.814	1.65
TAR &>15 TRIPS (A)	–	–	−30.536	−2.67
TAR &>15 TRIPS (B)	–	–	−22.311	−1.88
TAR & FAMILY (B)	–	–	−4.722	−2.35
Deviation of the distributions of the random parameters				
Sigma TAR (A) (Normal)	–	–	3.305	2.25
Sigma TAR (B) (Normal)	–	–	4.048	2.57
Deviation of the random latent effects				
SigmaW_n(A,B)	–	–	5.035	6.48
Log- likelihood	−943.998	–	−748.711	–
ρ^2	0.306	–	0.450	–
ρ^2 *(adj)*	0.301	–	0.446	–
Log- likelihood (Constants only)	−1360.993	–	−1360.993	–
Number of observations	1572	–	–	–

(A): Seve Ballesteros – Santander Airport (alternative 1).
(B): Bilbao Airport (alternative 2).
(C): Do not travel (alternative 3).

Other variables being considered which did not show random variation in taste were the access time to the airport (TACC), again only significant at airport B which is farthest away, and the fee for accessing the airport (TARACC) which was also divided by the income of each user. The number of transfers (STOPS) also generated disutility in the choice of both airports, however it was greater in the case of the smaller airport A. Travel due to work (BUSINESS) increased the utility of choosing the two airports and where low-cost flights were available (LOWCOST), the utility of choosing airport A increased, probably because this kind of flight is more commonly available at smaller airports.

A clearly significant error component was also specified to consider the correlation between the alternatives of choosing airports A and B rather than the option of not flying at all.

4.3. Elasticities and simulations

The estimated RPECL model was used to calculate the elasticities of the different attributes (Table 4). These elasticities were calculated using probability weighted sample enumeration. A 1% increase in the fare (TAR) for flights from Bilbao airport resulted in a greater fall in its choice probability than the same increase at the Seve Ballesteros – Santander airport. Furthermore, at the latter airport the crossed elasticity of choosing not to travel (0.521) was also higher, implying that such an increase in the fare could result in users thinking about not flying. Access time to the airport (TACC) strongly penalize Bilbao with an elastic demand, given the distance travelled by the interviewees, whereas for airport A, closer to the city, the elasticities were almost zero. The airport access fee (TARACC) showed elasticities which were clearly inferior to those of the fare cost. More transfers (STOPS) to reach final destination also reduced the choice probability of an airport. However, if the journey is being made for business, the direct positive elasticity of Bilbao (0.208) is greater than that of Santander (0.119), almost certainly due to the fact that Santander airport has fewer destinations available and is more closely associated with leisure travel. If the flight is low-cost, the elasticity was also positive for Santander, although clearly small and with inelastic demand.

Nine scenarios were designed to evaluate how user behaviour would change under different policies which provide incentives to use the Seve Ballesteros – Santander airport rather than Bilbao. Santander airport has the advantage of being located closer to the homes of the interviewees meaning the access factor produced fewer negative externalities due to less pollution, fewer accidents and less congestion associated with the longer travelling distance to Bilbao airport. Travelling to Bilbao using the S-10, A-8/E−70, BI-30 and BI-631 roads usually involves congestion at rush hour with certain stretches being notorious for accidents, especially those located closer to the city of Bilbao. Furthermore, greater demand for Santander airport guarantees that both airport infrastructures are used more efficiently in accordance with their capacity.

The nine scenarios defined in Table 5 were centred around the reduction of fares at the Seve Ballesteros – Santander airport (SC1/SC2), increased fares at Bilbao airport (SC3/SC4), increased access fees to Bilbao airport using a toll system or parking fee (SC5/SC6), a combined increase in both the fare and access fee at Bilbao airport (SC7/SC8) and making all the available flights at Santander airport low-cost (SC9).

