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Treatment of reference alternatives in SC surveys for air travel choice behaviour

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Abstract

Stated Choice (SC) surveys are increasingly being used instead of Revealed Preference (RP) surveys for the study of air travel choice behaviour. In many cases, the choice situations presented in these SC surveys are constructed around an observed trip, where this is often included as one of the alternatives. Classically, these RP alternatives have been treated in the same way as the SC alternatives. The applications presented in this paper show that this potentially leads to biased results, and that it is important to recognise the differences in the nature of the two types of alternative. Additionally, the paper discusses issues caused by respondents who consistently prefer the RP alternative over the SC alternatives, a common phenomenon in such SC data.

1 Introduction

An increasing number of studies of air travel choice behaviour make use of Stated Choice (SC) surveys, where previous studies had generally relied on the use of Revealed Preference (RP) data. Some examples of such SC studies are given by Bradley (1998), Proussaloglou and Koppelman (1999), Algers and Beser (2001), Adler et al. (2005), Hess et al. (2007a) and Hess (2007). While posing certain issues in terms of response quality (cf. Louviere et al., 2000), studies using SC data have the advantage of being based on accurate records of all information presented to respondents, which is not generally the case with RP data. As such, it should come as no surprise that SC studies are generally more successful in retrieving significant effects for crucial factors such as air fares and frequent flier benefits.

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Independently of the exact context, SC surveys regularly include a reference alternative that either corresponds to an observed/reported trip for the current respondent, or is very similar to such an observed/reported trip. In the context of air travel choice behaviour studies, this is for example the case with the data collected by Resource Systems Group in the US (Resource Systems Group Inc., 2003) which is used in the present study. Here, the reference alternative corresponds to the current observed trip, and the attributes of this RP alternative are kept fixed across choice situations.

An important issue arises in the use of such data. Indeed, it is not clear how the nature of the data, in terms of the inclusion of a reference alternative, affects choice behaviour. In this paper, we make two departures from the standard modelling approach to attempt to test for such effects. Firstly, we test the assumption whether the attributes for the reference alternative are treated differently from those of the hypothetical SC alternatives. Secondly, we investigate the existence of reference dependency, which would mean that respondents evaluate the attributes of the SC alternative relatively to those of the RP alternative, with the possibility of asymmetrical preference formation. This issue was recently discussed in a non-aviation context by Hess et al. (2007b). A separate issue, namely the presence of non-traders in the data, is discussed in an extension of the analysis.

The results from this study should be of crucial interest to choice modellers in the area of air travel behaviour research given the increasing reliance on SC surveys framed around observed trips. Furthermore, airlines are clearly very interested in knowing travellers' valuations of certain product attributes, and especially the evidence in relation to asymmetrical preference formation is important in the context of knowing how customers may react differently to improvements or otherwise in the quality of service attributes as well as cost.

Before proceeding, it should be noted that the issues dealt with in this paper are different from similar discussions in the case of studies combining RP and SC data in a joint analysis (see for example Ben-Akiva and Morikawa 1990). The difference lies in the fact that, with the present data, the RP alternative is included as an alternative in the SC survey.

The remainder of this paper is organised as follows. The next section briefly presents the data used in the analysis. This is followed in Section 3 by a discussion of the methodology used in the analysis. Results are presented in Section 4, and the paper closes with the conclusions in Section 5.

2 Data

The analysis makes use of SC data collected via the Internet by Resource Systems Group in the US (Resource Systems Group Inc., 2003). Specifically, we make use of the 2005 version of the survey, with a sample of $4,256$ observations collected from 532 travellers. For a previous application using these data, see Hess (2007).

Prior to the SC survey, information was collected on a traveller's most recent air trip, along with detailed socio-demographic information. Each traveller is then faced with 8 binomial choices, where in each case, a choice is offered between the current, or RP alternative, and an alternative option, the SC alternative. While the attributes of the RP alternative remain fixed across the 8 choice sets, those of the SC alternative are varied according to an experimental design. The airports and airlines used for the SC alternatives are selected on the basis of information gathered from respondents in terms of a ranking of the airports and airlines available to them.

Aside from the airport and airline names, from which access times can be inferred, the attributes used to describe the alternatives in the SC survey include flight time, the number of connections, the air fare, the arrival time (used to calculate schedule delays), the aircraft type, and the on-time performance of the various services. Access cost was not included (in the absence of an actual specification of the mode choice dimension), and no choice is given between different travel classes; this can be regarded as an upper-level choice, taken before the actual air journey choices. An example of one choice situation is shown in Figure 1.

