Modeling Passengers' Preferences on a Short-Haul Domestic Airline with Rank-Ordered Data

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In recent years, interest in finding methods to measure and analyze airline passengers' preferences has been growing. The current state of the air transportation industry encourages the implementation of tools and methodologies for such purposes. Initial modeling results of research on the preferences of domestic airline users are presented. A field survey (computerized questionnaire on a laptop computer) was conducted in five of Israel's domestic airports. Respondents were asked to rank four alternatives as main level-of-service variables. Separate models were estimated for three passenger trip purposes: personal, tourism, and business. The results of single-choice and rank-ordered logit models are compared for all available observations. The results indicate that the combination of first- and second-rank data sets produces coefficient estimates that are efficient but not significantly better than those of the single-choice logit models.

In recent years, the need to investigate user preferences has become a critical and urgent issue in the air transportation industry's struggle to survive. This situation is largely a result of a series of global and regional crises that began in 2000. The rate of these occurrences and the magnitude of their effects have stimulated rapid and significant changes in the operational and economic-competitive environment (*1*, *2*).

One of recent main trends is the success of low-cost carriers (LCCs) to attract a significant number of passengers at the expense of traditional full-service carriers (FSCs). At the same time, FSCs experienced difficulties in satisfying customers; this added further validity to the business tenet that identifying and addressing customers' expectations are basic conditions for a firm's success.

One of the main means to evaluate customers' perceptions is stated preference (SP) methods. A considerable body of literature addresses the design, performance, and analysis of SP surveys. Among the various methods used to present questions to respondents, the one most used in the transportation literature is the single-choice experiment, in which respondents are presented with a series of alternatives and asked to choose their most preferred option. A baseline alternative (corresponding to the status quo) usually is included in each choice set.

A method widely applied in marketing but also used in transportation is the ranking experiment, in which respondents are asked to rank their options from the most to the least preferred. The motivation for using this method is to obtain more information for a given data set than the single-choice method can provide. The single-choice process can be viewed as a special case of the ranking process, in which respondents simply choose the best alternative. Rank-ordered models are briefly described in the literature review section.

The purpose of this paper is to model preferences of airline travelers regarding various attributes related to domestic airline service. Results are described for an SP study in which the respondents were asked to rank their preferences with respect to four ticket alternatives. Separate models were estimated for three passenger trip purposes: personal, tourism, and business. The results of rank-ordered logit models are compared against those of single-choice logit models. Conclusions based on the research findings are presented in the last section.

LITERATURE REVIEW

Analyzing Passengers' Preferences

During the past quarter of a century, tools and methods for the measurement and analysis of passengers' preferences have been continuously developed and applied. The body of literature describing applications in air transportation has been growing since the 1970s. Early research efforts include, among others, the demand for service with new airplane types using SP techniques (*3*) and analysis of the value of time using discrete choice analysis (*4*). Recent research projects include the willingness to pay for various service attributes (*5*); choice of itineraries, airlines, and price levels (*6*, *7*); choice of airports (*8*); evaluation of service levels in airport passenger terminals (*9*); new airline products and services (*1*); and security and safety values in intercity transportation (*10*).

The need for evaluating passenger preferences regularly has become even more relevant and critical in the past 5 years for several reasons: the escalating competitive and operational environment, an urgent need to react to excess capacity, fierce competition between FSCs and LCCs, and soaring fuel prices. In parallel, passenger satisfaction with airline services and products has been in continuous decline (*11*). These events and trends have forced airlines to address many challenges, especially in customer service.

The great success of LCCs highlights the importance passengers ascribe to certain service characters. LCCs emphasize price and operational precision (e.g., taking off and landing without delay) while trading off service attributes that can be found in FSCs or in charter airlines. The impacts of such services on different traveler types are not clear from the literature. Typically, business travelers are

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comfort-oriented, whereas tourists are price-oriented (*1*). In contrast, research conducted among Swedish domestic airline passengers identified other high-ranked service attributes (*5*); results also showed that both business- and personal-trip passengers ranked the comfort attributes low. These examples point out the need for different approach toward each population segment.

