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An analysis of trends in air travel behaviour using four related SP datasets collected between 2000 and 2005

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Abstract

An ever growing number of studies are carried out to understand the behaviour of air travellers, and in particular the response to changes in crucial attributes such as air fares, travel time, and frequent flier benefits. Increasingly, these studies make use of data collected through stated choice surveys. However, while the different studies all produce interesting results in their own right, it should be recognised that the results are limited to the context of each specific study. In the present study, we attempt to address this issue by using data from four related surveys carried out between 2000 and 2005. The analysis shows a certain level of consistency in some of the sensitivities, but also highlights trends such as reduced WTP measures, potentially influenced by the growing number of low cost flight options, lack of service differentiation among the carriers, and increased use of online ticketing, which has led to greater fare transparency.

Keywords: air travel behaviour; stated choice; merged data

Introduction

Over the past decade, the U.S. domestic air service market has seen a number of very significant changes. The year 2000 capped an extended period of continuous growth in U.S. air passengers. That growth was accompanied by significant capacity issues at major airports with a corresponding increase in delays. These conditions changed dramatically after the terrorist attacks of September 2001. Air passenger and flight traffic dropped dramatically, with corresponding reductions in airport congestion, while total door-to-door air travel times were affected by the significant new security screening procedures that were instituted. Over the past eight years, conditions have continued to change, with air passenger levels exceeding year 2000 volumes by 2004, peaking in 2007 and falling again in 2008/2009 as a result of the economic recession. Low cost carriers penetrated virtually all of the major travel markets and their market shares relative to the legacy carriers rose dramatically.

This paper aims to answer the question as to whether and how much the basic choice processes that travellers use to select flight alternatives have changed over this period. Over the period of 2000 to 2008, five waves of a U.S. domestic air traveller survey were fielded (see, for example, Resource Systems Group, 2002). The survey, administered to approximately 600 travellers in each wave, includes detailed questions about all of the key aspects of the air travel experience. It also includes stated preference exercises that explore the trade-offs that travellers make among fare levels and

the numerous key components of air service. The core survey questions and the stated preference sections in particular are included in each wave, allowing analyses of year-to-year trends. In each wave, different topical emphases have been added, but the stated preference exercise remained as a common component used to estimate the trade-offs that travellers make among the core air travel service attributes that distinguish among alternative flight itineraries.

The data from these survey elements demonstrate clearly that the types of air trips being made have changed (e.g., fewer short trips because of the additional time required for security checks), that the ways in which customers acquire tickets have changed (substantial shift to flight searches and self-ticketing on the web) and that preferences among individual airlines and airports have shifted predictably as conditions and services have changed.

Data from the stated preference experiments in each of the individual survey waves have also been analysed in detail and the results have been presented in previous papers and presentations (see, for example, Adler et al 2005; Hess, 2007, 2008, 2009; Hess, et al 2007; Bhat, et al 2006; Theis et al 2006). While these papers used comparable stated preference data from different survey waves, the analyses were all focussed on different issues, used different methods and for various other reasons did not produce directly comparable results. What is new in the present paper is that we make use of a consistent specification and the same model structure across the stated preference data from the four survey waves representing the years 2000, 2001, 2002 and 2005.[1]

The remaining sections of this paper provide some descriptive information on the data from the four survey waves used for this study, then present a set of choice modelling results that address the central question posed above: *To what extent have the basic choice processes that travellers use to select flight alternatives changed?*

Data

Each of the survey questionnaires used the same basic structure for the stated preference exercises. The characteristics of the itinerary used for each traveller's most recent flight were shown as the "Current Flight" and an "Alternative Flight" was also presented to the same destination airport. Service details were changed in ways that made the alternative flight realistic, while allowing all service attributes, including originating airport, to change.