3 Methodology

This section describes the specification of the utility function used in the discrete choice models estimated in this analysis[1]. We will first look at the base specification, before proceeding with a discussion of the two adapted specifications used in this analysis. Finally, we look at the issue of the repeated choice nature of the data.

3.1 Base specification

The base specification used in this analysis is slightly different from that used in the earlier work by Hess (2007) in that a common coefficient is used for all levels

[1] For a detailed discussion of discrete choice models, see Train (2003).

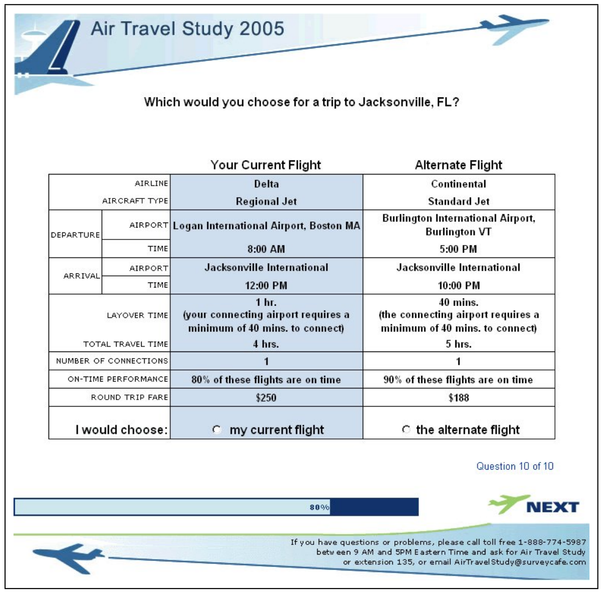

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Figure 1: Example screen-shot for SC survey

of memberships in frequent flier programmes, and that no distinction is made between flights with a single connection and flights with two connections[2].

All attributes were specified to enter the utility function in a linear fashion, such that the observed utility for the RP alternative is given by:

$$\begin{aligned} V_{\text{RP}} = {} & \beta_{\text{current}} \\ & + \beta_{\text{access time}} \cdot \text{access time}_{\text{RP}} \\ & + \beta_{\text{air fare}} \cdot \text{air fare}_{\text{RP}} \\ & + \beta_{\text{flight time}} \cdot \text{flight time}_{\text{RP}} \\ & + \beta_{\text{OTP}} \cdot \text{OTP}_{\text{RP}} \\ & + \beta_{\text{connecting}} \cdot \delta_{\text{connecting,RP}} \\ & + \beta_{\text{FF}} \cdot \delta_{\text{FF,RP}} \\ & + \beta_{\text{closest airport}} \cdot \delta_{\text{closest airport,RP}} \end{aligned} \tag{1}$$

where all β parameters are to be estimated from the data. The meaning of the first four entries in equation (1) should be clear. The fifth parameter, β_{OTP}, relates to the on-time performance (in percentage points) of an alternative. For the RP alternative, two levels were used for this attribute, depending on whether the flight was on time (100%) or not (0%), while, for the SC alternative, five levels

[2]Very few alternatives with two connections were included in the survey.

between 50% and 90% were used. The dummy variable $\delta_{\text{connecting,RP}}$ is set to 1 for flights with at least one connection, while $\delta_{\text{FF,RP}}$ is set to 1 if the respondent holds some form of frequent flier (FF) membership with the current airline. Finally, $\delta_{\text{closest airport,RP}}$ is set to 1 if the airport used in the RP alternative is the airport closest to the respondent's home. The utility function for the SC alternative is specified in a very similar fashion, with the absence of the RP constant (β_{current}), and with the SC as opposed to RP values for the various attributes and dummy variables.

3.2 Differential response to RP and SC attribute values

The specification used in this model is a simple adaptation from that used in Equation 1, in that all coefficients are alternative-specific. As such, we have:

$$\begin{aligned} V_{\text{RP}} = \beta_{\text{current}} & \\ & + \beta_{\text{access time,RP}} \cdot \text{access time}_{\text{RP}} \\ & + \beta_{\text{air fare,RP}} \cdot \text{air fare}_{\text{RP}} \\ & + \beta_{\text{flight time,RP}} \cdot \text{flight time}_{\text{RP}} \\ & + \beta_{\text{OTP,RP}} \cdot \text{OTP}_{\text{RP}} \\ & + \beta_{\text{connecting,RP}} \cdot \delta_{\text{connecting,RP}} \\ & + \beta_{\text{FF,RP}} \cdot \delta_{\text{FF,RP}} \\ & + \beta_{\text{closest airport,RP}} \cdot \delta_{\text{closest airport,RP}} \end{aligned} \tag{2}$$

The corresponding specification for the SC alternative lacks the constant, with all remaining attributes taking on the SC values, and interacting with SC-specific taste coefficients.

