Understanding air travellers' trade-offs between connecting flights and surface access characteristics

Daniel Johnson
Institute of Transport Studies,
University of Leeds, 34-40 University Road, Leeds LS2 9JT, UK
e-mail: D.H.Johnson@its.leeds.ac.uk

Stephane Hess
Institute of Transport Studies,
University of Leeds, 34-40 University Road, Leeds LS2 9JT, UK
e-mail: S.Hess@its.leeds.ac.uk

Bryan Matthews
Institute of Transport Studies,
University of Leeds, 34-40 University Road, Leeds LS2 9JT, UK
e-mail: B.Matthews@its.leeds.ac.uk[1]

January 2013

Abstract

This paper reports on a study which seeks to improve our understanding of how people choose between different kinds of flight at competing airports, and how their choices are affected by access conditions. In particular, using stated choice data collected in Scotland, it investigates whether improving surface access to airports that are in relatively close proximity to one another (Glasgow and Edinburgh) leads people to avoid taking indirect flights from their nearest airport in favour of direct flights from an alternative airport. In line with expectations, our estimation results from cross-nested logit models show strong aversion to connecting flights, resulting in a willingness to either pay higher fares for direct flights or accept non-trivial increases in access time. For the latter, even without the potential new direct rail link between the two airports, current access times are such that a scenario where direct flights were only available at the non-home airport, a substantial share of passengers would choose to travel from the alternative airport.

Keywords: *air travel behaviour; connecting flights; stated choice; cross-nested logit*

1. Introduction

Deregulation of US and European airline markets has allowed the development of different forms of route and network structure in air passenger transport, leading to greater choice for passengers regarding the airport they use and the type of service they fly with. The clearest examples of these differences is the contrast between the full service carrier, operating a hub and spoke network through a major hub airport (such as BA at Heathrow or Lufthansa at Frankfurt), as compared with the low-cost carrier operating a set of point to point services through a number of secondary airports. More recently, variations have emerged on these contrasting cases, involving hub and spoke networks being operated by alliances of airlines rather than by one airline and, on the other hand, point to point services serving some of the more major airports. Indeed, some of these point to point services, by linking in to major hub airports, start to provide for some of the onward connections features of the hub

[1] We would also like to acknowledge the help of Christiane Bielefeldt who commented on earlier versions of this paper and made useful suggestions during the research process.

and spoke network (though without features such as through-ticketing and connection guarantees).

What emerges, particularly in Europe, are situations where passengers are increasingly faced with choices regarding which airport they fly from and what kind of service they fly on. However, as noted by Kouwenhoven (2008), little is known about the influence of the type or level of airline service or airport quality-related factors on actual passenger behaviour. In this paper, we report on a study which seeks to improve our understanding of how people choose between different kinds of flight at competing airports, with a particular focus on how these choices are affected by access conditions. We seek to generate new evidence to develop the understanding of the interaction of the type or level of airline service and the ease of surface access upon the choice of airport. In particular, we investigate people's preferences between direct and indirect flights from two airports that are in relatively close proximity to one another, and whether improving surface access to them leads people to avoid taking indirect flights from their nearest airport. In addition, we were also interested to understand more about how people choose between surface access options.

The focus of the study is on Edinburgh Airport and Glasgow Airport, the two busiest airports in Scotland and only 67km apart from one another. With over 9m passengers and serving over 100 destinations, Edinburgh Airport proclaims itself to be Scotland's busiest airport, whilst Glasgow, with over 7m passengers and serving over 80 destinations, is by far the second busiest. A number of destinations are served by direct flights from both airports, including Heathrow, Paris CDG and Amsterdam, but there are also a number of destinations for which it is only possible to fly directly from one or other of the airports. For example, there are direct flights from Edinburgh to Brussels, Frankfurt, Vilnius and Zurich but not from Glasgow. At the same time, there are direct flights from Glasgow to Plymouth, Reykjavik, Dubai and Lahore, but not from Edinburgh.

Recent figures (BAA, 2009) show that, for 2009, 70% of Edinburgh Airport's passengers access the Airport by car or taxi, and that this figure is some 85% for Glasgow Airport. Furthermore, CAA data, (CAA, 2005) hows that most people use their nearest airport, with 61% of Edinburgh Airport's domestic passengers and 58% of its international passengers coming from the Lothian region, and some 90% of Glasgow Airport's domestic passengers and 63% of its international passengers coming from the Strathclyde region.

The primary aim of the study[2] was to investigate how travellers may respond in a situation where, for a given trip, their *home* airport is more likely to offer only connecting flights to their chosen destination, while direct flights are available from the alternative airport. As an example, would a traveller living in or around Glasgow be willing to travel to Edinburgh airport if the latter offered direct flights to the chosen destination, while only connecting flights are offered from Glasgow. A secondary aim was to discuss the impact of a new direct rail access link in this

[2] The work was undertaken as part of the EU FP7 project INTERCONNECT. The project is concerned with how to improve interconnectivity in long distance travel, and the impacts of making such improvements.

context. Our sample focused on individuals who flew from either of the two airports to locations where interchange was appropriate, eg London travellers were excluded. Using a customised stated choice (SC) design, systematically varying the attributes of the journey across a series of scenarios, we analyse how the different attributes are traded off against each other. We analyse the choice of airport and access mode jointly using a cross-nested logit (CNL) model to allow for flexible substitution patterns between options[3]. Our results highlight the strong aversion to connecting flights, showing very high willingness to accept higher air fares or increased access time in return for direct flights.

The novel aspect of our study in contrast with previous work making use of advanced nesting structure is a focus on the trade-offs between connecting flights and surface access characteristics while at the same time looking at the competition between two airports in different cities rather than airports within a single multi-airport city.

2. Literature Review

Work on airport choice behaviour dates back to Skinner's (1976) use of multinomial logit models on air passenger survey data for the Baltimore Washington DC region, where he found higher sensitivity to ground accessibility than to air journey level of service.