Model Estimation with Ranking Data

In estimating models with ranking data, the basic assumption is that the choice behavior underlying each rank position satisfies Luce's choice axiom, well known as the independence from irrelevant alternatives (IIA) (*12*). Then, the probability of a ranking can be easily linked to choice probabilities. The first empirical studies of this approach were published by Beggs et al. (*13*) and Chapman and Staelin (*14*). The model specification [following Ben-Akiva et al. (*15*)] is briefly presented here.

A ranking of J alternatives is equivalent to the following sequence: the highest-ranked alternative is chosen over all the other alternatives, the second-ranked alternative is chosen over all alternatives except the first, and so on. The decomposition of choice probabilities is given as

$$P(1,2,\ldots,J) = \prod_{j=1}^{J-1} P\left(j \mid j, j+1, \ldots, J\right) \qquad (1)$$

where $P(1,2, \ldots, J)$ is the probability of observing the rank order of Alternative 1 being preferred to Alternative 2, Alternative 2 preferred to Alternative 3, and so on. If the probability of choosing an alternative is given by the multinomial logit (MNL) model and it is further assumed that all choice probabilities follow the same logit model, then the probability of observing the rank-order sequence described above is

$$P_n(1,2,\ldots,J \mid \beta) = \prod_{j=1}^{J-1} \frac{\exp(\beta' x_{jn})}{\sum_{i=j}^{J} \exp(\beta' x_{in})} \qquad (2)$$

where β is a vector of unknown parameters and x_{jn} is a vector of attributes of alternative j for observation n. Therefore, the rank-ordered logit model is equivalent to $(J - 1)$ independent MNL models, where each model is calculated separately for each data set. Ben-Akiva et al. note that the term "rank-ordered logit" is equivalent to the term "exploded logit" used in the marketing literature (*15*).

The formula presented above assumes the choice process is similar for all ranks, that is, the scaling parameter in each choice process is equal to the same value (generally normalized to 1). It is known from the literature that the reliability of ranking information decreases with decreasing rank. Hausman and Ruud comment that the coefficient estimates decrease in magnitude as additional ranks are used in the estimation (*16*). They estimated models by using different scaling parameters for decreasing ranks and found that they outperformed the ordinary rank-ordered logit model.

In summary, the estimation of rank-ordered models may provide a valuable tool for forecasting, provided that the ranked data are stable. The main steps of the model estimation process conducted to verify the reliability of the ranking data are described later, following the SP experiment description.

SP EXPERIMENT

Survey Design

The method reported in this paper was specifically designed to evaluate passengers' preferences for short-haul domestic flights. To gather empirical data, a computerized field survey was designed with generic software. Interviews were conducted with laptop computers as a medium for the questionnaire and supporting data presentation (e.g., timetables, maps). The field survey was performed over 6 months at Israel's five main domestic airports.

The computerized questionnaire had two main sections. The first section included two subparts: investigation of preferred aircraft for domestic routes and passenger willingness to use a hub-and-spoke type of operation. The authors have reported these details elsewhere (*17*).

The second section was the SP questionnaire. Each respondent was presented with various options of purchasing domestic flight tickets among five domestic airfields. These flights are operated by two airlines: the well-established Arkia (AIZ) and the fairly new Israir (ISR). These two airlines compete for passengers on four of the five domestic routes used in the study.

Experiment Design

According to the current situation of short-haul domestic service in Israel, five major service parameters were defined and surveyed in the SP games: discount ticket price, full-fare ticket price, need to perform a connection, waiting time between flights (connection time), and flight duration. Currently, no frequent-flier programs are available for domestic flights in Israel; therefore, this variable was not considered in the experiment.

The questionnaire presented full-fare and discount ticket prices side by side to give the respondents an idea of the price difference between the two fares. In the model, the price parameters for these two options are labeled minimum (discount) and maximum (full-fare) prices, respectively.

To produce reasonable values for each variable in the SP experiment, the research used real data based on flight tickets offered by the airline companies on their Internet sites. The minimum and maximum ticket prices were expressed in new Israeli shekels (NIS; US\$1 = 4.40 NIS), including a security tax of 15 NIS. Ticket prices were the same in some experiments, which is not uncommon for some of the actual local flight options.