This adapted specification not only allows for differences in how respondent react to RP and SC attribute values, but also accounts for the differences in the on-time performance attributes for the two alternatives. Indeed, for the RP alternative, a distinction is simply made between flights arriving on time and flights that are delayed, while, for the SC alternatives, a probability of on-time arrival is presented.

3.3 Asymmetrical preference formation

The asymmetrical specification is again a simple adaptation of the specification from Equation 1. The utility of an alternative is specified relative to the reference alternative, i.e. the RP alternative, while additionally, we allow for differential response to increases and decreases (gains and losses) compared to the RP values. From this, we get:

$$V_{\text{RP}} = \beta_{\text{current}}, \tag{3}$$

and

$$
\begin{aligned}
V_{\mathrm{SC}} = {} & \beta^{+}_{\text{access time}} \cdot \delta_{\text{access time inc}} \cdot (\text{access time}_{\mathrm{SC}} - \text{access time}_{\mathrm{RP}}) \\
& + \beta^{-}_{\text{access time}} \cdot \delta_{\text{access time dec}} \cdot (\text{access time}_{\mathrm{RP}} - \text{access time}_{\mathrm{SC}}) \\
& + \beta^{+}_{\text{air fare}} \cdot \delta_{\text{air fare inc}} \cdot (\text{air fare}_{\mathrm{SC}} - \text{air fare}_{\mathrm{RP}}) \\
& + \beta^{-}_{\text{air fare}} \cdot \delta_{\text{air fare dec}} \cdot (\text{air fare}_{\mathrm{RP}} - \text{air fare}_{\mathrm{SC}}) \\
& + \beta^{+}_{\text{flight time}} \cdot \delta_{\text{flight time inc}} \cdot (\text{flight time}_{\mathrm{SC}} - \text{flight time}_{\mathrm{RP}}) \\
& + \beta^{-}_{\text{flight time}} \cdot \delta_{\text{flight time dec}} \cdot (\text{flight time}_{\mathrm{RP}} - \text{flight time}_{\mathrm{SC}}) \\
& + \beta^{+}_{\mathrm{OTP}} \cdot \delta_{\text{OTP inc}} \cdot (\mathrm{OTP}_{\mathrm{SC}} - \mathrm{OTP}_{\mathrm{RP}}) \\
& + \beta^{-}_{\mathrm{OTP}} \cdot \delta_{\text{OTP dec}} \cdot (\mathrm{OTP}_{\mathrm{RP}} - \mathrm{OTP}_{\mathrm{SC}}) \\
& + \beta^{+}_{\text{connections}} \cdot \delta_{\text{connections inc}} \cdot (\text{connections}_{\mathrm{SC}} - \text{connections}_{\mathrm{RP}}) \\
& + \beta^{-}_{\text{connections}} \cdot \delta_{\text{connections dec}} \cdot (\text{connections}_{\mathrm{RP}} - \text{connections}_{\mathrm{SC}}) \\
& + \beta^{+}_{\mathrm{FF}} \cdot \delta_{\text{FF inc}} \cdot (\mathrm{FF}_{\mathrm{SC}} - \mathrm{FF}_{\mathrm{RP}}) \\
& + \beta^{-}_{\mathrm{FF}} \cdot \delta_{\text{FF dec}} \cdot (\mathrm{FF}_{\mathrm{RP}} - \mathrm{FF}_{\mathrm{SC}}) \\
& + \beta^{+}_{\text{closest airport}} \cdot \delta_{\text{closest airport inc}} \cdot (\delta_{\text{closest airport,SC}} - \delta_{\text{closest airport,RP}}) \\
& + \beta^{-}_{\text{closest airport}} \cdot \delta_{\text{closest airport dec}} \cdot (\delta_{\text{closest airport,RP}} - \delta_{\text{closest airport,SC}})\,. \qquad (4)
\end{aligned}
$$

Here, the coefficients in the utility function for the SC alternative interact with the difference between the attribute values for the SC and RP alternatives. Separate coefficients are used for increases and decreases relative to the attribute value for the RP alternative, with $\beta^{+}_{\text{access time}}$ and $\beta^{-}_{\text{access time}}$ for example giving the coefficients for increases and decreases respectively in the access time attribute. The additional dummy term $\delta_{\text{access time inc}}$ is set to 1 only when the access time is longer for the SC alternative than for the SC alternative, with the same applying for $\delta_{\text{access time dec}}$ in the case of decreases relative to the RP alternative. The assumption of a symmetrical response can be tested by looking at the significance of the difference between coefficients for increases and decreases, say the difference between $\beta^{+}_{\text{access time}}$ and $\beta^{-}_{\text{access time}}$ in the case of access time.