The question of airport choice has been examined for many years through a number of studies, with accessibility and flight frequency consistently being highlighted as the key factors (Skinner, 1976; Ashford and Bencheman, 1987, Thompson and Caves, 1993, and Windle and Dresner, 1995). Other studies have identified aircraft type (eg Innes and Doucet, 1990) and ticket price (eg Bradley, 1998) as also being significant. Harvey (1987) used revealed preference (RP) data from the multi-airport San Francisco Bay area to estimate separate multinomial logit models for business and non-business travel, as a function of highway access time and flight frequency, with both having non-linear effects on utility. He finds that beyond a certain threshold level additional direct services to a destination do not make airports more attractive. However, there is a large disutility for connecting flights. The disutility of access time decreases with total time, and shorter flights have more sensitivity than long-haul. Fare and access mode were not included as attributes in this study.

There is also substantial evidence of variations across passengers in sensitivities, where Hess and Polak (2005) were the first to highlight this with the use of mixed logit models on the San Francisco Bay area RP data, showing significant heterogeneity in sensitivities across travellers. Ishi et al (2009) also look at choices between airports in the San Francisco Bay area comparing mixed and multi-nomial models with separate specifications for business and leisure travellers. Mixing distributions estimated on departure airport and airline dummies, value of access time

[3] While an error components model would allow for the same level of nesting flexibility, it would have led to very substantial increases in computational complexity and identification issues.

and travel delay. Again, results were similar to MNL, suggesting that much of the heterogeneity found in other studies may be due to different markets and trip types. A number of studies have focussed more specifically on the choice of airline. O'Connell and Williams (2005) highlight the growing intensity of direct competition between full service and no-frills airlines. The brand intensity of low fare airlines was such that most of those surveyed on a low cost carrier did not look at other carriers. Full fare passengers prefer reliability, quality, connections, frequent flyer discounts and comfort, whilst low cost passengers choose their flight almost exclusively on the basis of fare and are willing to travel through secondary airports.

Mason (2001) finds there that there is little distinction between business travellers who use low cost and network carriers, and argues that they do not represent two market groups – price and value for money are prime considerations for both groups.

Barrett (2004) looks at the difference in services operated between low-cost carriers and the more established airlines. De-regulated low cost airlines operate on a point to point basis so their passengers do not need to transfer at hub airports, being more willing to transfer to smaller airports outside of destination cities. Low fare airlines have brought service to underutilised secondary airports. They are clearly tough operators, and airports have to respond to the new market power.

Whitaker, Terzis, Soong and Yeh (2005) carried out a number of SC experiments to evaluate airline passenger preferences. Qualitative findings indicated that flights outside preferred schedules needed heavy discounting, while, in terms of airline products and services, many travellers were highly driven by check-in queue time.

The third dimension of air travel choice behaviour is that of ground level access. Gosling (2008) conducted a comprehensive review of nine airport ground access mode choice models, based on RP or SC. Whilst most models include travel time and travel cost, he concluded that there was still uncertainty over which other explanatory variables to include and the appropriate nesting structures of different modes.

A number of authors have correctly recognised that air travel behaviour is characterised by multi-dimensional choice processes which need to be analysed jointly rather than separately. Furuichi & Koppelman (1994) use an NL model for RP data on choice of departure and destination airport choice in Japan, finding significant effects by access time and cost and flight-frequency. Pels et al. (2001) use the San Francisco Bay area data to analyse the combined choice of airport and airline and find that that airline choice is linked to the choice of airport, while Pels et al. (2003) jointly analyse airport and access-mode choice, finding high sensitivity to access time, especially for business travellers. Hess and Polak (2006a) go further, by jointly analysing the choice of airport, airline, and access mode, once again finding high access time sensitivity and strong access mode and airline allegiance.

Hess and Polak (2006b) highlight the shortcomings of standard Nested Logit (NL) models for such multi-dimensional choice process and instead put forward the use of a Cross-Nested Logit (CNL) model which allows for the joint representation of correlation between airport, airline and access mode. They apply the model to RP data from the Greater London area (Gatwick, Luton, Stansted, London City, Heathrow), showing significant improvements in performance over simple NL models. As with other studies, access time is found to be a key factor in choice of airport, along with flight time and frequency and access cost. However, due to the quality of their data and the low sensitivity of business passengers, they were not able to estimate a significant effect of air fare, a common limitation of many studies using revealed preference data. Hess et al apply (2012) this approach to a SC dataset based on broader regional data from the East Coast of the US, reflecting passengers' travel to far outlying airports to access cheaper flights. Again, they find improvements from use of the CNL model.

Drabas and Wu (2013) also use a CNL model to analyse SP data on flight options to USA from Australia nested to account for correlations between airlines along dimensions of whether they were established, cheaper and offered connecting flights. Analysis was segmented to account for diversity of passengers and their past choices. They find their adapted form of CNL outperforms mixed and multinomial logit models.

De Luca (2012) looks at airport choice between 3 airports in Italy (two in Rome, one in Naples) to compare the performance of different modelling approaches. CNL was used to account for correlation between Rome based airports and those mainly served by non-legacy carriers. He also estimated the model as a mixed multinomial logit with normally distributed functions for airfare, frequency and access time. Nested, Cross nested and mixed models outperformed multinomial logit but not significantly so. He finds that access time is the main determinant of airport choice, air fare and frequency play smaller roles.

3. Survey work

The survey work made use of a sample of respondents who had recently undertaken a return journey by air (scheduled flights only) from either Glasgow or Edinburgh to one of a set of predefined destinations. This list included most of the main destinations served from either airport, but excluded a number of destinations for which connecting flights would not be seen as viable (primarily London). Respondents were asked to provide details on this specific air journey, along with details for their access journey to the airport. Respondents were also asked what their preferred schedule would have been in terms of flight departure time, which allowed us to investigate the sensitivity to schedule delay.

With the above aims in mind, a SC survey was designed in which respondents were faced with a number of hypothetical choice scenarios focussed around a recent trip. In particular, each respondent in the survey was presented with two sets of five such scenarios. In the first five scenarios, game 1, the respondent was given a choice between a flight at Glasgow airport and a flight at Edinburgh airport. The two flights were described on the basis of:

- the type of airline (*full service* or *no frills*);
- the flight departure time;
- whether it was a direct or connecting flight;
- the connection time (if applicable);
- the total air journey time; and

- the return air fare.