The factors that were used to describe the flight alternatives included the following basic service elements:

- Fare
- Scheduled trip time
- Number of connections
- On-time performance
- Aircraft type
- Airline
- Departure airport
- Arrival time (difference from most preferred time)

The stated preference exercises in the year 2000, 2001 and 2002 surveys were identically structured, with an example choice screen shown in Figure 1. The stated preference exercises in the 2005 survey wave were re-structured to provide more detailed information about flight connections in itineraries

[1] Data from the most recent 2008 survey wave are not included in this analysis as the extra complexity introduced by the inclusion of access mode choice in the 2008 data limits the scope for using the generic specification on that sample.

that included one or more connections; an example choice screen is shown in Figure 2. Despite the small differences between the 2005 survey and the remaining three surveys, there is still a high degree of similarity which should allow us to compare results across surveys without undue influence of the design.

In each of the four surveys, the underlying experimental design encouraged respondents to trade between the different attributes, e.g. a typical scenario might involve the choice between the current flight and a slower service that is however cheaper. A target sample of around 600 respondents was used in each sample, where this was collected via the internet from travellers who had made a domestic air trip in the last twelve months. In the first three waves of the survey, each respondent was presented with ten choice scenarios, while, in the 2005 edition, this was reduced to eight choice sets per respondent. The actual samples were collected in May 2000, June 2001, November 2002, and May 2005. The split in terms of various socio-demographic dimensions, namely income and journey purpose, was broadly comparable across the four samples, where roughly twenty percent of respondents were travelling for business reasons.

We also investigated trends along three other dimensions, namely the ticket purchase channel, fare transparency in the form of whether a respondent feels they found the best available fare, and the amount of time a respondent arrived at the airport prior to the scheduled departure time. Here, we observe the expected strong growth in internet bookings, especially through an airline's website. This growing reliance on internet bookings is also strongly linked to increasing fare transparency, as highlighted in the increasing share of respondents who feel they found the best available fare. Finally, we observed a strong increase in the amount of time respondents arrived prior to departure for 2002 and 2005, where this is almost surely linked to increased screening measures put into place after the terrorist attacks in September 2001, noting that the 2001 sample was collected prior to this, in June 2001.

Model specification

The analysis of the data made of use of discrete choice structures belonging to the family of random utility models (cf. Train, 2003). A linear in attributes specification of the utility function was used for all models, where, with a view to facilitating comparisons across datasets, as generic an approach as possible was used. With the main interest being the comparison of willingness to pay (WTP) indicators across datasets, the various models were all estimated in WTP space, thus providing direct estimates for the WTP measures (cf. Train & Weeks, 2005).

The final model specification involved the estimation of the following key parameters:

- An alternative specific constant (ASC) associated with the first alternative
- A marginal utility coefficient for fare, with the attribute being valued in $. In a WTP specification, this coefficient takes the role of a scale parameter
- The WTP for reductions in flight time and access time
- The WTP for reductions in early and late schedule delay
- The WTP for avoiding connecting flights, with separate measures for flights with one connection and flights with two connections
- The WTP for travelling on an airline where the passenger holds a frequent flier membership, with three possible levels, these being standard membership, silver membership and gold membership
- The WTP for improvements in on-time performance
- The WTP for flying on a specific type of aircraft, or combination of types in the case of connecting flights, with turboprop aircraft serving as the base

As mentioned above, the main aim of this paper is to compare results across the four datasets collected at separate points in time, and as such, simple model specifications were used. Nevertheless, it was deemed important to account for the fact that the MNL model does not provide an adequate treatment of the repeated choice nature of the SP data, and with this in mind, all models were estimated with a Jackknife procedure, leading to a correction of the standard errors (cf. Cirillo et al., 2000).

All models were estimated using Biogeme (Bierlaire, 2005). Separate models were estimated for business travellers and leisure travellers, along with a model for the full sample, which also incorporates the small number of trips made for *other* reasons.

Results

Joint model

As a first step in our analysis, we estimated a model jointly on all four datasets. This model makes the assumption that the relative sensitivities to different attributes (e.g. flight time *vs* fare) have stayed constant over time. The model however allows for possible scale differences across datasets, i.e. acknowledging the fact that the modelled utility may have a bigger absolute influence on choice probabilities in some of the datasets. To this extent, scale parameters were estimated in this joint model, with the base being the 2000 dataset.