Another difference however arises compared to the base approach. While a common factor was used for all levels of connections and all levels of frequent flier membership in Equation 1, a different approach is used here. As such, the difference is taken between the actual number of connections, and also between the tiers in the frequent flier programmes[3]. This multiplicative approach makes the assumption of linearity in the sensitivities[4], and no evidence was found to suggest that this assumption is not justified.

[3]Four tiers are used; no membership, standard membership, elite membership and elite plus membership.

[4]I.e. an increase from one connection to two connections carries the same penalty as a change from a direct flight to a flight with a single connection.

3.4 Treatment of repeated choice nature of data

For each of the specifications above, additional error components were included to account for the repeated choice nature of the data. The resulting models were estimated using simulation, with the simulation (approximation to integration) carried out at the level of individual respondents rather than individual choice situations.

With $V_{\mathrm{n,t,i}}$ giving the observed utility for alternative i in choice situation t for respondent n, we now have:

$$\begin{aligned} U_{\mathrm{n,t,RP}} &= V_{\mathrm{n,t,RP}} + \varepsilon_{\mathrm{n,t,RP}} + \varphi\,\xi_{\mathrm{n,RP}} \\ U_{\mathrm{n,t,SC}} &= V_{\mathrm{n,t,SC}} + \varepsilon_{\mathrm{n,t,SC}} + \varphi\,\xi_{\mathrm{n,SC}}, \end{aligned} \tag{5}$$

where $\varepsilon_{\mathrm{n,t,RP}}$ and $\varepsilon_{\mathrm{n,t,SC}}$ are the usual type I extreme value terms, distributed identically and independently over alternatives and observations. The two additional terms $\xi_{\mathrm{n,RP}}$ and $\xi_{\mathrm{n,SC}}$ are normally distributed random variables with a mean of zero and a standard deviation of 1, distributed independently across alternatives and individuals, but not across observations for the same individual. In conjunction with the multiplication by φ, this specification allows for an individual-specific effect that is shared across alternatives. The inclusion of this term can in general be expected to lead to an upwards correction of the standard errors (cf. Ortúzar et al., 2000; Ortúzar and Willumsen, 2001).

4 Results

This section presents the results from the various stages of the analysis. We first look a the results for the base model in Section 4.1. This is followed by a discussion of the results for the model allowing for a differential response to RP and SC attribute values in Section 4.2 and the model allowing for asymmetrical preference formation in Section 4.3. Finally, Section 4.4 discusses the problems caused by non-traders. All models were estimated in BIOGEME (cf. Bierlaire, 2005) and included the additional error components discussed in Section 3.4. The simulation-based estimation was carried out using 500 Halton draws (cf. Halton, 1960). Finally, with the context of the present analysis being mainly methodological rather than practical, no distinction is made between separate purpose segments, and not socio-demographic interactions were tested.

4.1 Base model

The estimation results for the base model are shown in Table 1. All seven marginal utility coefficients are of the expected sign and significantly different from zero at high levels of confidence. The results indicate that increases in air fare, flight time and access time have a negative effect on utility, while increases in on-time performance have a positive effect. Respondents also have a preference for direct flights, flights on an airline where they receive frequent flier benefits, and flights from the airport closest to their ground-level origin. The positive estimate for the constant associated with the RP alternative indicates that, all else being equal, respondents have a strong preference for their current trip, showing a high level of inertia. The standard deviation of the error components is significantly different from zero, suggesting the presence of an individual-specific effect.