The scenario resulting in the greatest increase in demand for using Santander airport corresponded to a 50% reduction in flight costs (SC2), followed by the combined increase of flight costs and access fees at Bilbao airport (SC8) and making all Santander airport flights low-cost (SC9). The 25% increases made to fares (SC3) or the access fee (SC5) at Bilbao airport had a more modest effect, even when they were combined (SC7). This was especially the case with the increased fees for accessing the airport, because given the lower elasticity of this variable, the increased demand to use airport A, Seve Ballesteros – Santander, would be lower than 1.5%. This indicates that in order for a smaller airport to continue attracting nearby passengers from a larger more distant airport, providing more low-cost flights, or at least with fares clearly lower than those provided by the larger rival, could be the more successful policy. This policy could result in attracting travellers showing a higher disutility towards the fare, in other words, they are younger, travel in family groups or are frequent fliers. These actions could guarantee a more balanced use of both infrastructures as the larger airport providing a wider range of routes and services would have a larger catchment area and a broader ability to attract passengers. This wider sphere of influence could even nullify the sphere of influence of the smaller airport if they are particularly close to each other, especially if the fares being charged from the larger airport are relatively small. In addition, more moderate fares could attract users who would otherwise not travel by plane.

Table 4
Direct and Cross point elasticities for the ML model.

Attribute (Alternative)	A (Seve Ballesteros – Santander)	B (Bilbao)	C (Do not Travel)
TAR (A)	−0.380	0.579	0.521
TAR (B)	0.244	−0.527	0.255
TACC (A)	−0.006	0.009	0.006
TACC (B)	0.507	−1.076	0.451
TARACC (A)	−0.066	0.102	0.083
TARACC (B)	0.047	−0.110	0.085
STOPS (A)[a]	−0.457	0.356	0.329
STOPS (B)[a]	0.141	−0.467	0.130
BUSINESS (A)[a]	0.119	−0.771	−0.726
BUSINESS (B)[a]	−0.611	0.208	−0.538
LOWCOST (A)[a]	0.045	−0.114	−0.067

[a] Arc elasticities.

Table 5
Percentage demand change in the simulated scenarios.

Scenarios		A (Seve Ballesteros – Santander)	B (Bilbao)	C (Do not Travel)
Variable	Scenario description	Results		
	(SC0) Baseline scenario	59.84%	31.74%	8.42%
TAR	(SC1) Fare reduction at airport A (25%)	+6.13%	−5.01%	−1.12%
	(SC2) Fare reduction at airport A (50%)	+13.14%	−10.87%	−2.27%
	(SC3) Fare increase at airport B (25%)	+3.39%	−3.90%	+0.51%
	(SC4) Fare increase at airport B (50%)	+6.37%	−7.33%	+0.96%
TARACC	(SC5) Increased access fee to airport B (25%)	+0.68%	−0.86%	+0.18%
	(SC6) Increased access fee to airport B (50%)	+1.35%	−1.71%	+0.36%
TAR/ TARACC	(SC7) Increased fare at airport B and increased access fee (both by 25%)	+3.98%	−4.66%	+0.68%
	(SC8) Increased fare at airport B and increased access fee (both by 50%)	+7.50%	−8.80%	+1.30%
LOWCOST	(SC9) All flights at airport A are Low-cost	+6.62%	−5.63%	−0.99%

5. Discussion and conclusions

Competition to attract passengers to nearby airports offering services and numbers of flights which are clearly differentiated in magnitude may result in the smaller airports being underused. This research applied a stated preferences survey to a group of travellers to explore their preferences in a case study based on three alternatives: (1) smaller airport A, (2) larger airport B and (3) not travelling. The resulting data was used to estimate MNL and RPECL models to find the most relevant attributes presenting the greater elasticities conditioning the choice made.

The estimated RPECL model and the elasticities obtained showed that an increase in access time to the more distant airport, in this case Bilbao, can cause elastic behaviour in the fall in demand. This important effect of the access time to an airport has also been detected in previous research such as Birolini et al. (2019), Leon (2012) and Pels et al. (2003). Nevertheless, the fee for accessing airports provided a clearly lower elasticity to that of the fares charged for the flights themselves, meaning the latter factor could be considered as the fundamental variable when trying to design policy to incentivise user choice. The fact that an airport offers direct flights to attractive destinations may also increase demand, especially when combined with lower fares.