In addition, four different access options were given for each of the two airports, namely *drive & park*, *dropped off*, *taxi*, and *bus*. In the second set of five scenarios, game 2, a fifth mode, namely a *direct rail link*, was added, where this was in some cases a *high speed rail link*. This is motivated by potential interest in a future direct rail link between the two airports (SKM, 2003). The different access modes were described to respondents in terms of time and cost. For respondents who had indicated that either or both drive & park and dropped off were not available options, the choice set was adjusted accordingly.

The actual attribute levels presented varied across scenarios, with the specific variations used coming from an advanced experimental design. In particular, this design presents scenarios that require trading between attributes (i.e. gains in one attribute are traded off against losses in another attribute), where this increases the ability to retrieve meaningful estimates of the relative sensitivities to the various attributes with a finite sample size. As mentioned above, the main interest was in the choice between a connecting flight at the home airport and a direct flight at the alternative airport. For obvious reasons, this situation did however not apply in each single scenario as this would have led to perfect collinearity in the data. Rather, the rate of connecting flights was simply set to a higher level at the home airport in the experimental design.

In each scenario, the respondent was asked to choose his or her preferred pairing of airport and access mode, while a *No travel* option was also included.

The following design specifications were used for the different attributes:

- Airline type: between two thirds and three quarters of flights are on full service airlines
- Flight departure time: pivoted around the departure time reported for the recent trip, with five levels, namely 2 hrs;-1 hr; no change;+1 hr;+2 hrs. No flights were presented with departures before 6AM or after 11PM.
- Direct or connecting flight: around 50% of flights at the home airport were direct flights, while this increased to over 2/3 at the alternative airport.
- Connection time: five different levels, namely 45 minutes, 60 minutes, 90 minutes, 120 minutes, and 180 minutes.
- Air journey time: composed of direct flight time, connection time, and an additional indirect routing effect, pivoted around values from look-up tables.
- Return air fare: pivoted around the reported air fare, with five levels, namely -50%; -20%, 0%, +20%, +50%.
- Access time: pivoted around values from look-up tables, with five levels, namely -30%; -15%, 0%, +15%, +30%.
- Access cost: pivoted around values from look-up tables, with five levels, namely -30%; -15%, 0%, +15%, +30%.

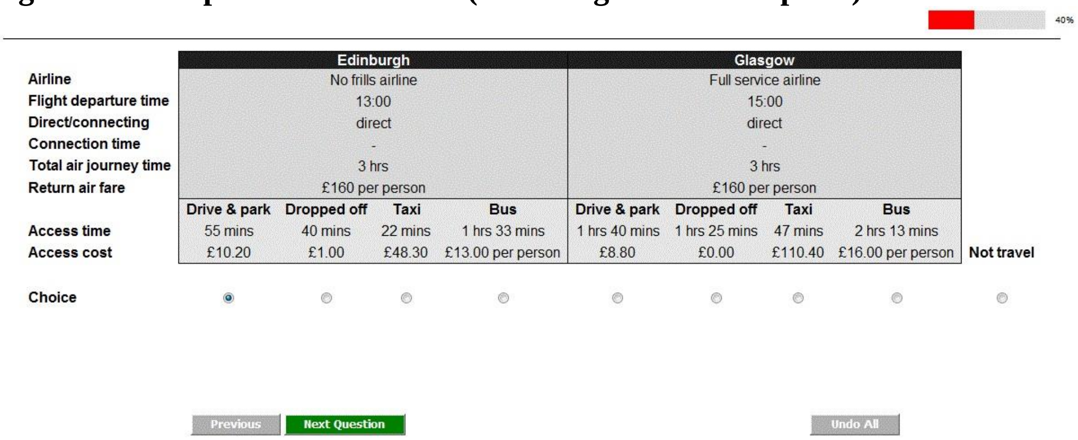
The survey was implemented as an on-line self-completion questionnaire. Survey respondents were recruited primarily through an online panel with just under a quarter of respondents being sampled offline.

In order to be in scope for the survey, individuals had to have undertaken scheduled return flight in the last six months to one of a list of popular destinations, as described earlier.

To support the customisation of the survey to the individual's access origin, time and cost look-up tables were constructed detailing times and costs of representative taxi, bus and car options from 163 postcode districts (eg EH6, for Edinburgh areas of Leith and Newhaven) close to the airport. Areas further away were broken down into 11 larger postal areas (eg IV for Inverness). An initial sample of 342 respondents was obtained, where, for the present exploratory work, representativeness of the wider population was not a primary aim. After data cleaning, a final sample of 303 respondents was used for the analysis, leading to 3,030 separate choice scenarios.

Figure 1 and Figure 2 show two examples of choice scenarios, the first one taken from the first five choices and the second from the second five choices, including the rail access option. These are based on a respondent whose reference trip was a flight from Edinburgh to Rome, costing £200.

Figure 1: Example choice scenario (excluding rail access option)