Table 1: Estimation results for base model

Respondents	532
Observations	4,256
LL	-1,522.76
par.	9
adj. ρ^2	0.4808

	est.	asy. t-rat.
β_{current}	1.0902	5.67
$\beta_{\text{access time}}$	-0.0069	-6.14
$\beta_{\text{air fare}}$	-0.0165	-8.66
$\beta_{\text{flight time}}$	-0.0050	-6.08
β_{OTP}	0.0109	3.95
β_{FF}	0.3520	2.62
$\beta_{\text{closest airport}}$	0.5705	5.05
$\beta_{\text{connecting}}$	-0.7507	-5.18
φ	1.0932	7.16

Willingness to pay for improvements	
access time reductions (\$/hour)	25.06
flight time reductions (\$/hour)	18.13
on time arrival (\$)	66.06
FF benefits (\$)	21.38
departure from closest airport (\$)	34.65
direct flight (\$)	45.60

The implied willingness to pay indicators show that the valuation of access time reductions is almost 40% larger than the valuation of flight time reductions. The results also show that frequent flier benefits are valued almost as highly as a reduction in access time by one hour, with the valuation of direct flights being even higher.

4.2 Model with differential response to RP and SC attribute values

The estimation results for the model allowing for a differential response to RP and SC attribute values are summarised in Table 2. The base model in Section 4.1 is a simplified version of the present model, such that a likelihood-ratio test can be used in the comparison of the two models. We obtain an improvement in log-likelihood (LL) by 12.52 units, at the cost of 7 additional parameters, giving us a test value of 25.05, with a χ^2_7 critical value of 14.07, such that this improvement is indeed statistically significant.

The estimation results present the coefficient values from the utility functions of the two alternatives, along with t-ratios of the differences between RP and SC coefficients.

Table 2: Estimation results for model allowing for differential response to RP and SC attribute values

Respondents	532
Observations	4,256
LL	-1,510.24
par.	16
adj ρ^2	0.4826

	RP alternative		SC alternative		
	est.	asy. t-rat.	est.	asy. t-rat.	t-rat (diff)
β_{current}	1.2018	2.23	-	-	-
$\beta_{\text{access time}}$	-0.0107	-4.08	-0.0064	-5.49	1.72
$\beta_{\text{air fare}}$	-0.0156	-8.29	-0.0170	-8.89	1.59
$\beta_{\text{flight time}}$	-0.0044	-4.67	-0.0056	-5.97	1.40
β_{OTP}	0.0084	2.73	0.0136	3.57	1.10
β_{FF}	0.4468	2.50	0.3197	2.25	0.72
$\beta_{\text{closest airport}}$	0.3321	1.85	0.6663	4.97	1.57
$\beta_{\text{connecting}}$	-0.9144	-4.36	-0.6778	-3.85	0.95
φ	1.0435	7.70	1.0435	7.70	-

Willingness to pay for improvements	RP alternative	SC alternative
access time reductions ($/hour)	41.19	22.40
flight time reductions ($/hour)	16.83	19.81
on time arrival ($)	53.80	79.86
FF benefits ($)	28.62	18.76
departure from closest airport ($)	21.27†	39.10
direct flight ($)	58.57	39.78

† calculation involves parameter significant only at the 93% level of confidence.

Here, we can observe that for none of the attributes, the difference in the sensitivities for the SC and RP alternatives is significant at the usual 95% level. However, levels of 91%, 89% and 88% are obtained in the case of $\beta_{\text{access time}}$, $\beta_{\text{air fare}}$ and $\beta_{\text{closest airport}}$, with 84% in the case of $\beta_{\text{flight time}}$. For the remaining three coefficients, the significance levels for differences are lower, at 73% for β_{OTP}, 53% for β_{FF} and 66% for $\beta_{\text{connecting}}$.

In terms of actual differences between the RP and SC alternatives, we observe that the sensitivity to access time changes is 68% higher for the RP alternative. With the air fare coefficient being 10% higher for the SC alternative, this leads to a much higher monetary valuation of travel time savings on the access journey for the RP. On the other hand, the degree by which flight time increases are valued more negatively for the SC alternative overturns the higher air fare sensitivity, leading to a higher monetary valuation of flight time reductions for the SC alternative. Major differences also arise for

β_{OTP}, β_{FF} and $\beta_{\text{connecting}}$, but the significance levels for these differences are too low to make any inferences. Finally, although the difference is only significant at the 88% level, the sensitivity towards increases in the on-time performance is twice as large for the SC alternative as for the RP alternative. Here, the different range for the levels for the attribute in the two alternatives at least partly explains these differences.

4.3 Model with asymmetrical response formation

The estimation results for the model allowing for asymmetrical preference formation are summarised in Table 3. Separate coefficients were estimated for increases and decreases relative to the RP alternative for the seven explanatory attributes. In each case, asymptotic t-ratios for the differences between the coefficients for increases and decreases were calculated, taking into account the differences in sign between coefficients.