The weight of the fare on conditioning choice is also seen in the simulated scenarios, where the demand for Seve Ballesteros - Santander airport increased by the largest measure with a 50% reduction in fares. Similarly, if the smaller airport provides only low-cost flights, it could also see a significant, though more moderate increase in demand, by attracting passengers from its larger rival (younger passengers, families, frequent fliers) and convincing people to travel by plane. The conclusion is that in order for two nearby airports to be used in a more balanced way, the smaller airport needs to provide more competitive fares and direct flights to attractive destinations. This action could compensate to a certain degree for the fact that the larger airport, given its greater supply of routes and services, has a much larger sphere of influence which could practically nullify any demand for the smaller airport. A more balanced distribution in demand for both airports could help to avoid traffic congestion around the larger airport and longer journeys with their resulting negative externalities (congestion, pollution, accidents). The policy of trying to attract passengers based on cheaper flights has already been introduced by some regional authorities for their smaller airports around Spain and other European countries through the signing of specific agreements with LCC (Barbot, 2006; Jimenez & Suau-Sanchez, 2020). This strategy could be at risk in certain cases given the recent trend by LCC to prioritise business travel and encourage the use of larger primary airports (Dobruszkes et al., 2017; Dziedzic & Warnock-Smith, 2016).

The research presented here could be extended in the future to study other cases where there is competition between nearby airports. Further research would determine whether or not the same variables found to be relevant in this study could be extended to other areas. It would also be possible to include traveller opinions on such subjects as environmental awareness to evaluate how much effect they have on airport choice.

CRediT authorship contribution statement

Rubén Cordera: Writing – review & editing, Writing – original draft, Validation, Methodology, Conceptualization. **Luigi dell'Olio:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Conceptualization. **Silvia Sipone:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Funding acquisition, Data curation. **José Luis Moura:** Investigation, Formal analysis.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research has been possible thanks to the Margarita Salas Grant financed with NextGenerationEU funds from the European Union through the "Plan de Recuperación Transformación y Resiliencia" (Recovery, Transformation and Resilience Plan).

References

Adler, N., & Berechman, J. (2001). Measuring airport quality from the airlines' viewpoint: An application of data envelopment analysis. *Transport Policy, 8*, 171–181. https://doi.org/10.1016/S0967-070X(01)00011-7

Adler, N., Brudner, A., Gallotti, R., Privitera, F., & Ramasco, J. J. (2022). Does big data help answer big questions? The case of airport catchment areas & competition. *Transportation Research Part B: Methodological, 166*, 444–467. https://doi.org/10.1016/J.TRB.2022.10.013

AENA. (2021). *Estadísticas de Tráfico Aéreo (air traffic statistics)*.

AENA. (2023). *Price guide 2023 february edition*. Madrid.

Barbot, C. (2006). Low-cost airlines, secondary airports, and state aid: An economic assessment of the Ryanair–Charleroi Airport agreement. *Journal of Air Transport Management, 12*, 197–203. https://doi.org/10.1016/J.JAIRTRAMAN.2006.04.001

Bellizzi, M. G., dell'Olio, L., Eboli, L., & Mazzulla, G. (2021). Detecting passengers' heterogeneity on airlines' services using SP data. *Journal of Air Transport Management, 96*, Article 102123. https://doi.org/10.1016/j.jairtraman.2021.102123

Ben-Akiva, M., Mcfadden, D., Train, K., Walker, J., Bhat, C., Bierlaire, M., Bolduc, D., Boersch-Supan, A., Brownstone, D., Bunch, D. S., Daly, A., De Palma, A., Gopinath, D., Karlstrom, A., & Munizaga, M. A. (2002). Hybrid choice models: Progress and challenges. *Marketing Letters, 13*(3 13), 163–175. https://doi.org/10.1023/A:1020254301302, 2002.

Bergantino, A. S., Capurso, M., & Hess, S. (2020). Modelling regional accessibility to airports using discrete choice models: An application to a system of regional airports. *Transportation Research Part A Policy Pract, 132*, 855–871. https://doi.org/10.1016/J.TRA.2019.12.012

Birolini, S., Malighetti, P., Redondi, R., & Deforza, P. (2019). Access mode choice to low-cost airports: Evaluation of new direct rail services at Milan-Bergamo airport. *Transport Policy, 73*, 113–124. https://doi.org/10.1016/J.TRANPOL.2018.10.008

Brownstone, D., & Train, K. (1998). Forecasting new product penetration with flexible substitution patterns. *Journal of Econometrics, 89*, 109–129. https://doi.org/10.1016/S0304-4076(98)00057-8