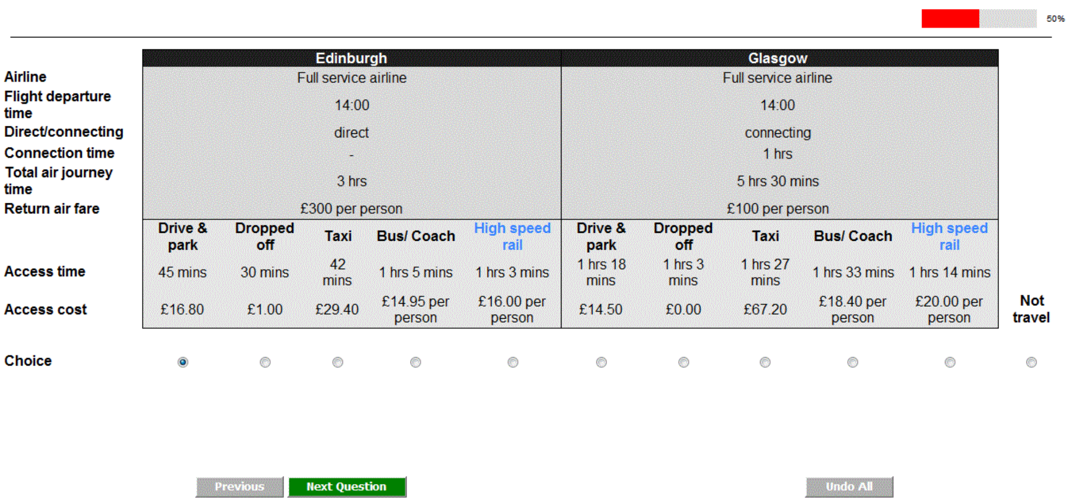


40%

	Edinburgh				Glasgow				
Airline	No frills airline				Full service airline				
Flight departure time	13:00				15:00				
Direct/connecting	direct				direct				
Connection time	-				-				
Total air journey time	3 hrs				3 hrs				
Return air fare	£160 per person				£160 per person				
	Drive & park	Dropped off	Taxi	Bus	Drive & park	Dropped off	Taxi	Bus	
Access time	55 mins	40 mins	22 mins	1 hrs 33 mins	1 hrs 40 mins	1 hrs 25 mins	47 mins	2 hrs 13 mins	
Access cost	£10.20	£1.00	£48.30	£13.00 per person	£8.80	£0.00	£110.40	£16.00 per person	Not travel
Choice	◉	○	○	○	○	○	○	○	○

Previous | Next Question | Undo All

Figure 2: Example choice scenario (including rail access)



50%

	Edinburgh					Glasgow					
Airline	Full service airline					Full service airline					
Flight departure time	14:00					14:00					
Direct/connecting	direct					connecting					
Connection time	-					1 hrs					
Total air journey time	3 hrs					5 hrs 30 mins					
Return air fare	£300 per person					£100 per person					
	Drive & park	Dropped off	Taxi	Bus/ Coach	High speed rail	Drive & park	Dropped off	Taxi	Bus/ Coach	High speed rail	
Access time	45 mins	30 mins	42 mins	1 hrs 5 mins	1 hrs 3 mins	1 hrs 18 mins	1 hrs 3 mins	1 hrs 27 mins	1 hrs 33 mins	1 hrs 14 mins	
Access cost	£16.80	£1.00	£29.40	£14.95 per person	£16.00 per person	£14.50	£0.00	£67.20	£18.40 per person	£20.00 per person	Not travel
Choice	◉	○	○	○	○	○	○	○	○	○	○

Previous | Next Question | Undo All

4. Model specification and estimation

The SC data collected in this project was analysed with the help of discrete choice models belonging to the family of random utility models (cf. Train, 2003). They explain individual choices on the basis of the concept of utility maximisation; decision makers evaluate the various alternatives that are available to them and choose the one that provides them with the greatest utility (or smallest disutility). The utility of an alternative is a function of attributes of the alternative and characteristics of the decision maker. The main emphasis is on the sensitivities of the respondent to changes in the attributes, commonly referred to as tastes or marginal utilities.

The final specification used in our models used the following parameters:

Table 1: parameters in utility function

Parameter type	Attribute	Unit
marginal utility (continuous attribute)	access cost	£
marginal utility (continuous attribute)	access time	minutes
dummy parameter (0/1 attribute)	45 minute connection	0/1
dummy parameter (0/1 attribute)	60 minute connection	0/1
dummy parameter (0/1 attribute)	90 minute connection	0/1
dummy parameter (0/1 attribute)	120 minute connection	0/1
dummy parameter (0/1 attribute)	180 minute connection	0/1
marginal utility (continuous attribute)	air fare	£
marginal utility (continuous attribute)	early schedule delay (i.e. arrival earlier than preferred arrival time)	minutes
marginal utility (continuous attribute)	late schedule delay (i.e. arrival later than preferred arrival time)	minutes
dummy parameter (0/1 attribute)	Edinburgh departure (normalised to zero)	0/1
dummy parameter (0/1 attribute)	Glasgow departure	0/1
dummy parameter (0/1 attribute)	home airport departure	0/1
dummy parameter (0/1 attribute)	access by car (normalised to zero)	0/1
dummy parameter (0/1 attribute)	access by drop off (normalised to zero)	0/1
dummy parameter (0/1 attribute)	access by coach (normalised to zero)	0/1
dummy parameter (0/1 attribute)	access by convential rail (normalised to zero)	0/1
dummy parameter (0/1 attribute)	access by high speed rail (normalised to zero)	0/1
dummy parameter (0/1 attribute)	access by taxi (normalised to zero)	0/1
dummy parameter (0/1 attribute)	flying on legacy airline (normalised to zero)	0/1
dummy parameter (0/1 attribute)	flying on no frills airline	0/1
dummy parameter (0/1 attribute)	no travel	0/1

It is important to recognise that the degree of randomness in the choices (from an analyst's perspective) may differ between the two sets of five choices (given the additional rail alternative in game 2). With this in mind, we also estimated an additional scale parameter (*scale2*) for the second game. This scale parameter (which is normalised to 1 for game 1) is inversely proportional to the variance of the error

term. This means that an estimated value greater than 1 for *scale2* means lower response error and more deterministic choices (from the analyst's perspective) in the second set of five choices.
The sample used for estimation was too small for segmentation by purpose, but we allowed for continuous interactions with journey time and air fare. In particular (where used), for attribute *x*, we estimated $\beta(z_n/z)^{\lambda}\cdot z$. Here, we interact the sensitivity to attribute x with the socio-demographic variable *z* (e.g. income), which has a mean value of z in the sample population, and a value of z_n for respondent *n*. The additional parameter λ now gives the elasticity of the sensitivity β to changes in *z*.