The need to make a connection was related to two situations of airplane stopover: boarding extra passengers at an airport located en route, or changing airplanes during a connecting flight. Given the geographical conditions in Israel, a maximum of one connection was presented to survey respondents. Waiting time, measured in minutes, represents the duration of each connection. Where there is no connection, waiting time is 0, so a certain degree of correlation is expected between these two variables.

Each respondent was asked to perform four SP games, according to the number of real lines operating from each airfield related to the questionnaire. Each SP game was made up of four ticket alternatives that respondents were asked to rank according to degree of attractiveness. One of the ticket alternatives in each game represented a real line operated today, whereas the three other options in the set contained hypothetical data. Hypothetical levels for each attribute were determined on the basis of actual data, to preserve maximum realism. Table 1 presents the range of values used in the SP experiments.

TABLE 1 Range of Values in SP Experiments

Parameter	Range	Increment	No. of Levels
Price (NIS)	100–400	50	7
Stopovers	0 or 1	1	2
Waiting time in stopovers (min)	0–25	5	5
Flight time (min)	30–70	10	5

Because not all types of airplanes serve each airfield included in the survey and not all origin–destination combinations exist at each airfield included in the survey, the questionnaires were adapted to include every possibility. A total of 175 airline ticket combinations were created.

Field Survey

Face-to-face interviews were conducted at five of Israel's major domestic airfields between June 2004 and January 2005. The survey was conducted in two waves at these airfields to interview both summer and winter passengers.

A surveyor visited each airfield equipped with a laptop computer loaded with all the questionnaire forms appropriate to the specific airfield and the day's flight schedules (found on the Internet). All interviews were conducted at the gate area, where passengers arrived after having completed check-in and security checks to wait for their flights. The surveyor approached travelers and requested their participation in the survey. No incentives were offered.

Of 170 passengers randomly approached for interview, 155 agreed to be interviewed. The average proportion of refusals was relatively low (9.7%), although the refusal rate varied greatly from one airfield to another and by flight, time of day, and survey cycle. The average interview time was 17 minutes.

Table 2 summarizes the sample obtained from the field survey. Because four SP experiments were conducted for each respondent, the total number of observations for the analysis should be equal to 620. However, no choice was recorded for 13 experiments; therefore, those observations were excluded from the data set.

Most passengers on personal trips lived in outlying areas and used air travel as the main transportation mode for several purposes: traveling to university, receiving medical treatment, or obtaining other services located far from their residences. Although the geographic distance between peripheral areas is no more than 400 km (250 mi), factors such as mountainous terrain and relatively poor infrastructure make travel to the center of Israel difficult; thus, air transportation is essential for certain travelers. In some cases, the cost of air fare is paid for or subsidized by various bodies (e.g., government, health-care funds, or airline companies) to enable certain passengers to fly frequently.

The business travelers represent employees of many companies and professionals who use air transportation for short work visits to inspect and operate branches and logistic centers. They also use air transportation to attend conventions and business meetings and to visit exhibitions taking place mostly in Eilat, in southern Israel.

TABLE 2 Distribution of Survey Respondents in Subgroups

Trip Purpose	Respondents	Valid Observations
Personal	29	120
Tourists	74	283
Business	39	154
Other	13	50
Total	155	607

Descriptive Statistics

Table 3 lists a selection of the main sample characteristics obtained at all five airports, for the overall sample (155 respondents) and for each main passenger type.

The average sample age is young, for both men and women. About three-quarters of the respondents were men; similar proportions exist among each passenger type, with small variations. As expected, personal and business travelers use domestic flights in Israel most frequently, and tourists use airline service less frequently (consistent with local leisure patterns).

Table 3 shows that tourists comprise a relatively high proportion of nonworking persons. However, the definition of "nonworking" can refer to various subcategories (e.g., pensioners, students, and teenagers), not necessarily only to unemployed persons.