Chen, R., & Lei, Z. (2017). Airport dominance and airline pricing power: An investigation of hub premiums in the Chinese domestic market. *Transportation Research Part A Policy Pract, 103*, 509–524. https://doi.org/10.1016/J.TRA.2017.05.023

Cheung, T. K. Y., Wong, W. hung, Zhang, A., & Wu, Y. (2020). Spatial panel model for examining airport relationships within multi-airport regions. *Transportation Research Part A Policy Pract, 133*, 148–163. https://doi.org/10.1016/J.TRA.2019.12.011

Choi, J. H., Wang, K., Xia, W., & Zhang, A. (2019). Determining factors of air passengers' transfer airport choice in the Southeast Asia – North America market: Managerial and policy implications. *Transportation Research Part A Policy Pract, 124*, 203–216. https://doi.org/10.1016/J.TRA.2019.03.008

ChoiceMetrics. (2018). *Ngene 1.2 user manual & reference guide*. Sydney, Australia: ChoiceMetrics.

Cidell, J. (2014). Spoke airports, intentional and unintentional ground travel, and the air travel decision-making process. *Transportation Research Part A Policy Pract, 69*, 113–123. https://doi.org/10.1016/J.TRA.2014.08.015

Czerny, A. I., & Lang, H. (2023). Modeling airport networks for theoretical policy analyses. *Journal of the Air Transport Research Society, 1*, 54–62. https://doi.org/10.59521/27376273D7284F00

dell'Olio, L., Ibeas, A., & Cecín, P. (2010). Modelling user perception of bus transit quality. *Transport Policy, 17*, 388–397. https://doi.org/10.1016/j.tranpol.2010.04.006

Dell'Olio, L., Ibeas, A., & Cecin, P. (2011). The quality of service desired by public transport users. *Transport Policy, 18*, 217–227. https://doi.org/10.1016/j.tranpol.2010.08.005

Dobruszkes, F., Givoni, M., & Vowles, T. (2017). Hello major airports, goodbye regional airports? Recent changes in European and US low-cost airline airport choice. *Journal of Air Transport Management, 59*, 50–62. https://doi.org/10.1016/J.JAIRTRAMAN.2016.11.005

Dziedzic, M., & Warnock-Smith, D. (2016). The role of secondary airports for today's low-cost carrier business models: The European case. *Research in Transportation Business & Management, 21*, 19–32. https://doi.org/10.1016/J.RTBM.2016.07.002

Escobari, D. (2017). Airport, airline and departure time choice and substitution patterns: An empirical analysis. *Transportation Research Part A Policy Pract, 103*, 198–210. https://doi.org/10.1016/J.TRA.2017.05.034

Espino, R., Martín, J. C., & Román, C. (2008). Analyzing the effect of preference heterogeneity on willingness to pay for improving service quality in an airline choice context. *Transport Resource E Logistics Transport Review, 44*, 593–606. https://doi.org/10.1016/J.TRE.2007.05.007

Evangelinos, C., Staub, N., Marcucci, E., & Gatta, V. (2021). The impact of airport parking fees on the tourist's airport/airline choice behavior. *Journal of Air Transport Management, 90*, Article 101961. https://doi.org/10.1016/J.JAIRTRAMAN.2020.101961

Garrow, L. A. (2010). *Discrete choice modelling and air travel demand: Theory and applications, discrete choice modelling and air travel demand: Theory and applications*. Ashgate Publishing Ltd.

Gokasar, I., & Gunay, G. (2017). Mode choice behavior modeling of ground access to airports: A case study in istanbul, Turkey. *Journal of Air Transport Management, 59*, 1–7. https://doi.org/10.1016/J.JAIRTRAMAN.2016.11.003

Gokasar, I., & Gunay, G. (2020). Modeling and implications of airport ground egress mode choice. *KSCE Journal of Civil Engineering, 25*(2 25), 669–679. https://doi.org/10.1007/S12205-020-5523-8, 2020.