We estimated the following interaction terms using this specification:

Table 2: Interaction parameters

Attribute	Elasticity in relation to
access cost	income
access time	total journey time
connections	total journey time
fare	income
early schedule delay	total journey time
late schedule delay	total journey time

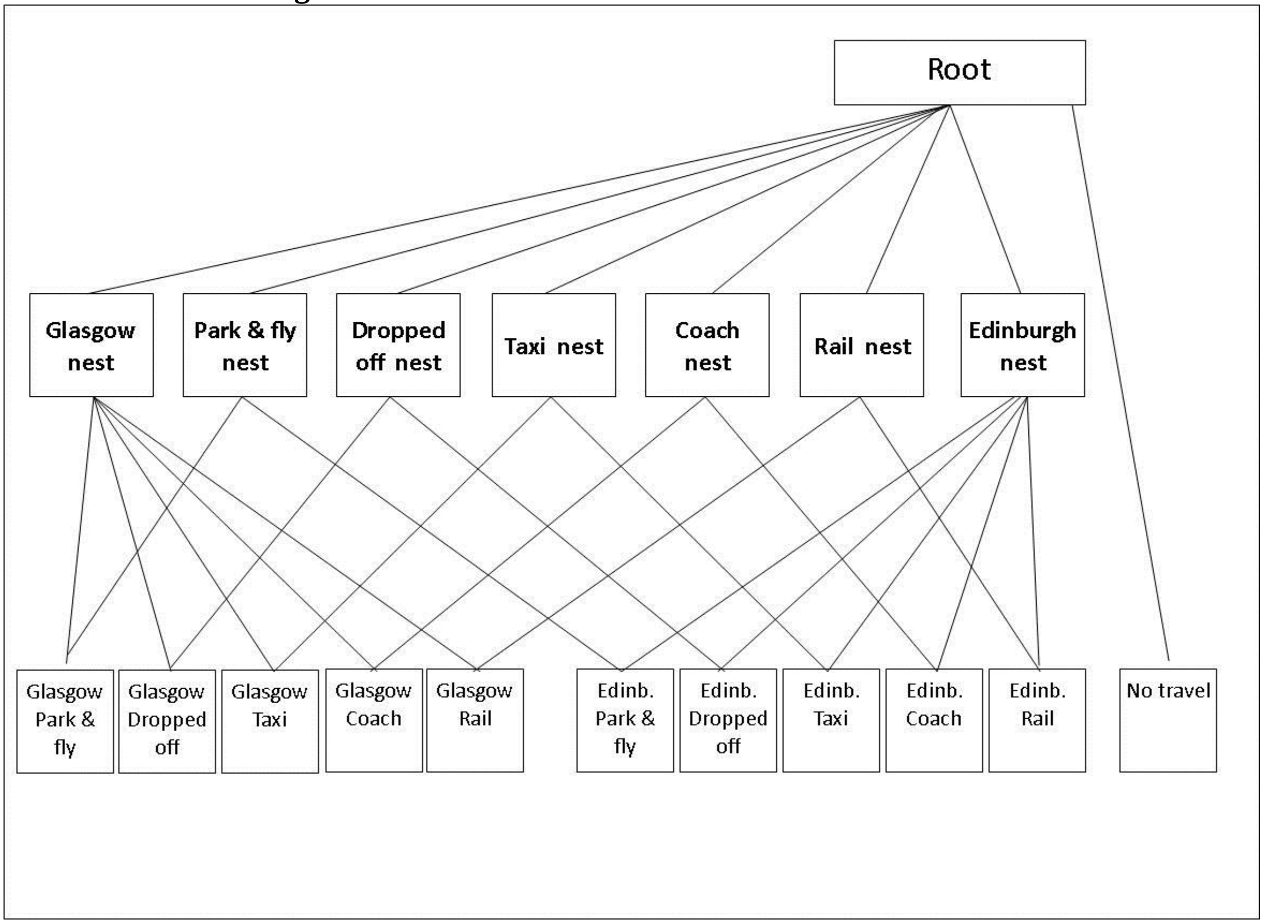
For each respondent in each choice task, there are two possible airports, each with up to five access modes, depending on personal availabilities, as well as whether the choice scenario is for game 1 or game 2. There is also a no-travel alternative. This thus leads to a choice between up to 9 different alternatives in game 1, and up to 11 different alternatives in game 2.

The model structure chosen for the present analysis is a Cross-Nested Logit (CNL) model (cf. Vovsha, 1997). This is based on the same justification as in Hess & Polak (2006b) and Hess et al. (2012), and the detailed arguments are not reproduced here.

The main point is that the choice process in the survey is two dimensional, with a respondent being asked to make a choice both along the airport dimension and along the access mode dimension. Here, we would expect heightened substitution between two alternatives sharing a given airport, but also between two options sharing an access mode. In other words, if a respondent's current airport-access mode combination becomes unavailable, he/she will be more likely to switch to another option that keeps one of the dimensions of choice constant, rather than changing both airport and access mode. We thus aim to allow for correlation along both dimensions of choice. In other words, we want to allow for heightened correlation between two options sharing the same airport, as well as heightened correlation between two options sharing the same access mode, but no correlation between options at different airports using different access mode.

For this purpose, each alternative is in these models specified as a pair of alternatives, made up of one airport and one access mode, with the exception of the *No Travel* option. The actual model structure is illustrated in Figure 3. In a CNL model, we avoid the restriction of making the nests (or groups) of alternatives mutually exclusive, meaning that an alternative can belong to multiple nests, leading to more flexible substitution patterns. In the present context, the CNL structure makes use of one nest for each airport and one nest for each access mode, i.e. 7 nests in total. Each alternative in this model is still made up of an airport and access mode pair, but now belongs to two nests, one airport nest and one access mode nest[4]. This allows for correlation between two alternatives sharing the same airport, and between two alternatives sharing the same access mode. The model allows simultaneously for the correlation along each of the two dimensions of choice, where additional parameters are estimated to capture this correlation.