The distribution of respondents shows that AIZ's market share is bigger than that of ISR's but proportional to each company's market

TABLE 3 Main Sample Characteristics for Each Passenger Type

	Personal	Business	Tourists	Other	Total
Respondents	29	39	74	13	155
Gender					
Male	21	27	57	10	116
Female	8	12	17	3	39
Average age					
Male	31.3	39.4	28.2	22.3	30.4
Female	26.3	34.4	27.3	20.7	31.2
Participation in work force					
Working	22	33	37	2	94
Not working	6	1	25	11	43
No answer	1	5	12	0	18
Average annual number of flights (standard deviation)					
Domestic	6.50 (3.85)	6.00 (4.47)	2.38 (3.51)	7.96 (3.82)	4.53 (4.34)
International	1.07 (2.51)	1.82 (2.35)	1.04 (1.97)	0.30 (0.60)	1.18 (2.13)
Airlines in use					
AIZ	17	29	35	6	87
ISR	12	10	39	7	68
Average ticket price (NIS, one way)					
Average	280.2	305.4	264.7	278.5	279.0
AIZ	255.0	295.3	255.0	305.8	269.4
ISR	315.8	334.6	273.5	214.0	291.8
Average flight duration (min)					
Duration	55	52	52	55	53

share recorded in Israel's general population (60% and 40%, respectively). Nevertheless, AIZ has the dominant market share among the business travelers.

The current market share can be explained by ticket prices: those of AIZ are lower than those of its competitor. Ticket price is assumed to carry a great weight for the institutional bodies that subsidize personal travelers. A similar explanation can be assumed for business travelers, whose flight expenses generally are covered by an employer. Although the literature defines business travelers as less money-oriented, the dire business reality that demands cutting expenses along with the acute economic depression in Israel between 2001 and 2004 can support such an explanation. Moreover, AIZ's larger market share is also expressed by more frequent flights. The combination of higher flight frequency and lower ticket prices makes its service more attractive.

The proportion of tourists using ISR's services is indeed larger, but by a small amount, even though its average air fares are higher than the those of its competitor. Possible explanations are the relative flexibility of tourists' flight schedules and the possibility that flight tickets could be included in the overall cost of a vacation package, in which the per-flight price is not of major concern.

MODEL ESTIMATION

Single-Choice Process

The first step in the analysis was to estimate single-choice logit models. The alternative that received a respondent's highest ranking was defined as the "chosen alternative." Table 4 summarizes results for Model Set 1, which includes four MNL models (for all observations and for results segmented by each main passenger type).

In the model estimated using all observations, all variables are significant at the 5% level. In addition, the flight time and maximum price variables are significant at the 5% level for every passenger type. The magnitude of these variables does not vary much in each of the estimated models. All coefficient estimates exhibit the expected negative sign.

The log likelihood with respect to zero coefficients and the log likelihood with respect to constants (calculated using the proportions of the chosen alternative) are similar, because the highest-ranked alternative was approximately one-fourth of the four ticket options presented in the sample.

Inspection of the variance–covariance matrix shows a relatively high correlation between the airplane switch and wait time variables (0.83). This value was expected from the SP experiment, because in ticket options with no stopover, the waiting time was equal to 0. The correlation between minimum and maximum ticket prices is 0.74. All other correlations are relatively small.

Because the respondents ranked their alternatives, two additional choice models can be estimated: the choice of the second-ranked alternative among the three remaining options, and the choice of the third-ranked alternative (a binary choice). The importance of estimating these models is to check the consistency of the parameter estimates for lower-ranked alternatives.

Model Set 2 compares the estimation results for each single-choice process. Data Set 1 represents the choice among four alternatives (same as in Model Set 1). Data Set 2 represents the choice among three alternatives, after excluding the highest-ranked alternative from the data set. Accordingly, Data Set 3 represents the choice among two alternatives, after excluding the first- and second-ranked alternatives from the Data Set 1. The total number of observations differs slightly in each case.

Table 5 summarizes the estimation results using all passengers in the data set. To simplify the analysis, the segmented populations are not included in these models. The first estimated model is identical to the model estimated in Table 3.