The detailed estimation results for the joint model, estimated on all four datasets, are summarised in Table 1, with 4,792 observations from business travellers, 16,095 observations from leisure travellers, and a full sample of 22,089 observations, where this includes trips made for *other* reasons.

The joint model makes the assumption that any differences across the four samples relate solely to scale, captured in the estimation of the three scale parameters. With this specification, we obtained adjusted ρ^2 measures of 0.452 for the business traveller model, and 0.497 for the leisure model. As a comparison, a model was also estimated in which all parameters were dataset specific. This led to the expected improvements in the combined log-likelihood, but the higher number of parameters (78 instead of 22) meant that the actual improvements in fit are only marginally important, with adjusted ρ^2 measures of 0.454 for the business traveller model, and 0.499 for the leisure model.

Looking first at the scale differences across the four datasets, where the t-ratios are calculated in relation to a base value of 1, the only conclusive evidence is of lower scale in the final dataset, suggesting a choice process that is less well explained by the parameters included in the model. Turning our attention to the remaining results, we can see that overall, the sensitivity to access time is higher than that for flight time, by between 15% and 25%, depending on the segment. The actual WTP is more than twice as high for business travellers than for leisure travellers for both time components, where this difference is statistically significant at high levels of confidence.

Interestingly, across all segments, the WTP for avoiding flights with two connections is less than twice the WTP for avoiding flights with a single connection, where the actual WTP is again markedly higher for business travellers, by a factor of almost three, but with a high associated standard error for this difference.

The expected differences between the two main segments arise when looking at the WTP for flying on an airline where the respondent holds a frequent flier membership. Not only are the WTP figures much higher for business travellers, but the valuation for *gold* membership attains only a lower level of significance in the leisure segment, most probably due to the low number of leisure travellers who hold this highest level of membership. It is worth highlighting the wide confidence intervals for

these measures, with the difference between the business and leisure segments only being significant at high levels of confidence in the case of gold membership.

While there is some evidence of business travellers preferring larger aircraft, this is evidence is not as persuasive in the leisure segment. We observe low WTP for avoiding shifts in departure time (from the preferred time), with the penalty for early (scheduled) delay surprisingly being higher than that for late schedule delay. Finally, the WTP for on-time arrival is higher for business travellers (difference significant at the 90% level).

Trends

In this section, we look at the estimation results for the dataset specific models. In particular, one model was estimated for each year in which the survey was carried out. With the interest being on establishing trends over time, we focus on a summary presentation of the main WTP indicators, as shown in Table 2. Several of the estimates were not statistically significant, indicated as n.s. Additionally, Table 2 gives an indication of the statistical significance of the differences across years, representing 99%, 95% and 90% levels of confidence as ***, **, and * respectively.

By looking through the results, we once again observe the obvious and expected differences between the two main segments, with the WTP measures being much higher for business travellers. Additionally, we observe some interesting trends in WTP measures, although the overall significance levels for differences are relatively small.

The most striking observation is the very visible drop in the WTP measures when moving from the three initial samples to the 2005 sample. This drop in WTP measures is due at least in part to the increased presence of low cost carriers and lack of service differentiation along with the increase in online ticket shopping. Both of these factors likely have increased fare sensitivity (and transparency) and thus reduced WTP. In the past two years, reductions in the travel budget for business travellers are also likely playing a contributing role; and a study incorporating more recent data would be of interest in this context.

Looking first at the valuations of flight time and access time reductions, the changes in the latter are especially interesting. Here, we see an increase from 2000/2001 to 2002, possibly reflecting a desire for additional time savings in the face of increased delays caused by additional security checks. On the other hand, we then see a strong reduction when moving to 2005, partly explained by the above discussion in relation to fare sensitivity changes, but also a greater willingness to travel to outlying airports served by low cost carriers.

Our next comparison looks at the WTP for avoiding connecting flights. Given the low representation of flights with two connections, we primarily focus on the WTP for avoiding flights with a single connection. Here, two observations can be made. Firstly, the WTP measures are again higher for business travellers than for leisure travellers. More striking however is the fact that while there is a gradual drop in the WTP for business travellers for avoiding flights with single connections, there is a small increase for leisure travellers.