Given the different treatment used for connections and frequent flier benefits (cf. Section 3), likelihood-ratio tests cannot be used to compare the model to those presented in Section 4.1 and Section 4.2. For this reason, preference is given to the adjusted ρ^2 measure, which suggests that the performance offered by the asymmetrical model is superior to that offered by the base model and the model allowing for a differential response to RP and SC attributes.

All coefficients are of the expected sign, with increases in desirable attributes being valued positively, and decreases negatively, with the converse applying in the case of undesirable attributes. However, three of the coefficients, namely $\beta^{-}_{\text{access time}}$, β^{+}_{OTP} and β^{+}_{FF} are not significantly different from zero at any reasonable level of confidence. This is a direct result of the design of the survey, where increases in the tier of FF membership and on-time performance were presented relatively rarely, as were reductions in access time. The base model especially is unable to account for this and the parameter estimates from that model are potentially biased as a result.

While the low significance levels of some of the parameters need to be taken into account, the results give an indication that losses are valued more negatively than gains are positively, i.e. the coefficients associated with an amelioration are not as large as those associated with a reduction in attractiveness. The only exception to this arises in the case of $\beta_{\text{closest airport}}$. The asymmetry is especially noticeable for changes in air fare, where the difference, which attains a high level of statistical significance, is of the order to 2 : 1. In real terms, this would mean that airlines could expect much larger drops in passenger numbers following increases in air fares than increases in passenger numbers following corresponding drops in air fares.

An important difference arises between symmetrical and asymmetrical models in the calculation of trade-offs. With coefficients associated with increases as well as reductions in attribute values, we can now calculate separate indicators for the willingness to pay for improvements in an attribute, and the willingness to accept a less desirable attribute value in return for a lower air fare. The differences between these two ratios give an indication of the asymmetries in preference formation. As an example, we can see that a much bigger monetary incentive is required to accept an increase in the flight time by one hour than the corresponding willingness to pay for a reduction in this flight time by one hour. The latter is lower than the symmetrical trade-off produced in the two

Table 3: Estimation results for model allowing for asymmetrical preference formation

Respondents	532
Observations	4,256
LL	-1,498.8
par.	16
adj ρ^2	0.4865

	decreases		increases		
	est.	asy. t-rat.	est.	asy. t-rat.	t-rat (diff)
β_{current}	0.3978	2.04	-	-	-
$\beta_{\text{access time}}$	0.0023	0.89	-0.0078	-5.81	1.78
$\beta_{\text{air fare}}$	0.0127	7.46	-0.0263	-5.20	2.75
$\beta_{\text{flight time}}$	0.0046	2.88	-0.0053	-5.73	0.39
β_{OTP}	-0.0151	-3.87	0.0058	1.32	1.38
β_{FF}	-0.3982	-3.25	0.0689	0.29	1.20
$\beta_{\text{closest airport}}$	-0.4706	-3.10	0.7661	3.49	1.02
$\beta_{\text{connecting}}$	0.6211	3.52	-0.6666	-3.92	0.19
φ	1.0050	8.18	1.0050	8.18	-

Willingness to pay for improvements	
access time reductions ($/hour)	5.20†
flight time reductions ($/hour)	10.39
on time arrival ($)	22.19†
gaining tier of FF benefits ($)	2.62†
moving to closest airport ($)	29.10
reduced number of connections ($)	23.59

Drop in fare required to accept poorer conditions	
access time increases ($/hour)	-36.96
flight time increases ($/hour)	-24.99
late arrival ($)	-119.54
drop in tier of FF benefits ($)	-31.42
moving away from closest airport ($)	-37.14
increased number of connections ($)	-52.60

† calculation involves parameters not significant at the 95% level of confidence.

models in Section 4.1 and Section 4.2, while the former is significantly higher. This gives an indication of the risk of biased results in symmetrical models. The models also suggest that the penalty resulting from a drop in on-time performance from 100% to 0% is equivalent to the benefit of a reduction in air fare by $120.

4.4 Non-traders

A common problem with SC data is the potential presence of non-traders. These are respondents who, across the various choice situations they are faced with, do not engage in trading-off between attributes. As such, they might for example always be observed to choose the fastest alternative, or the cheapest alternative. One of the reasons for this phenomenon is that the variations in attributes presented to respondents are not extreme enough to encourage a shift in their behaviour. As an illustration, a respondent with a very high value of time will eventually choose the slower and cheaper alternative, at a point when the savings in travel time for the faster alternative, relative to the additional travel cost, exceed his/her valuation of travel time savings. If no sufficiently expensive alternative is ever presented, then the respondent will continue to choose the faster but more expensive alternative. Another reason for the presence of non-traders is the way SC surveys present the data, meaning that some respondents might for example always choose the first alternative (left to right reading). Finally, in cases where one of the alternatives presented in the survey corresponds to a current trip, inertia could lead a respondent to always give preference to the current trip.