As expected from the literature, the models estimated using the lower rankings (Data Sets 2 and 3, in this case) are less significant than the highest-ranked choice. In addition, the airplane switch dummy variable was not significant. However, noticeably, all other variables maintain their magnitude for the second-ranked model compared with the first-ranked model. The following formal statistical test was performed to test for the equality of individual coefficients across the data sets:

$$\frac{\beta_k^1 - \beta_k^2}{\sqrt{\mathrm{var}(\beta_k^1) + \mathrm{var}(\beta_k^2)}} \qquad (3)$$

TABLE 4 Model Set 1 Estimation Results (*t*-Statistics in parentheses)

	All Passengers	Personal	Tourists	Business
Price min. (NIS)	−0.0031	−0.0022	−0.0029	−0.0049
	(−2.9)	(−0.8)	(−1.9)	(−2.3)
Price max. (NIS)	−0.010	−0.012	−0.010	−0.0088
	(−9.1)	(−3.9)	(−6.5)	(−4.1)
Airplane switch	−0.51	−0.60	−0.46	−0.59
	(−2.0)	(−1.1)	(−1.2)	(−1.2)
Wait time (min)	−0.048	−0.036	−0.038	−0.061
	(−3.7)	(−1.3)	(−2.0)	(−2.4)
Flight time (min)	−0.041	−0.033	−0.044	−0.030
	(−9.3)	(−3.3)	(−6.9)	(−3.4)
Total observations	607	120	283	154
Likelihood (zero)	−841.5	−166.4	−392.3	−213.5
Likelihood (const.)	−840.8	−163.5	−391.2	−211.1
Final likelihood	−535.6	−103.4	−260.9	−130.3
Rho-bar (zero)	.36	.38	.33	.39
Rho-bar (const.)	.36	.37	.33	.38

TABLE 5 Model Set 2 Estimation Results (*t*-Statistics in parentheses)

	Data Set 1 (4 alternatives)	Data Set 2 (3 alternatives)	Data Set 3 (2 alternatives)
Price min. (NIS)	−0.0031	−0.0029	−0.0013
	(−2.9)	(−2.8)	(−1.0)
Price max. (NIS)	−0.010	−0.0073	−0.0070
	(−9.1)	(−6.4)	(−5.1)
Airplane switch*	−0.51	0.10	0.11
	(−2.0)	(0.4)	(0.4)
Wait time (min)	−0.048	−0.049	−0.023
	(−3.7)	(−4.0)	(−1.8)
Flight time (min)	−0.041	−0.039	−0.033
	(−9.3)	(−8.8)	(−6.6)
Total observations	607	604	605
Likelihood (zero)	−841.5	−663.6	−419.4
Final likelihood	−535.6	−511.1	−353.8
Rho-bar (zero)	.36	.23	.16

*Airplane switch is a dummy variable (no units).

TABLE 6 Tests for Equality of Individual Coefficients Across Data Sets

	Data Set 1 vs. 2	Data Set 2 vs. 3
Price min.	–0.13	–0.96
Price max.	–1.70	–0.17
Airplane switch	–1.71	–0.03
Wait time	0.06	–1.47
Flight time	–0.32	–0.90

The test results (Table 6) indicate no significant differences at the 5% level. At the 10% level, the hypothesis that the variables are equal for only two variables can be rejected: the full fare price and airplane switch dummy, in Data Sets 1 and 2. For most variables, the hypothesis that the coefficients are equal cannot be rejected.

Because the results do not reject the hypothesis that the coefficients are equal, Hausman and Ruud's test for proportionality of the coefficient vectors was not performed (*16*). Although the variables in each data set decrease in magnitude, they are not statistically significant, which means that the data sets can be combined to estimate the model using the rank-ordered logit estimator.

Rank-Ordered Logit

The next step in the analysis was to estimate rank-ordered logit models. From the four alternatives, three combinations of ranking data could be modeled: Data Sets 1 and 2 (first-ranked over the second), Data Sets 2 and 3 (second-ranked over the third) and the "exploded" logit using all three data sets. Table 7 lists the results for Model Set 3, in the same format as Table 5. In all models, the number of observations is equal to 603, which corresponds to the cases in which respondents completed all four rankings.

Following Ben-Akiva et al. (*15*), a likelihood ratio test was performed to test the hypothesis that the coefficients are equal between any combinations of data sets. The likelihood ratio test statistic is given as $[-2\,(L_R - L_U)]$, where L_R and L_U are the log likelihoods for the restricted and unrestricted models, respectively. L_R is given by the rank-ordered logit likelihood results (Model Set 3), and L_U is given by the sum of the log likelihoods for the models estimated separately from each data set (Model Set 2). This statistic is χ^2-distributed with $(K_U - K_R)$ degrees of freedom, where K_U and K_R are the number of parameters in the restricted and unrestricted models, respectively.