The results for on-time performance (OTP) are very stable for business travellers (no significant estimate in 2005), while, for leisure travellers, there is evidence of a drop in the WTP, potentially linked to a growing acceptance that delays in air travel are commonplace.

The results for the WTP for flying on an airline are affected by issues with significance in many segments, showing increases in the WTP increases with the status of membership, alongside reductions in the WTP over time, potentially as a result of reduced actual tangible benefits.

Conclusions

There is growing interest in trying to understand what drives air travel behaviour, with an increasing number of studies looking at the choice of airport, airline, or access mode. However, while individual studies, especially those based on stated choice data, have been able to produce generally robust and plausible results, it should be recognised that the results for each study are limited to the context of the particular data used in that study. The present paper looks at the estimation of models on four related datasets collected between 2000 and 2005. While there were dramatic changes in air travel conditions over the years 2000 to 2002, there appeared to be less change in the basic travel preferences and choices exhibited by U.S. travellers, with results comparatively stable across segments. Nevertheless, the analysis shows some interesting trends, most notably a decrease in air travellers' willingness to pay measures, especially in 2005, which we explain by the growing availability of low cost flight options, reduced frequent flier programme benefits, increased use of online ticketing and the lack of service differentiation among the major U.S. air carriers.

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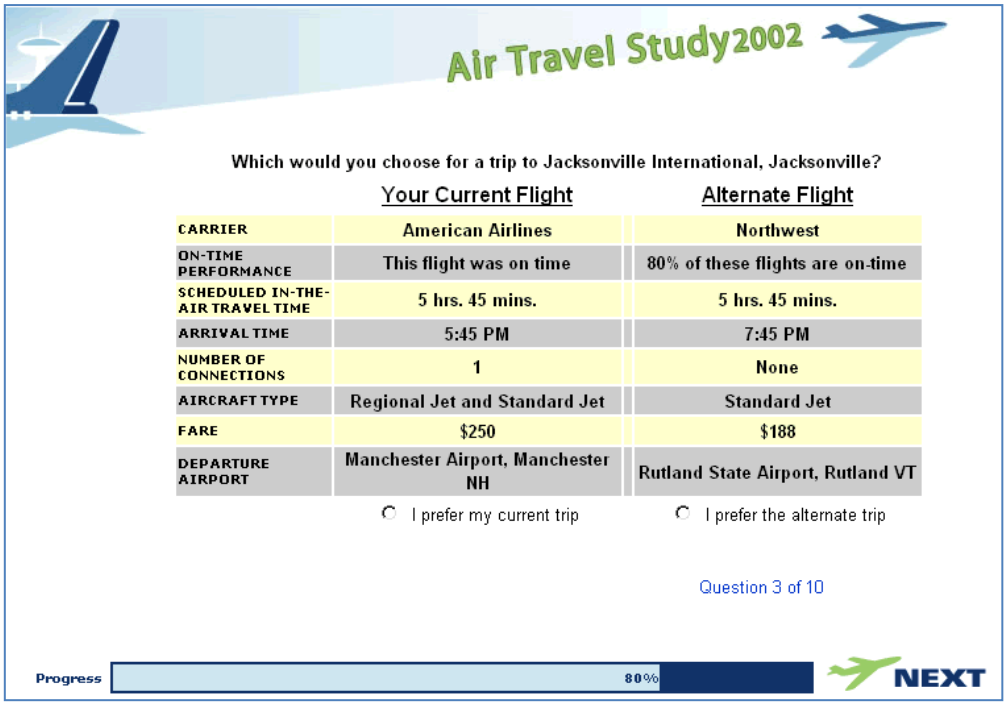