Figure 3: Cross nested logit structure



[4] On a technical aside, the CNL specification works by allocating an alternative by different proportions into different nests, collapsing back to a NL model when all allocation parameters are equal to 1, i.e. an alternative belongs into one nest. In the present context, the allocation parameters were all fixed to a value of 1/2, meaning that an alternative belongs to one airport nest and one access mode nest. The estimation of actual values for the two non-zero allocation parameters for each alternative would have been very difficult due to the high number of parameters and would arguably not have provided any further benefits from an interpretation perspective. This follows the same approach as in Hess & Polak (2006b) and Hess et al. (2012).

5. Model results

Main estimation results

All model estimation work reported in this paper was carried out using BIOGEME (Bierlaire, 2005), where the standard errors were corrected to account for the repeated choice nature of the data used in the analysis by using the panel specification of the sandwich estimator (cf. Daly & Hess, 2010).

During the estimation work, we estimated Multinomial Logit, Nested Logit and Cross Nested Logit (CNL) models. In line with the above discussions, our expectation was that superior performance would be obtained by the CNL model (in comparison with MNL and NL), and this was the case. The model also yielded more reasonable willingness-to-pay (WTP) patterns. As a result, we will now focus solely on the outputs from this model.
The final estimation results for the CNL model are summarised in Table 1.

Table 1: CNL estimation results

Respondents	303
Observations	3030
Model parameters	31
Null Log-likelihood	-6961.607
Final log-likelihood	-5662.11
Ajdusted ρ2	0.182

Sensitivities to service characteristics

	est.	t-rat. (0)
access cost (£)	-0.0232	-5.85
access time (mins)	-0.00691	-3.65
connection of 45 minutes	-0.438	-3.32
connection of 60 minutes	-0.324	-4.09
connection of 90 minutes	-0.398	-4.71
connection of 2 hours	-0.415	-6.87
connection of 3 hours	-0.481	-5.13
fare (£)	-0.00154	-7.83
early schedule delay (mins)	-0.00043	-0.76
late schedule delay (mins)	-0.00052	-1.52

Airport constants

	est.	t-rat. (0)
Edinburgh	0	-
Glasgow	0.114	1.98
Home airport	0.221	3.55

Airline constants

	est.	t-rat. (0)
Legacy airline	0	-
No frills airline	0.13	2.89

Access mode constants

	est.	t-rat. (0)
Park and fly	0	-
Dropped off	-0.436	-3.09
Rail	-0.171	-1.55
High speed rail	0.0437	0.37
Coach	-1.3	-5.68
Taxi	-0.718	-4.3

No travel constant

	est.	t-rat. (0)
No travel	-2.97	-9.05

Elasticity parameters

	est.	t-rat. (0)
Income on access cost	-0.0345	-0.15
Flight time on access time	-0.517	-2.07
Flight time on connections	-0.511	-3.43
Income on flight fare	-0.427	-3.37
Flight time on early schedule delay	-0.293	-0.27
Flight time on late schedule delay	-0.6	-0.99

Scale parameter

	est.	t-rat. (0)
Scale for second game	1.26	15.19

Airport nesting parameters

	est.	t-rat. (1)
Edinburgh	1	-
Glasgow	0.6993	1.83

Access mode nesting parameters

	est.	t-rat. (1)
Park & fly	0.3534	1.2
Dropped off	0.0461	3.41
Taxi	0.4762	1.13
Coach	0.8696	0.16
Rail	1	-

We observe the expected negative and significant sensitivities to increases in access cost, access time, and air fare. We also observe a negative response to connecting flights. Here, longer connections are penalised more than connections of one hour or ninety minutes, but there is also a higher dislike of very short (i.e. 45 minutes) connections. The sensitivity to early and late schedule delay (i.e. shifts from the preferred departure time) is not significant at the usual levels of confidence. In terms of constants, we observe a slight preference for Glasgow over Edinburgh, with a higher preference for the *home* airport. For access modes, we see that all else being equal, *drive and park* (the base) has the highest utility, along with high speed rail. The lowest utility is obtained for *dropped off* and *taxi* (where these effects are net of cost and time). Surprisingly, the models show a very slight preference for *no frills* airlines. In terms of interaction effects, we see decreasing sensitivity to access time and connections on longer flights, along with decreasing fare sensitivity with higher income. The other interactions are not statistically significant, although they are all of the expected sign. Finally, we note that the scale parameter for the second game is greater than 1, indicating a somewhat reduced error variance for responses in game 2.

In terms of nesting parameters, an estimate less than 1 shows heightened correlation, while an estimate equal to 1 shows an absence of correlation. Here, we observe heightened correlation between flights at Glasgow airport, but not between flights at Edinburgh airport; this could suggest higher allegiance by passengers to Glasgow than to Edinburgh. For access modes, no correlation is observed between rail alternatives, but this is maybe not surprising in the context of a *new* mode. On the other hand, we see high correlation (and hence mode allegiance) for all other access modes, although this is lower for coach (higher nesting parameter meaning lower correlation).

Given the non-linear utility specification, willingness to pay (WTP) values vary as a function of income and journey time. WTP indicators for a range of 9 representative individuals with a 'short', 'medium' and long flight times of 60, 180 and 420 minutes respectively and 'low', 'medium' and 'high' annual incomes of £20,000, £40,000 and £80,000 respectively, are shown in Table 2. An illustration of the impact of flight duration and income on WTP for access time reductions is also given in Figure 4.

The WTP for access time reductions is given by the ratio between the access time and access cost coefficients. Here, we observe decreasing WTP measures with increasing flight duration, while the impact of income is negligible (and not statistically significant). The actual values are higher than value of time measures for example in a commuting context, but in line with values from other airline studies – such high values are to be expected given the greater financial penalty associated with missing a flight.