TABLE 7 Model Set 3 Estimation Results (*t*-Statistics in parentheses)

	Data Sets 1 & 2	Data Sets 2 & 3	Data Sets 1, 2, & 3
Price min. (NIS)	–0.0030	–0.0022	–0.0024
	(–4.0)	(–2.6)	(–3.7)
Price max. (NIS)	–0.0089	–0.0072	–0.0085
	(–11.1)	(–8.0)	(–12.1)
Airplane switch	–0.20	0.07	–0.17
	(–1.1)	(0.3)	(–1.1)
Wait time (min)	–0.049	–0.036	–0.040
	(–5.4)	(–3.7)	(–5.5)
Flight time (min)	–0.040	–0.036	–0.039
	(–13.1)	(–11.0)	(–14.8)
Total observations	603	603	603
Likelihood (zero)	–1498.4	–1080.4	–1916.4
Final likelihood	–1047.5	–868.2	–1413.7
Rho-bar (zero)	.30	.20	.26

TABLE 8 Tests for Equality of Coefficients Across Model Sets

	Data Sets 1 & 2	Data Sets 2 & 3	Data Sets 1, 2, & 3
Test statistic	1.6	6.6	26.4
Degrees of freedom	5	5	10
Chi-square (0.05)	11.1	11.1	18.3
P-value	0.9013	0.2521	0.0032

The results listed in Table 8 show that for the exploded logit model (i.e., the one that uses the full ranking), it is possible to reject the hypothesis that the coefficient vectors are equal across all data sets. However, for any combination of two data sets, it is not possible to reject the hypothesis. In particular, the model that uses the first and second rankings gives similar results to the single-choice models estimated separately.

The final set of models (Model Set 4) was estimated using the rank-ordered logit model for Data Sets 1 and 2, for each passenger type. The results are listed in Table 9. The model estimated for all passengers is identical to the first model presented in Table 7.

A comparison of the results listed in Table 9 with those of Table 4 indicates that the rank-ordered logit model presents significant results (5% level) for most variables. The airplane switch dummy variable was significant only for the business passenger segment; for other market segments, this variable was not significant in either model set (single-choice or rank-ordered). In contrast, the wait time variable was more robust for all segments.

SUMMARY AND CONCLUSIONS

This paper presents estimated results based on SP experiments. The decision to conduct the survey inside the terminals (after check-in and security check) was motivated by the fact that the passengers would have the best information about their actual flight characteristics and

TABLE 9 Model Set 4 Estimation Results (*t*-Statistics in parentheses)

	All Passengers	Personal	Tourists	Business
Price min. (NIS)	–0.0030	–0.0054	–0.0025	–0.0026
	(–4.0)	(–2.8)	(–2.5)	(–1.6)
Price max. (NIS)	–0.0089	–0.0072	–0.0085	–0.010
	(–11.1)	(–3.8)	(–7.9)	(–5.9)
Airplane switch	–0.20	0.23	–0.026	–0.70
	(–1.1)	(0.6)	(–0.2)	(–2.0)
Wait time (min)	–0.049	–0.040	–0.053	–0.046
	(–5.4)	(–2.0)	(–5.3)	(–2.6)
Flight time (min)	–0.040	–0.041	–0.038	–0.035
	(–13.1)	(–5.8)	(–8.4)	(–5.8)
Total observations	603	118	282	153
Likelihood (zero)	–1498.4	–293.2	–700.7	–380.2
Final likelihood	–1047.5	–198.6	–512.8	–255.3
Rho-bar (zero)	.30	.32	.27	.33

enough time to complete a 15- to 20-minute questionnaire. Because the survey was conducted among airline passengers, the results reflect the preferences of only the current passenger population.

The results obtained in this study for the rank-ordered logit models are in line with previous empirical results using this type of model. The main effect observed is the decrease in the magnitude of the coefficients with decreasing rank, although it was not possible to statistically reject the hypothesis that the coefficients were equal.

The rank-ordered logit models did not outperform the single-choice logit models; however, this does not mean that rank-ordered models are not suitable for application. The results presented in this paper indicate that at least for the first two rankings, the choice process is consistent, meaning that it is possible to forecast the ranking among three options.