Figure 1: Example choice scenario in 2002 survey

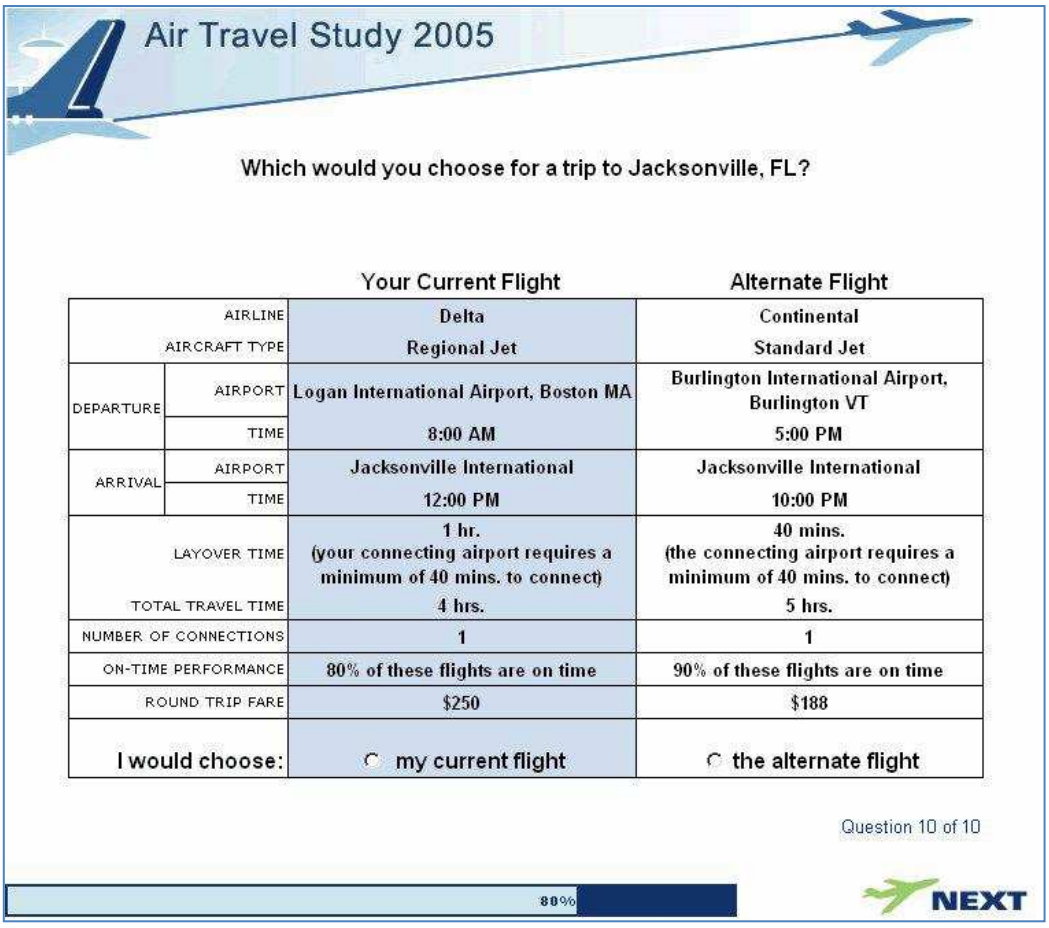

Figure 2: Example choice scenario in 2005 survey

Table 1: Estimation results on merged data

		Business		Leisure		Full sample		
	Log-likelihood	-1,796.569		-5,591.38		-8,168.71		
	Adj. ρ^2	0.452		0.497		0.465		
	Observations	4,792		16,095		22,089		
		est.	**t-rat.**	**est.**	**t-rat.**	**est.**	**t-rat.**	**t-ratio for differences between business & leisure**
	ASC	0.63	4.94	0.71	12.74	0.68	14.69	
	fare ($)	-0.01	-8.24	-0.02	-23.07	-0.01	-24.07	
WTP	flight time ($/hr)	70.20	7.02	27.60	17.51	35.04	17.09	4.21
WTP	access time ($/hr)	88.20	6.62	31.92	9.19	41.82	15.90	4.09
WTP	1 connection ($)	58.90	2.55	21.50	5.78	29.00	7.08	1.60
WTP	2 connections ($)	101.00	3.06	37.60	5.79	46.10	5.66	1.89
WTP	standard FF ($)	29.90	1.67	18.20	3.76	21.10	4.08	0.63
WTP	silver FF ($)	96.40	3.44	61.00	6.09	74.80	6.86	1.19
WTP	gold FF ($)	181.00	4.96	51.90	1.79	98.00	3.59	2.77
WTP	regional jet ($)	13.80	0.56	-11.00	-1.32	-9.76	-1.18	0.95
WTP	standard jet ($)	45.10	2.13	-1.82	-0.24	4.56	0.65	2.08
WTP	wide body ($)	73.30	1.98	25.20	3.23	37.80	5.20	1.27
WTP	prop & regional($)	7.54	0.23	-9.65	-0.97	-11.80	-1.20	0.50
WTP	prop & jet ($)	24.40	0.87	-0.93	-0.20	-3.77	-0.76	0.89
WTP	regional & jet ($)	62.10	1.77	-6.63	-0.62	-1.93	-0.15	1.87
WTP	widebody & prop ($)	34.30	0.95	-2.12	-0.24	0.73	0.06	0.98
WTP	widebody & regional ($)	11.70	0.24	-3.35	-0.36	1.21	0.12	0.30
WTP	widebody & jet ($)	20.70	0.60	3.57	0.39	11.70	1.04	0.48
WTP	sde ($/hr)	10.74	1.72	2.66	3.40	3.21	2.92	1.28
WTP	sdl ($/hr)	4.21	1.27	1.64	1.53	1.58	1.44	0.74
WTP	OTP ($/%)	1.03	4.09	0.61	16.04	0.70	15.98	1.63
		est.	**t-rat (1)**	**est.**	**t-rat (1)**	**est.**	**t-rat (1)**	