With the data used in this analysis, the last of the above reasons applies. Out of the 532 respondents, 118 respondents always choose their current alternative (over the various SC choice situations), while 3 respondents always reject their current alternative in favour of the SC alternative. This is an illustration of the fact that, for a large share of respondents, the current trip is so close to their *optimal* trip that none of the SC alternatives presented can encourage switching away from the status quo.

The presence of non-traders in SC data potentially has a significant impact on the model estimates. As an example, respondent who always choose the more expensive alternative will bias the cost coefficients downwards in the case where the model is unable to explain this behaviour in some other way. To attempt to quantify the impacts of non-traders in the present data, the three models estimated thus far were reestimated on the reduced sample of 411 respondents, with results presented in Table 4, Table 5 and 6.

The first observation that can be made is that, for each of the three model structures, the exclusion of the non-traders leads to a drop in the adjusted ρ^2 measure by over 15%. This suggests that in a dataset that includes the non-traders, the models are more easily able to reproduce the observed choices, which is not altogether surprising. As in the case of the models including the non-trading part of the sample, the asymmetrical model offers the best performance, ahead of the model with a differential treatment of RP and SC attribute values, and the base model.

The first observation that can be made when comparing the models estimated on the trading subsample is the much lower relative value for the constant for the RP alternative. In fact, other than in the base model, the constant is no longer significantly different from zero. This suggests that, in the first three models, this constant to a large degree captured the inertia of the non-traders.

We now look in more detail at the estimation results of the three models estimated on the data collected from those who choose either RP and SC alternatives at least once over their 8 choice situations.

For the base model, all coefficients remain statistically significant and of the expected

Table 4: Estimation results for base model after excluding non-traders

Respondents	411
Observations	3,288
LL	-1,361.49
par.	9
adj ρ^2	0.3987

	est.	asy. t-rat.
β_{current}	0.4980	6.09
$\beta_{\text{access time}}$	-0.0064	-5.94
$\beta_{\text{air fare}}$	-0.0151	-8.39
$\beta_{\text{flight time}}$	-0.0043	-6.02
β_{OTP}	0.0088	4.55
β_{FF}	0.3586	2.93
$\beta_{\text{closest airport}}$	0.4377	4.09
$\beta_{\text{connecting}}$	-0.6117	-4.76
φ	0.6071	6.35

Willingness to pay for improvements	
access time reductions ($/hour)	25.61
flight time reductions ($/hour)	17.07
on time arrival ($)	58.36
FF benefits ($)	23.76
departure from closest airport ($)	29.00
direct flight ($)	40.53

sign. The valuations of travel time savings remain largely unaffected when removing the non-traders from the sample. The change in the valuation of FF benefits is also rather small, with an increase by $2. However, for the remaining three trade-offs, we observe some more significant changes. As such, the willingness to pay for an on-time arrival is reduced by $8, while the willingness to pay a premium for flying from the closest airport also drops by $5, as does the willingness to pay for a direct flight. At least for the latter two of these trade-offs, these differences can partly be explained directly from the data. Indeed, for non-traders, the RP airport is the airport closest to their ground-level origin in 83% of cases, while this drops to 71% in the case of traders. Similarly, only 13% of non-traders chose a connecting flight for their current trip, while this increases to 41% in the case of traders. From this, it should come as no surprise that the model that includes non-traders assigns a higher sensitivity to these two attributes. It is open to discussion whether this should be seen as a bias in the result, or as being representative of the sample at hand.

Moving on to the two more advanced models, all coefficients are again of the expected sign, but some issues arise with parameter significance, where these are similar to those

Table 5: Estimation results for model allowing for differential response to RP and SC attribute values after excluding non-traders

Respondents	411
Observations	3,288
LL	-1,336.77
par.	16
adj. ρ^2	0.4064

	RP alternative		SC alternative		
	est.	asy. t-rat.	est.	asy. t-rat.	t-rat (diff)
β_{current}	0.2972	0.66	-	-	-
$\beta_{\text{access time}}$	-0.0069	-3.40	-0.0063	-5.74	-0.32
$\beta_{\text{air fare}}$	-0.0141	-8.13	-0.0159	-8.87	1.80
$\beta_{\text{flight time}}$	-0.0037	-4.44	-0.0043	-5.15	0.73
β_{OTP}	0.0064	3.19	0.0123	3.26	-1.43
β_{FF}	0.5005	3.26	0.2872	2.15	1.40
$\beta_{\text{closest airport}}$	0.1834	1.21	0.5677	4.46	-2.07
$\beta_{\text{connecting}}$	-0.4399	-2.49	-0.8018	-4.94	1.63
φ	0.5520	6.13	0.5520	6.13	-