The models estimated in this paper assumed that passengers were homogeneous with respect to the attractiveness of the different alternatives. Hess and Polak recently modeled airport choice behavior, taking into account random taste heterogeneity among decision makers (*18*). Train notes that it is possible to estimate rank-ordered data by using mixed-logit models, which can take into account taste variation (*19*). This line of investigation is left for further research.

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REFERENCES

1. Adler, T., C. S. Falzarano, and G. Spitz. Modeling Service Trade-Offs in Air Itinerary Choices. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1915*, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 20–26.
2. Whitaker, B., G. Terzis, E. Soong, and W. Yeh. Stated Preference as a Tool to Evaluate Airline Passenger Preferences and Priorities. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1915,* Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 55–61.
3. Davidson, J. D. Forecasting Traffic on STOL. *Operational Research Quarterly,* Vol. 24, 1973, pp. 561–569.
4. Gronau, R. *The Value of Time in Passenger Transportation: The Demand for Air Travel.* National Bureau of Economic Research, New York, 1970.
5. Carlsson, F. Private vs. Business and Rail vs. Air Passengers: Willingness to Pay for Transport Attributes. *Working Papers in Economics,* Vol. 14, Department of Economics, Gothenburg University, Sweden, 1999.
6. Coldren, G. M., F. S. Koppelman, K. Kasturirangan, and A. Mukherjee. Modeling Aggregate Air-Travel Itinerary Shares: Logit Model Development at a Major U.S. Airline. *Journal of Air Transport Management,* Vol. 9, No. 6, 2003, pp. 361–369.
7. Proussaloglou, K., and F. Koppelman. The Choice of Air Carrier, Flight, and Fare Class. *Journal of Air Transport Management*, Vol. 5, 1999, pp. 193–201.
8. Pels, E. Airport Economics and Policy: Efficiency, Competition, and Interaction with Airlines. Ph.D. thesis. Vrije Universiteit, Amsterdam, Netherlands, 2000.
9. Correia, A., and S. C. Wirasinghe. Evaluating Level of Service at Airport Passenger Terminals: Review of Research Approaches. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1888,* Transportation Research Board of the National Academies, Washington, D.C. 2004, pp. 1–6.
10. Liu, R., and G. Li. The Subjective Values of Safety and Security. Presented at 83rd Annual Meeting of the Transportation Research Board, Washington, D.C., 2004.
11. Bowen, B. D., and D. E. Headley. *The Airline Quality Rating 2005.* Aviation Institute, University of Nebraska, Omaha, and W. Frank Barton School of Business, Wichita State University, Kans., 2005.
12. Luce, R. D. *Individual Choice Behavior: A Theoretical Analysis.* John Wiley, New York, 1959.
13. Beggs S., S. Cardell, and J. Hausman. Assessing the Potential Demand for Electric Cars. *Journal of Econometrics,* Vol. 16, 1981, pp. 1–19.
14. Chapman, R. G., and R. Staelin. Exploiting Rank Ordered Choice Set Data Within the Stochastic Utility Model. *Journal of Marketing Research,* Vol. 19, 1982, pp. 288–301.
15. Ben-Akiva, M., T. Morikawa, and F. Shiroishi. Analysis of the Reliability of Preference Ranking Data. *Journal of Business Research,* Vol. 23, 1991, pp. 253–268.
16. Hausman, J. A., and P. A. Ruud. Specifying and Testing Econometric Models for Rank-Ordered Data. *Journal of Econometrics,* Vol. 34, 1987, pp. 83–104.
17. Feinstein, U., and S. Bekhor. Investigating Passengers' Preferences on a Short-Haul Domestic Airline in the Light of Current Competitive Environment. Presented at 9th Air Transport Research Society World Conference, Rio de Janeiro, Brazil, 2005.
18. Hess, S., and J. W. Polak. Accounting for Random Taste Heterogeneity in Airport Choice Modeling. In *Transportation Research Record: Journal of the Transportation Research Board, No. 1915*, Transportation Research Board of the National Academies, Washington, D.C., 2005, pp. 36–43.
19. Train, K. *Discrete Choice Methods with Simulation.* Cambridge University Press, Cambridge, United Kingdom, 2003.

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