scale	2000	1.00	-	1.00	-	1.00	-	
scale	2001	0.87	-1.56	1.02	0.48	0.98	-0.55	
scale	2002	1.06	0.58	0.97	-0.49	0.95	-1.16	
scale	2005	0.73	-3.43	0.81	-3.90	0.80	-4.57	

Table 2: Trends in WTP measures

business travellers

	2000	2001	2002	2005	2000 vs 2001	2000 vs 2002	2000 vs 2005	2001 vs 2002	2001 vs 2005	2002 vs 2005
flight time ($/hr)	76.80	85.20	93.00	42.84						**
access time ($/hr)	85.20	72.00	102.00	67.20						
1 connection ($)	196.00	88.70	63.30	43.70		**	*			
2 connections ($)	207.00	108.00	174.00	131.00						
standard FF ($)	41.10	94.70	n.s.	n.s.						
silver FF ($)	114.00	n.s.	79.60	n.s.						
gold FF ($)	109.00	n.s.	329.00	n.s.		***				
OTP ($/%)	0.99	1.01	1.04	n.s.						

leisure travellers

	2000	2001	2002	2005	2000 vs 2001	2000 vs 2002	2000 vs 2005	2001 vs 2002	2001 vs 2005	2002 vs 2005
flight time ($/hr)	35.64	29.94	29.76	17.70			***		***	***
access time ($/hr)	29.22	31.20	41.22	29.76						
1 connection ($)	18.40	13.70	22.70	40.40					**	
2 connections ($)	26.70	38.20	50.60	44.00						
standard FF ($)	22.90	13.50	23.10	8.61						
silver FF ($)	77.20	n.s.	73.20	47.20						
gold FF ($)	n.s.	n.s.	n.s.	n.s.						
OTP ($/%)	0.73	0.67	0.49	0.43			*		*	

full sample

	2000	2001	2002	2005	2000 vs 2001	2000 vs 2002	2000 vs 2005	2001 vs 2002	2001 vs 2005	2002 vs 2005
flight time ($/hr)	43.56	38.64	44.52	21.06			***		***	***
access time ($/hr)	36.24	40.74	57.24	36.30		***		**		**
1 connection ($)	43.20	23.20	35.80	45.20						
2 connections ($)	48.30	50.30	72.50	61.30						
standard FF ($)	34.60	18.80	16.60	n.s.						
silver FF ($)	93.80	n.s.	92.40	44.50						*
gold FF ($)	90.40	n.s.	114.00	n.s.						
OTP ($/%)	0.77	0.74	0.66	0.45			*		*	