Willingness to pay for improvements	RP alternative	SC alternative
access time reductions (\$/hour)	29.41	23.81
flight time reductions (\$/hour)	15.64	16.24
on time arrival (\$)	45.51	77.69
FF benefits (\$)	35.43	18.09
departure from closest airport (\$)	12.98†	35.75
direct flight (\$)	31.13	50.49

† calculation involves parameter significant only at the 77% level of confidence.

already observed in the models that included the non-trading section of the sample. The more interesting differences arise when looking at the implied valuations. Here, we can observe some marked differences to the models that include the non-traders. As an example, when comparing the results in Table 2 and Table 5, we can see that the valuations for RP and SC attributes get closer, with the exception of the valuation of direct flights, where this is now higher for SC than for RP alternatives, with the converse being the case in the original models. In the asymmetrical model, we observe a drop in the willingness to pay for improvements, along with an increase in the reductions in fare required to accept poorer conditions.

Table 6: Estimation results for model allowing for asymmetrical preference formation after excluding non-traders

Respondents	411
Observations	3288
LL	-1327.29
par.	16
adj ρ^2	0.4106

	decreases		increases		
	est.	asy. t-rat.	est.	asy. t-rat.	t-rat (diff)
β_{current}	-0.2628	-1.49	-	-	-
$\beta_{\text{access time}}$	0.0005	0.22	-0.0078	-6.35	2.45
$\beta_{\text{air fare}}$	0.0110	6.46	-0.0257	-5.17	2.89
$\beta_{\text{flight time}}$	0.0037	3.05	-0.0045	-5.38	0.60
β_{OTP}	-0.0146	-3.79	0.0025	0.75	1.98
β_{FF}	-0.3938	-3.52	0.2066	0.93	0.72
$\beta_{\text{closest airport}}$	-0.2700	-1.87	0.6897	3.53	1.56
$\beta_{\text{connecting}}$	0.3774	2.68	-0.6349	-3.83	1.15
φ	0.5333	6.38	0.5333	6.38	-

Willingness to pay for improvements	
access time reductions ($/hour)	1.26†
flight time reductions ($/hour)	8.54
on time arrival ($)	9.76†
gaining tier of FF benefits ($)	8.04†
moving to closest airport ($)	26.83
reduced number of connections ($)	14.68

Drop in fare required to accept poorer conditions	
access time increases ($/hour)	-42.56
flight time increases ($/hour)	-24.71
late arrival ($)	-132.26
drop in tier of FF benefits ($)	-35.67
moving away from closest airport ($)	-24.45†
increased number of connections ($)	-57.50

† calculation involves parameters not significant at the 95% level of confidence.

5 Conclusions

This paper has discussed several important issues arising in the specification of models using SC data in the field of air travel choice behaviour. Increasingly, such SC surveys include a reference alternative corresponding closely to an observed trip for a given individual. In this paper, we have argued that the presence of this reference alternative potentially leads to a need for departures from a classical modelling approach in which all alternatives are treated in the same way. Two possible approaches have been discussed in this paper, either making use of separate coefficients for RP and SC attributes, or allowing for asymmetrical preference formation around the attributes of the RP alternative. Both departures lead to gains in model performance as well as substantially different results.

A further topic discussed in this paper is the potential impact of non-traders on model results. Non-traders, i.e. respondents who do not trade off the attributes of alternatives against each other, are a common observation in SC data, and they play a major role in datasets that include a reference alternative, as is the case in the present study. The analysis has shown that, by dropping these respondents from the data, we obtain significantly different model results. It is however not clear whether the models with or without the non-traders should be regarded as producing *biased* results. This is an important question, and deserves further attention. Future studies should attempt to address this issue at the data stage, presenting respondents with situations that are extreme enough to encourage trading off between attributes.

In closing, it should be noted that the study presented in this paper makes use of a relatively basic utility specification, and does not allow for any variations in tastes as a function of socio-demographics, such as trip purpose, income, or trip distance. As such, the implied valuations from this study are of little use for policy work. However, this was not the aim of the present paper, and the conclusions in terms of modelling methodology should be relatively unaffected by this.

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