Harvey, G. (1987). Airport choice in a multiple airport region. *Transportation Research Part A: General, 21*, 439–449. https://doi.org/10.1016/0191-2607(87)90033-1

Hensher, D. A. (2010). Hypothetical bias, choice experiments and willingness to pay. *Transportation Research Part B: Methodological, 44*, 735–752. https://doi.org/10.1016/J.TRB.2009.12.012

Hensher, D. A., & Greene, W. H. (2003). The mixed logit model: The state of practice. *Transportation, 30*, 133–176. https://doi.org/10.1023/A:1022558715350/METRICS

Hensher, D. A., Rose, J. M., & Greene, W. H. (2015). *Applied choice analysis, applied choice analysis*. Cambridge University Press. https://doi.org/10.1017/CBO9781316136232

Hess, S., & Polak, J. W. (2005). Mixed logit modelling of airport choice in multi-airport regions. *Journal of Air Transport Management, 11*, 59–68. https://doi.org/10.1016/J.JAIRTRAMAN.2004.09.001

Hess, S., & Polak, J. W. (2006). Airport, airline and access mode choice in the San Francisco Bay area. *Papers in Regional Science, 85*, 543–567. https://doi.org/10.1111/J.1435-5957.2006.00097.X

Hess, S., Ryley, T., Davison, L., & Adler, T. (2013). Improving the quality of demand forecasts through cross nested logit: A stated choice case study of airport, airline and access mode choice. https://doi.org/10.1080/18128602.2011.5777589, 358–384.

INE. (2021). Padrón municipal de Habitantes (Municipal Register of Inhabitants) [WWW Document]. URL https://www.ine.es/dyngs/INEbase/es/categoria.htm?c=Estadistica_P&cid=1254734710990. (Accessed 8 October 2023).

International Civil Aviation Organization (ICAO). (2019). *The world of air transport in 2019*.

Ishii, J., Jun, S., & Van Dender, K. (2009). Air travel choices in multi-airport markets. *Journal of Urban Economics, 65*, 216–227. https://doi.org/10.1016/J.JUE.2008.12.001

Jimenez, E., & Suau-Sanchez, P. (2020). Reinterpreting the role of primary and secondary airports in low-cost carrier expansion in Europe. *Journal of Transport Geography, 88*, Article 102847. https://doi.org/10.1016/J.JTRANGEO.2020.102847

Krinsky, I., & Robb, A. L. (1986). On approximating the statistical properties of elasticities. *The Review of Economics and Statistics, 68*, 715. https://doi.org/10.2307/1924536

Leon, S. (2012). Airport choice modeling: Empirical evidence from a non-hub airport. *Journal of the Transportation Research Forum, 50*, 5–16. https://doi.org/10.5399/OSU/JTRF.50.2.2711

Loo, B. P. Y. (2008). Passengers' airport choice within multi-airport regions (MARs): Some insights from a stated preference survey at Hong Kong international airport. *Journal of Transport Geography, 16*, 117–125. https://doi.org/10.1016/J.JTRANGEO.2007.05.003

Louviere, J. J., Hensher, D. A., Swait, J. D., & Adamowicz, W. (2000). *Stated choice methods: Analysis and applications, stated choice methods*. Cambridge University Press. https://doi.org/10.1017/CBO9780511753831

Lu, J., Meng, Y., Timmermans, H., & Zhang, A. (2021). Modeling hesitancy in airport choice: A comparison of discrete choice and machine learning methods. *Transportation Research Part A Policy Pract, 147*, 230–250. https://doi.org/10.1016/J.TRA.2021.03.006

Marcucci, E., & Gatta, V. (2011). Regional airport choice: Consumer behaviour and policy implications. *Journal of Transport Geography, 19*, 70–84. https://doi.org/10.1016/J.JTRANGEO.2009.10.001

Marcucci, E., & Gatta, V. (2012). Dissecting preference heterogeneity in consumer stated choices. *Transport Resource E Logistics Transport Review, 48*, 331–339. https://doi.org/10.1016/J.TRE.2011.08.003

Martín, J. C., Román, C., & Espino, R. (2007). Willingness to pay for airline service quality. *Transport Reviews, 28*, 199–217. https://doi.org/10.1080/01441640701577007

McFadden, D., & Train, K. (2000). Mixed MNL models for discrete response. *Journal of Applied Econometrics, 15*, 447–470.

Nesset, E., & Helgesen, Ø. (2014). Effects of switching costs on customer attitude loyalty to an airport in a multi-airport region. *Transportation Research Part A Policy Pract, 67*, 240–253. https://doi.org/10.1016/J.TRA.2014.07.003

Ortúzar, J. de D., & Willumsen, L. G. (2011). *Modelling transport*. Wiley-Blackwell.