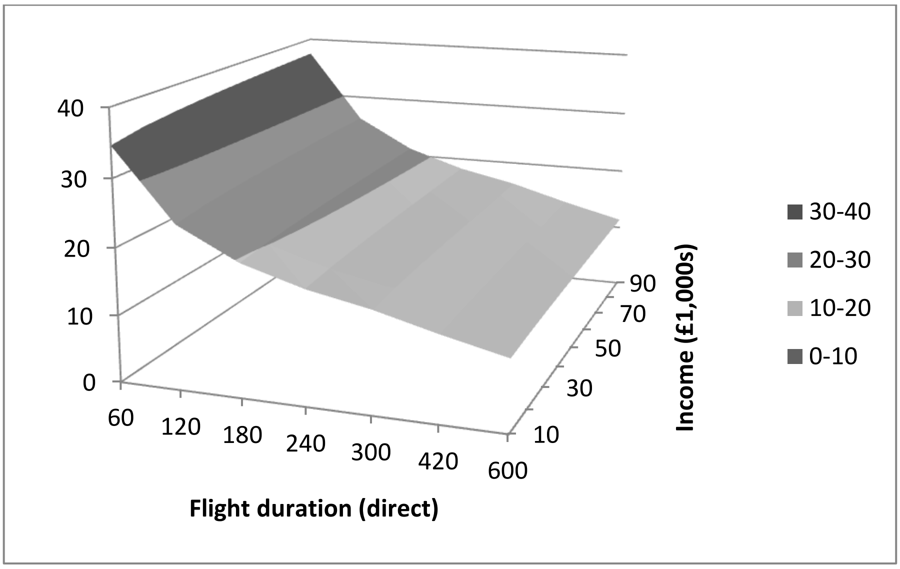
When looking at the WTP measures for avoiding early (SDE) or late schedule delay (SDL) as shown in Table 2, we need to take into account the high associated standard errors. Nevertheless, we observe a higher WTP for avoiding late schedule delay than for avoiding early schedule delay, with a strong associated income effect (as these are now calculated against air fare sensitivity), and a less strong impact of flight time.

Finally, the WTP measures for avoiding connecting flights are very high, especially for very short and long connections. We see a reduction in the WTP on longer flights, which is to be expected, while the WTP increases substantially with income. All in all, this shows that when faced with a choice between a direct and a connecting flight, travellers need substantial incentives to accept the indirect option.

Table 2: WTP indicators for range of representative individuals.

Flight time (direct, minutes)	Short 60	Medium 180	Long 420	Short 60	Medium 180	Long 420	Short 60	Medium 180	Long 420
Annual Income	**Low 20**	**Low 20**	**Low 20**	**Medium 40**	**Medium 40**	**Medium 40**	**High 80**	**High 80**	**High 80**
WTP for reducing access time (£/hr)	35.5	20.12	12.98	36.36	20.61	13.3	37.24	21.11	13.62
WTP for reducing SDE (£/hr)	17.42	12.63	9.85	23.43	16.98	13.25	31.5	22.83	17.81
WTP for reducing SDL (£/hr)	31.9	16.5	9.93	42.89	22.19	13.35	57.67	29.83	17.94
WTP for avoiding 45 minute connections	397.43	226.7	147.03	534.31	304.78	197.67	718.35	409.76	265.76
WTP for avoiding 60 minute connections	293.99	167.69	108.76	395.25	225.45	146.22	531.38	303.11	196.59
WTP for avoiding 90 minutes connections	361.13	205.99	133.6	485.52	276.95	179.62	652.75	372.34	241.49
WTP for avoiding 120 minutes connections	376.56	214.79	139.31	506.26	288.78	187.29	680.63	388.24	251.8
WTP for avoiding 180 minute connections	436.44	248.95	161.47	586.77	334.7	217.08	788.87	449.98	291.85

Figure 4: WTP for reducing access time as a function of income and flight time (£/hr)



A more accurate picture of the distribution of WTP measures in the sample can be obtained by computing the values for each individual in the sample, hence taking into account the sample distribution in terms of income and flight duration. The results from this calculation are shown in Table 3, once again showing very high WTP measures overall. While the level of heterogeneity is small for the WTP for reducing access time, it is far more substantial for other WTP measures, with a coefficient of variation around 4.

Table 3: Sample level WTP indicators

	WTP for access time (GBP/hr)	WTP for SDE (GBP/hr)	WTP for SDL (GBP/hr)	WTP for avoiding conn with 45 (GBP)	WTP for avoiding conn with 60 (GBP)	WTP for avoiding conn with 90 (GBP)	WTP for avoiding conn with 120 (GBP)	WTP for avoiding conn with 180 (GBP)
min	31.25	9.21	16.09	203.22	150.33	184.66	192.55	223.17
mean	33.62	23.42	40.90	516.46	382.04	469.30	489.34	567.17
sd	0.70	5.40	9.44	119.17	88.15	108.28	112.91	130.86
max	34.53	31.66	55.28	698.18	516.46	634.42	661.52	766.72

The main finding from the analysis so far is that travellers have a very strong aversion to connecting flights, especially in the case of short haul routes. The model estimates show a very high willingness by respondents to pay higher fares in return for direct flights. Similarly, it is possible to compute trade-offs between access times and connecting flights. Looking at the sample level distribution of these indicators, we obtain the results in Table 4. The resulting trade-offs show the amount of extra access time respondents are willing to incur in return for avoiding a connecting flight. Here, the values observed in Table 4 show that the aversion to connecting flights is so high that in a scenario where direct flights were only available at the *non-home* airport, the access time to this alternate airport would be sufficiently low to guarantee a high level of interconnecting passengers, independently of the existence of a direct rail link, and even when taking into account the higher baseline preference for the *home* airport. We again highlight that the sensitivity to very short connections (45 minutes) is higher than that to a 60 minute connection. Additionally, it is noticeable that while, for short connections, respondents would on average be willing to accept access journey increases that go beyond the amount of any connection time, this situation is reversed for very long connection; i.e. there does come a point where the per minute access time sensitivity goes beyond the per minute connection time sensitivity. Clearly, with the levels shown in Table 4, such a scenario would not arise in the context of travel to Glasgow or Edinburgh.

Table 4: Willingness to accept longer access time in return for avoiding connections (sample level)

	Willingness to accept longer access time in return for avoiding conn with 45 (mins)	Willingness to accept longer access time in return for avoiding conn with 60 (mins)	Willingness to accept longer access time in return for avoiding conn with 90 (mins)	Willingness to accept longer access time in return for avoiding conn with 120 (mins)	Willingness to accept longer access time in return for avoiding conn with 180 (mins)
min	51.49	38.09	46.79	48.79	56.54
mean	105.01	77.68	95.42	99.50	115.32
sd	48.70	36.03	44.26	46.15	53.48
max	215.16	159.16	195.51	203.86	236.29

6. Conclusions

The aim of this study was to conduct an analysis of air travel behaviour using stated choice data. Specifically, the main focus was on studying travellers' preferences in relation to connecting flights, and how they might react to a situation in which only connecting flights were offered from their *home* airport, while direct flights were offered from an alternative airport. The results highlight the strong aversion to connecting flights. In particular, we observe very high willingness to accept higher air fares in return for direct flights. Similarly, we observe a strong willingness to accept increased access time in return for a direct flight, sufficient to motivate travel to the alternate airport, even without the presence of a high speed rail option.

References

Ashford N, Bencheman M (1987) Passengers' choice of airport: an application of the multinomial logit model. *Transportation Research Record* 1147: 1-5

BAA (2009), BAA Market Research Travel Services Report, BAA, London.

Barrett, S.D., (2004), How do the demands for airport services differ between full-service carriers and low-cost carriers?, Journal of Air Transport Management 10 (2004) 33–39

Bierlaire, M., 2005. An introduction to BIOGEME Version 1.4. biogeme.ep.ch.

Bradley, M. A. (1998), Behavioural models of airport choice and air route choice, in J. de D. Ort´uzar, D. Hensher & S. R. Jara-Diaz, eds, 'Travel behaviour research: updating the state of play (IATBR 94)', Elsevier Oxford, pp. 141–159.

Civil Aviation Authority (2005) Passenger Survey Report: Survey of passengers at Aberdeen, Bournemouth, Durham Tees Valley, Edinburgh, Gatwick, Glasgow, Heathrow, Inverness, Leeds Bradford, Luton, Manchester, Newcastle, Prestwick & Stansted, CAA, London, http://www.caa.co.uk/docs/81/2005CAAPaxSurveyReport.pdf

Daly, A.J. and Hess, S. (2010), Simple Approaches for Random Utility Modelling with Panel Data, paper presented at the European Transport Conference, Glasgow, October 2010.

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

Drabas, T. and Wu, C. (2013), Modelling air carrier choices with a Segment Specific Cross Nested Logit Model, Journal of Air Transport Management, Volume 32, September 2013, Pages 8–16.

Furuichi, M. & Koppelman, F. S. (1994), "An analysis of air traveler's departure airport and destination choice behaviour", Transportation Research, vol. 28A, no. 3, pp. 187-195.

Gosling, G.D. (2008), Airport Ground Access Mode Choice Models, a synthesis of airport practice, Airport Cooperative Research Program synthesis 5, Transport Research Board, available via http://onlinepubs.trb.org/onlinepubs/acrp/acrp_syn_005.pdf

Harvey, G., 1987, Airport choice in a multiple airport region. Transportation Research Part A 21,439–449.

Hess, S., Ryley, T., Davison, L. & Adler, T. (2012), Improving the quality of demand forecasts through cross nested logit: a stated choice case study of airport, airline and access mode choice, Transportmetrica, in press (DOI: 10.1080/18128602.2011.577758).
Hess, S., Polak, J.W. (2005), Mixed Logit modelling of airport choice in multi-airport regions. Journal of Air Transport Management 11 (2), 59–68.
Hess, S. & Polak, J.W. (2006a), Airport, airline and access mode choice in the San Francisco Bay area, Papers in Regional Science, 85(4), pp. 543-567.
Hess, S. & Polak, J.W., (2006b), Exploring the potential for cross-nesting structures in airport-choice analysis: a case-study of the Greater London area, *Transportation Research Part E*, 42, pp. 63-81.
Innes,J.D.,Doucet,D.H.,(1990).Effects of access distance and level of service on airport choice. Journal of Transportation Engineering 116, 507–516.
Ishii, J., Jun, S., Van Dender, K., (2009). Air travel choices in multi-airport markets. Journal of Urban Economics 65 (2), 216–227.
Mason, K. (2001), "Marketing Low-Cost Airline Services to Business Travellers", *Journal of Air Transport Management*, 7, 103-109.
O'Connell, J.F., and Williams, G., (2005), Passengers' perceptions of low cost airlines and full service carriers: A case study involving Ryanair, Aer Lingus, Air Asia and Malaysia Airlines, Journal of Air Transport Management 11.
Pels, E., Nijkamp, P., and Rietveld, P. (2001), Airport and airline choice in a multi-airport region: an empirical analysis for the San Francisco bay area. *Regional Studies.* 35, pp.1-9
Pels, E., Nijkamp, P., Rietveld, P. (2003),. Access to and competition between airports: a case study for the San Francisco Bay area, Transportation Research A 37, 71–83.
SKM (2003), Rail Links to Glasgow and Edinburgh Airports, Final Report, http://www.earlproject.com/new_downloads/feasibility/SKMFinalReport.pdf
Skinner, R. E. Jr. (1976) Airport choice: an empirical study *Transportation Engineering Journal*, 10, pp. 871-883
Thompson A, Caves R (1993) The projected market share for a new small airport in the south of England. *Regional Studies* 27(2): 137-147
Train, K.E. (2003), Discrete choice methods with simulation, Cambridge University Press, Cambridge, MA.
Whitaker, B., Terzis, G., Soong, E., Yeh, W., (2005), Stated Preference as a Tool to Evaluate Airline Passenger Preferences and Priorities, Transportation Research Record: Journal of the Transportation Research Board, 1915, pp 55-61.
Windle, R. and Dresner, M. (1995), Airport choice in multi-airport regions *Journal of Transportation Engineering*, 121, pp. 332-337
Vovsha, P. (1997), 'Application of a Cross-Nested Logit model to mode choice in Tel Aviv, Israel, Metropolitan Area', Transportation Research Record 1607, 6–15.