Paliska, D., Drobne, S., Borruso, G., Gardina, M., & Fabjan, D. (2016). Passengers' airport choice and airports' catchment area analysis in cross-border Upper Adriatic multi-airport region. *Journal of Air Transport Management, 57*, 143–154. https://doi.org/10.1016/J.JAIRTRAMAN.2016.07.011

Pels, E., Nijkamp, P., & Rietveld, P. (2001). Airport and airline choice in a multiple airport region: An empirical analysis for the San Francisco Bay area. *Regional Studies, 35*, 1–9. https://doi.org/10.1080/00343400120025637

Pels, E., Nijkamp, P., & Rietveld, P. (2003). Access to and competition between airports: A case study for the San Francisco Bay area. *Transportation Research Part A Policy Pract, 37*, 71–83. https://doi.org/10.1016/S0965-8564(02)00007-1

Pels, E., Njegovan, N., & Behrens, C. (2009). Low-cost airlines and airport competition. *Transport Resource E Logistics Transport Review, 45*, 335–344. https://doi.org/10.1016/J.TRE.2008.09.005

Revelt, D., Train, K., Revelt, D., & Train, K. (1998). Mixed logit with repeated choices: Households' choices of appliance efficiency level. *The Review of Economics and Statistics, 80*, 647–657. https://doi.org/10.1162/003465398557735

Rose, J. M., & Bliemer, M. C. J. (2009). Constructing efficient stated choice experimental designs. https://doi.org/10.1080/01441640902827623, 587–617.

Sillano, M., & de Dios Ortúzar, J. (2005). Willingness-to-pay estimation with mixed logit models: Some new evidence. *Environment & Planning A, 37*, 525–550. https://doi.org/10.1068/A36137

Sun, X., Wandelt, S., Hansen, M., & Li, A. (2017). Multiple airport regions based on inter-airport temporal distances. *Transport Resource E Logistics Transport Review, 101*, 84–98. https://doi.org/10.1016/J.TRE.2017.03.002

Sun, X., Wandelt, S., & Zhang, A. (2021). Comparative accessibility of Chinese airports and high-speed railway stations: A high-resolution, yet scalable framework based on open data. *Journal of Air Transport Management, 92*, Article 102014. https://doi.org/10.1016/J.JAIRTRAMAN.2020.102014

Thelle, M. H., & Sonne, M. la C. (2018). Airport competition in Europe. *Journal of Air Transport Management, 67*, 232–240. https://doi.org/10.1016/J.JAIRTRAMAN.2017.03.005

Train, K. E. (2009). Discrete choice methods with simulation. *Discrete choice methods with simulation* (2nd ed.). Cambridge University Press. https://doi.org/10.1017/CBO9780511805271. Second Edition.

Tsamboulas, D. A., & Nikoleris, A. (2008). Passengers' willingness to pay for airport ground access time savings. *Transportation Research Part A Policy Pract, 42*, 1274–1282. https://doi.org/10.1016/J.TRA.2008.03.013

Wei, W., & Cheng, W. (2022). Design of air passenger travel choice intention prediction system based on deep learning. *Scientific Programming*. https://doi.org/10.1155/2022/7340552, 2022.

Wiltshire, J. (2018). Airport competition: Reality or myth? *Journal of Air Transport Management, 67*, 241–248. https://doi.org/10.1016/J.JAIRTRAMAN.2017.03.006

Yang, C. W., & Liao, P. H. (2016). Modeling the joint choice of access modes and flight routes with parallel structure and random heterogeneity. *Transport Resource E Logistics Transport Review, 95*, 19–31. https://doi.org/10.1016/J.TRE.2016.09.001

Yang, C. W., Lu, J. L., & Hsu, C. Y. (2014). Modeling joint airport and route choice behavior for international and metropolitan airports. *Journal of Air Transport Management, 39*, 89–95. https://doi.org/10.1016/J.JAIRTRAMAN.2014.05.001

Zhang, Y., Wang, K., & Fu, X. (2017). Air transport services in regional Australia: Demand pattern, frequency choice and airport entry. *Transportation Research Part A Policy Pract, 103*, 472–489. https://doi.org/10.1016/J.TRA.2017.05.028